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A Guidebook for Local Catchment Management in Cities

UNITED NATIONS HUMAN SETTLEMENTS PROGRAMME (UN-HABITAT)

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Foreword

With its vast expanse of polar ice sheets, sub-surface aquifers, rivers, lakes and wetlands, the planet Earth is a rich repository of freshwater resources. But only a small fraction of this freshwater is accessible and usable for our survival and well being, and it is very unequally distributed in geographic terms. Nevertheless, with the prudent policies and practices, we can make the best and equitable use of available water.

Over the years, significant progress has been achieved in provision of water supply to millions of people. Yet a sizable population, at least 1.1 billion per 2000 estimates, is deprived of access to safe water. Recognizing the vital need for water as a life support system, the Millennium Development Goals (MDGs) have set a target to halve the world's population without access to safe water by 2015. It is a challenging but not an impossible task, if concerted efforts are made focusing on local action. To this end, the need for mobilisation of resources and capacity building of local institutions can hardly be over emphasized.

The concept of Integrated Water Resources Management (IWRM) has gained coinage in recent years as a means for promoting sustainable water management. The main focus of attention in the planning and implementation of IWRM is on local water catchments. As history reveals, human settlements developed around water catchment areas. However with rapid and often unplanned urbanisation and the use of inappropriate technologies, local catchments in urban centers have been neglected and severely threatened by encroachment and pollution. Reliance on local sources of water has decreased and the cost of water supply has increased. There is a need to revive the traditional wisdom of local water catchment management with the appropriate infusion of modern technologies to bring about "contemporary relevance".

Water for African Cities and Water for Asian Cities are two regional programmes established by UN-HABITAT to support sustainable water management in rapidly developing urban areas and the attainment of the Millennium Development Goals. Working with several partners, including the Asian Development Bank and the African Development Bank, these programmes aim to strengthen local capacity through a blend of "know-how" and "do-how". The present Guidebook on Management of Local Catchments in Cities provides an overview of the principles and practices required for sustainable urban water catchment management. It also contains case studies from Australia, India, Latin America and South Africa to showcase "Do's" and "Don'ts".

I trust that this publication will stimulate local action for water resources management and thus contribute to providing access to safe water for all and to meeting the Millennium Development Goals.

Anna Kajumulo Tibaijuka
Executive Director, UN-HABITAT

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Acronyms

AAWSA	-	Addis Ababa Water and Sewerage Authority
ADRA	-	Adventist Development and Relief Agency
AWN	-	Africa Water Network
BOD	-	Biochemical Oxygen Demand
Ca	-	Calcium
CBD	-	Central Business District
CBO	-	Community Based Organization
Cd	-	Cadmium
Cl	-	Chloride
COD	-	Chemical Oxygen Demand
Cr	-	Chromium
Cu	-	Copper
DDC	-	District Development Committee
DN	-	Daily Nation (a Kenyan Daily newspaper)
DSS	-	Decision Support System.
ECA	-	Economic Commission for Africa
EIA	-	Environmental Impact Assessment
EMIS	-	Environmental Management Information Systems
EPM	-	Environmental Planning and Management
F	-	Fluoride
FGD	-	Focus Group Discussion
GEMS	-	Global Environment Monitoring System
GIS	-	Geographical Information System
ICM	-	Integrated Catchment Management
IPM	-	Integrated Pest Management
K	-	Potassium
LPG	-	Liquefied Petroleum Gas
Mg	-	Magnesium
Mn	-	Manganese
MOA	-	Ministry of Agriculture
MOU	-	Memorandum of Understanding
N	-	Nitrogen
Na	-	Sodium
Ni	-	Nickel
NEC	-	National Environment Council

NEMA	-	National Environmental Management Authority
NGO	-	Non-Governmental Organization
P	-	Phosphorous
Pb	-	Lead
RBA	-	Rapid Bio assessment Method
SCP	-	Sustainable Cities Programme
TDS	-	Total Dissolved Solids
TSS	-	Total Suspended Solids
TWQR	-	Target Water Quality Range
UN	-	United Nations
UMP	-	Urban Management Programme
UNEP	-	United Nations Environmental Programme
UN-HABITAT	-	United Nations Human Settlements Programme.
WDM	-	Water Demand Management
WHO	-	World Health Organization
WWTW	-	Waste Water Treatment Works
WC	-	Water Closet type of toilet
Zn	-	Zinc

Executive Summary

Over the years, the pressure on the limited freshwater resources has considerably increased due to growing demand and abuse of the catchment areas The imperatives for an integrated approach, linking *water management, land-use,* the *environment* and *human activities* and involving cooperative governance by local authorities and other stakeholders, is now recognised as the logical way forward. To translate this approach into action, it is necessary to develop enduring partnerships among the participating institutions and organisations in the catchment area. Along side, the policies, laws and regulations should be geared to provide the enabling framework as needed for formulation and implementation of action plans at the local level.

This guidebook provides basic information on how cities can protect their fresh water resources through proper management of the local catchments. It is for achieving the Millennium Development Goals (MDGs) which have set a target for halving the proportion of people without sustainable access to safe drinking water and basic sanitation, by 2015. The guidebook deals with the principles and practices for better management of water resources which, in turn, will lead to general improvement in the health of the local population, food security, environmental protection and sustainable development.

Key issues in Urban Catchment Management

1. Development and establishment of a Catchment Management Strategy and action plans with a wide acceptance and appeal as well as facilitation of their implementation by the various stakeholders.
2. Implementation of Integrated Water Resources Management (IWRM) at the local level to regulate allocation, abstraction, conservation, development and control of the water resources.
3. Coordination of integrated action plans at the local level and establishment of an effective conflict resolution mechanism.
4. Development of enforceable standards of air and water quality and acceptable emission limits of pollutants in the catchment.
5. Establishment of an efficient enforcement mechanism for the set environmental quality standards.
6. Laying down of mandates and capacity building in the institutions mandated to ensure natural resource management in the catchment area.
7. Provision of access to basic water and sanitation services for the urban poor especially those living in informal settlements.
8. Implementation of good practices in the management of liquid and solid wastes in the catchment area.
9. Arrangements for alternative means of livelihood for the people who have to eke out their existence through unsustainable exploitation of natural resources in the catchment area
10. Implementation of rational land use planning or zoning to protect fragile ecosystems in the catchment area.

11. Institutionalisation of the requirement for Environmental Impact Assessment (EIA) prior to investment decisions for major development projects in the catchment area. This should be complemented by a disclosure programme requiring operating companies to publish and submit to the government annual reports indicating the consumption of natural resources as also levels of emissions and effluents.
12. Development of guidelines and Codes of Environmentally Sustainable Practices for each of the key sectors viz. agriculture, industry, forestry, fisheries etc.
13. Public education on environmental issues and mobilisation to enable participation in informed decision-making processes in all catchment management matters.
14. Development of an effective environmental and water quality-monitoring programme.
15. Development of indicators for monitoring and evaluating the success of the catchment management strategy.
16. Implementation of public water sector reforms to improve governance and to recover the cost of supplying water in the catchment. This should help to improve service delivery to water users in the urban area. Immediate implementation of the Water Demand Management (WDM) programme to improve water use efficiency should be undertaken.
17. Fund raising to finance the implementation of the activities in the action plans outlined in the catchment management strategy. With improved revenue collection from water billing, a fund should be set aside to cater for protection of the environment and the water quality-monitoring programme.

Catchment Management Strategy (CMS) and Action Plan

A CMS is an organized and integrated course of actions aimed at attaining specified objectives in a given water management area over a defined period of time such as five years. The objectives include cost-effective protection and enhancement of the land and water resources to improve the social well-being, environmental quality and sustainable utilisation of the natural resources in the catchment. In developing a CMS, all the relevant facts must be analysed well so that appropriate decisions can be taken in formulating an action plan consisting of various activities aimed at achieving the expected results.

Strategies for Management of Water Resources in Urban Catchments

- Water resource protection strategy

  This strategy is aimed at achieving the set Target Water Quality Range (TWQR) over a specified period. The strategy includes the establishment of the nature and extent of point sources and non- point sources of pollution.

- Water use strategy

  This strategy involves issues of licensing and authorization. Water allocation and use are important in addressing the issue of social equity.

- Water resource development strategy

  The strategy involves the development of a database of supply infrastructure viz. reservoirs, water treatment plants, distribution system and identification of areas with current and projected shortages of water supply.

- Water resource conservation strategy

  Urban demand-side water management is aimed at meeting increasing service demands without increasing water supplies or compromising the quality of service.

  It includes the development of guidelines for demand management strategies for user sectors e.g. agriculture and industries. It also involves development of a system of identifying water-stressed areas or areas where water use is not efficient.

- Water resource control strategy

  This is a strategy for reviewing, upgrading and maintaining a satisfactory monitoring system. It includes development of strategies for flood and drought control etc.

- Institutionalising Cooperative Governance

  Known weaknesses of collaborative catchment management should be addressed and ways of overcoming them devised. Mechanisms of coordination amongst and within the government institutions and communities should be established to enable a participatory process in decision-making.

- Strategies for Pollution Control

  General guidelines should be developed for pollution control dealing specifically with improvement of surface and ground water quality by reducing environmental impacts due to human activities. These should include codes of practices in the respective sectors.

  The catchment can be divided into two or three sub-catchments depending on the river system and the geographical size. In each sub-catchment, one can identify the highly polluted sites or 'hot spots' from the water quality data obtained.

Commonly recommended remediation measures include:

- Pollution control at source
- Waste storage
- Waste recycling
- Wastewater treatment
- In stream aeration
- Low flow augmentation
- Wetlands and impoundments

Expected Outputs and Specific Interventions

These include specific activities involving all stakeholders to enhance the protection, conservation and sustainable utilisation of the natural resources in the catchment for socio-economic development while preserving the integrity of the ecosystem as much as possible.

1.0 Introduction

Over the years, the pressure on the limited freshwater resources has considerably increased due to growing demand and abuse of the catchment areas. The increasing pressure on land, forests and other natural resources continues to cause large-scale destruction of the environment and disruption of the hydrological cycle.

Many countries have already been categorised as suffering from 'water stress' and the list continues to grow (UN-HABITAT, 2003a). The problem has been further aggravated by pollution from the various economic sectors notably, agriculture and industrial activities. Of particular concern are the human settlements in urban areas where the social infrastructure development lags far behind the population growth. In the absence of proper water supply and sanitation facilities, the problems are more acute in such settlements, which call for prudent and innovative ways of managing the available water resources in a sustainable manner.

This guidebook is intended to provide basic information on how the cities can protect their fresh water resources through proper management of the local catchments. It is for achieving the Millennium Development Goals (MDGs) which have set a target for halving the proportion of people without sustainable access to safe drinking water and basic sanitation by 2015 (UN-HABITAT, 2003a). The guidebook provides the principles and practices for better management of water resources which, in turn, will lead to general improvement in the health of the local population, food security, environmental protection and sustainable development.

1.1 Situation Analysis

The high growth rates of population and rural-urban migration cumulatively contribute to the rapid urbanisation (UN-HABITAT, 2003b). Cities have been described as engines of economic development (Mbugua, 2003). However, the economic and infrastructural developments in the rapidly growing cities are not commensurate to meet the needs of increasing population. As a result, large sections of urban dwellers particularly those belonging to poorer communities are denied of vital basic services such as clean water and sanitation, health and education.

The domestic, agricultural and industrial sectors are among the major users of water. Recreation and ecosystem maintenance also require their fair share of the water resources. Improper water allocation in many developing countries has led to a situation where over 80% of the available water is used by the agricultural and the industrial sectors leaving less than 25% for domestic use (UN-HABITAT, 2003b). As a result, the water utilities are able to provide water supplies only intermittently with the risk of contaminated supplies due to leakage of sewage and contaminated water into the empty water pipes. In the past, there has been little or no concern for the environment while allocating the available water. Failure to retain 'ecological reserve flow' has resulted in disruption of ecosystem integrity in many cases with the attendant loss of biodiversity (Holtzhausen, 2002).

Lack of social equity in water allocation has further marginalized the urban poor making them more prone to water borne infections due to use of unsafe drinking water obtained from polluted sources. This places a heavy burden on the city's health care system in providing treatment for water borne diseases.

In spite of the water shortages, profligate use and wastage of water in urban areas, pipe leakages and illegal connections received little attention until recently. The unaccounted water, if significantly reduced, could make more water available for users in the catchment; raise revenue for development of more water infrastructure or help to subsidise water charges in poor urban communities.

Water shortages are also caused by pollution of water resources in the catchment, which renders the quality of water unsuitable for downstream users. Increasing pollution of surface water resources due to anthropogenic causes has contributed to the growing water scarcity due to reduction of utilisable water. The cost of water treatment has also increased due to the increased pollution load. This has had a direct influence on the water tariffs by pushing up the cost of piped water beyond the reach of the urban poor.

The destruction of forests for fire wood and timber products or to make clearings for slash and burn agriculture has left the soil vulnerable to erosion by surface runoff, increased silting of the rivers and the severity and frequency of flooding events in the catchments. Lack of water infiltration due to the eroded and hardened surface has also curtailed the recharging of ground water.

1.2 Land Use and Associated Pollution Problems

Improper land use and land use changes affect the hydrological cycle and consequently the quantity and quality of the water resources. Studies on the impact of urban areas on the hydrological cycle indicate that:

- Surface runoff is increased due to reduction in infiltration and recharge of the aquifer systems;
- Flooding incidences and severity increase;
- Groundwater abstraction causes a drop of the water table and land subsidence;
- Pollutant loads to water courses increase due to increased surface run-off;
- Poorly maintained sewers and poorly constructed pit latrines lead to seepage and overflow of pollutants to the ground and surface water resources;
- Groundwater is contaminated by pollutants from industrial effluents and poorly managed solid and liquid waste disposal practices; and
- Ecological integrity of sensitive sites is disrupted and biodiversity reduced in the recipient waters.

Most of the pollution problems in urban areas can be directly linked to indiscriminate land uses and human incursions (See Plates 1 and 2). The common land uses and associated pollution problems typical of many urban areas are summarised in Fig.1.

Plate 1. Building sand harvested from river banks on sale in an urban area.

Plate 2. Gravel from a stone quarry on sale at a roadside in a peri-urban area.

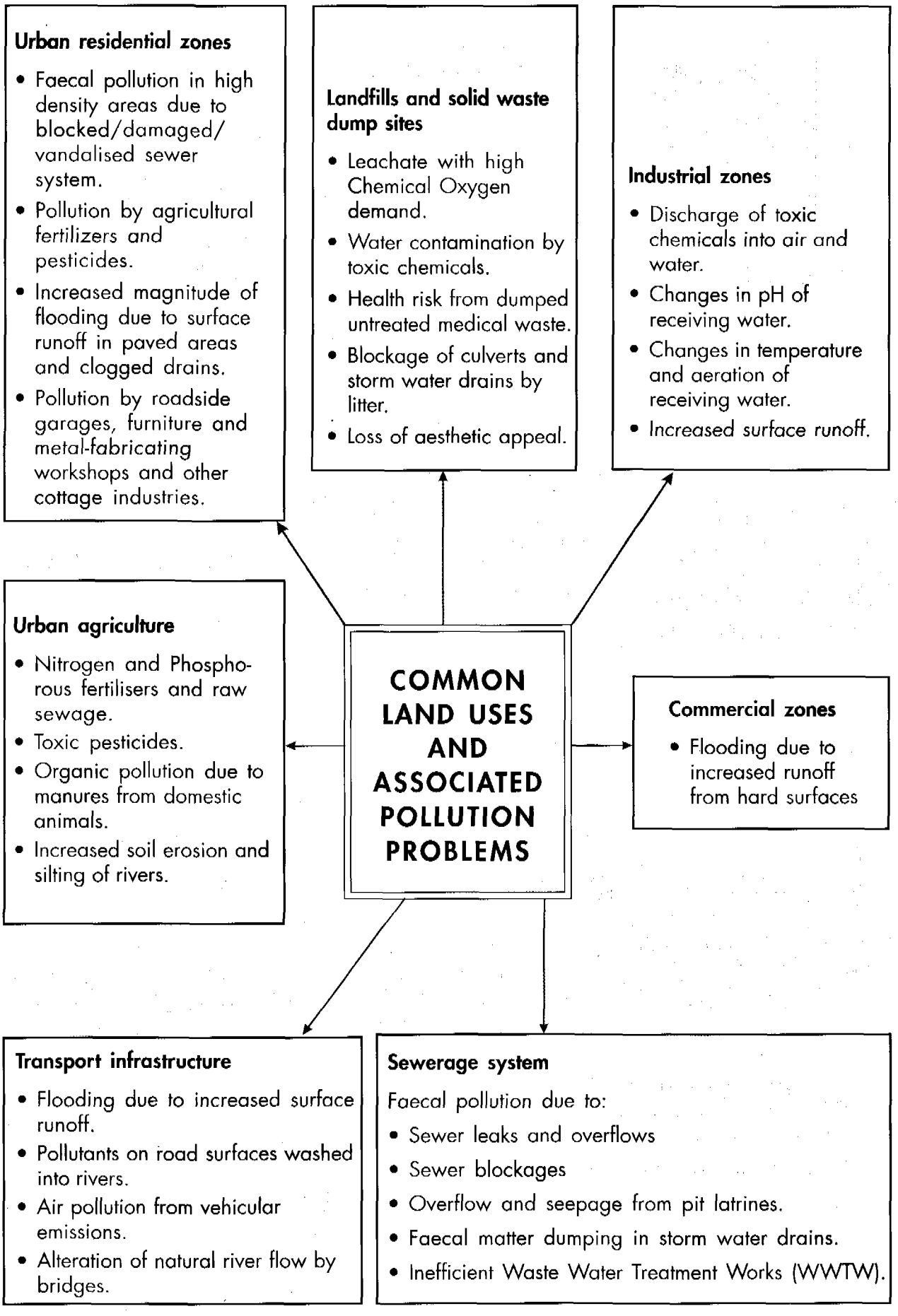

Fig. 1. Common land uses and associated pollution problems

Human settlements

The high-density areas are prone to pollution due to inadequate water and sanitation infrastructure, vandalism of sewer networks and poor maintenance of existing drainage system leading to faecal contamination of surface and ground water resources (Plate 3). In unplanned or informal settlements, seepage or overflow from pit latrines, dumping of faecal matter in storm water drains or garbage heaps and faecal matter from 'bush toilets' are major causes of surface water pollution. This exposes the human population living downstream to health risks due to water borne diseases. An additional concern is the enrichment of water sources with nitrates and phosphates present in the sewage. In the built up areas, there is increased surface run off from the large paved areas, which contributes to flooding and associated problems.

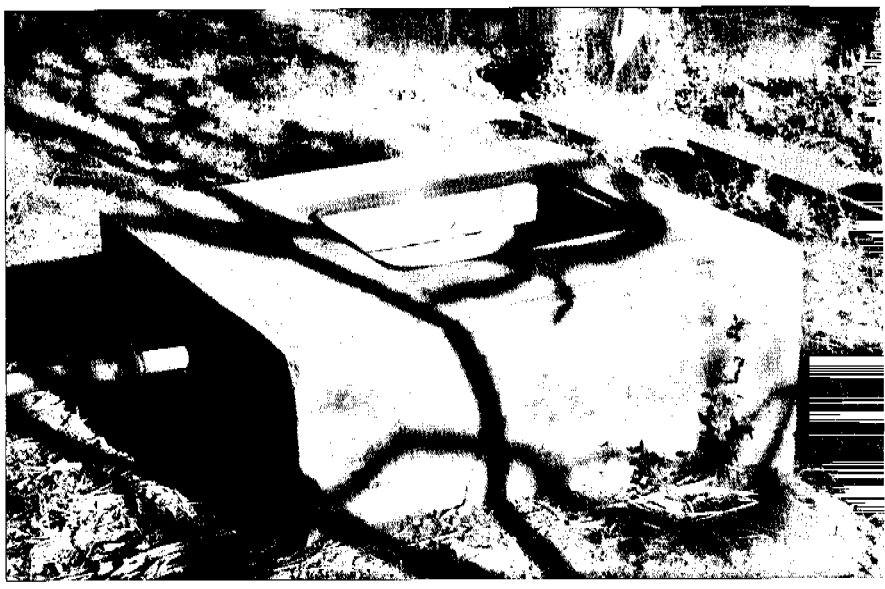

Plate 3. A vandalised inspection covers for a sewer drain. Stones and other objects may fall in and block the drain.

Urban agriculture

Agricultural fertilisers containing nitrates and phosphates, as also pesticides used for intensive gardening in some urban areas are notable sources of pollution. Many urban poor use the untreated sewage for irrigating and fertilising their crop-fields for food production and income generation (Plate 4). Untreated sewage has an offensive smell and there is risk of contaminating surface and ground water and also disease transmission to the farmers many of whom work without protective clothes and shoes.

Animals including dogs, poultry and cattle kept by city residents produce manures, which are washed into river courses during the rains. The manures contribute to the organic pollution of the water sources and also expose humans and animals downstream to the risk of contracting infectious diseases. In other areas, the propagation of invasive alien vegetation along riverbanks is of great concern. In some cases, the introduced species pose a threat to local biological diversity.

Plate 4. Urban agriculture: Irrigating crop-fields with untreated sewage which may contaminate surface and ground water sources.

Industrial zones

High pollution risk in these zones is due to discharge of industrial effluents into storm water networks. The effluents may contain high levels of various toxic or harmful chemicals. The pollutants may increase the salinity of the water and cause changes in pH depending on whether they are acidic or alkaline. This may adversely affect the biological diversity in the habitat. Some industries discharge hot water which can cause the temperature rise in the receiving water and may result in the death of many aquatic organisms. Large paved areas that are characteristic of these zones result in increased storm water runoff which washes solid waste, including non-biodegradable plastics and other litter, into the rivers and dams.

Food related industries including milk processing plants and slaughter houses are major polluters where the effluents are not treated before these are discharged into watercourses. Leather tanning units also cause significant pollution of surface water. The organic matter present in the effluents increases the Biochemical Demand (BOD), which is harmful to the aquatic organisms in the receiving water bodies. In addition, heavy metals such as Chromium used in processing raw hides and skins pollute the environment.

Hydrocarbons and the transport sector

Sizable quantities of used oils drained from storage tanks; transport carriers, motor vehicles and other fuel combustion systems are dumped in the environment and are finally washed into water courses (Plate 5). The oil slick on the water surface acts as an oxygen barrier leading to death of aquatic animals. The oils also contain heavy metals many of which are harmful to human health and other living organisms.

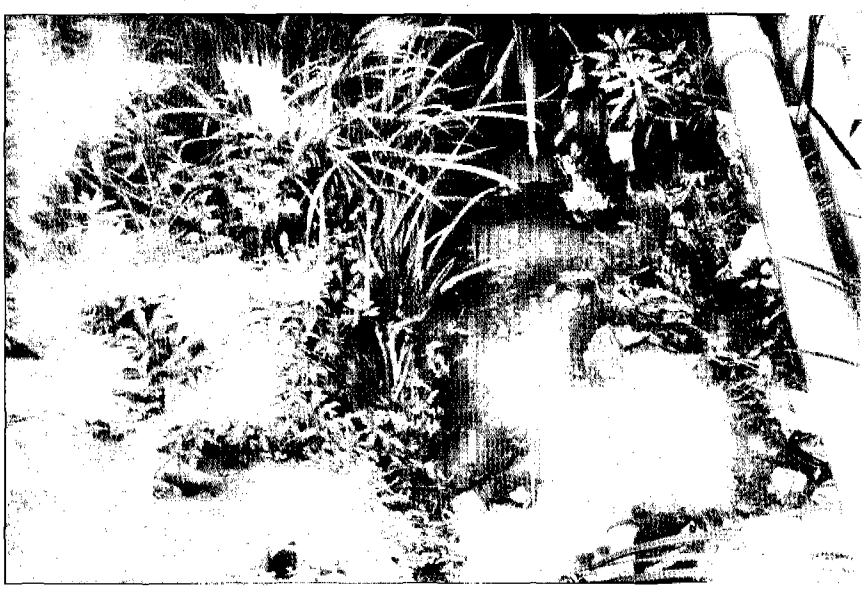

Plate 5. Used engine oil dumped in an open drain by garage workers in an urban area.

Increased runoff from the hard road surfaces carries spilled hydrocarbon products and other materials into the watercourses. The storm water also carries solid waste to the rivers where it may cause blockage of the river channel thus worsening the flooding conditions upstream of the affected rivers.

Commercial zones

Increased storm water and flooding is a common sight in commercial areas where the large paved areas do not allow water to infiltrate into the ground. Indiscriminate disposal of solid wastes causes aesthetic as also environmental problems (such as choking of sewer lines with plastics bags). Heavy vehicular traffic and operation of DG sets create air pollution problems.

Mining

Mining is a major cause of pollution in some areas. The pollutants in mining activities include acid mine drainage (AMD) which causes very low pH and death of all aquatic life in the receiving water. The acid also dissolves heavy metal ores present in the rocks thus introducing heavy metal pollutants in the surface water. Increased salinity is yet another problem accentuated by high sulphate levels in AMD. Quarries for building materials and sand harvesting on riverbanks are known to cause increased soil erosion and silting of rivers (Plate 6).

Plate 6. Stone quarrying in a peri-urban area. The loosened soil is washed by rain down the slope to the river where it is deposited as silt.

Waste water treatment works

Discharge from the Waste Water Treatment Works (WWTW) and drainage from sludge drying beds may find their way into water courses resulting in contamination of the water with faecal pathogens and an increase in the BOD of the water. Nitrates and phosphates present in the effluent enrich the water leading to eutrophication (algal bloom).

Landfill sites and solid wastes

Leachate from unlined landfill sites may reach and contaminate ground and surface water resources. This increases the BOD of water due to bio-degradable pollution and promotes eutrophication of water bodies. Solid waste causes loss of aesthetic appeal and also blockage of drains and conduits under bridges resulting in flooding (Plate 7).

Plate 7. A river channel blocked by solid waste in an urban area. This worsens the flooding conditions during rainy seasons.

Geological and other natural causes

Apart from anthropogenic pollutants, the natural geological formations in some areas can cause water pollution. Millions of people in some parts of the world e.g. Bangladesh, China and India are affected by high Arsenic content in ground water (Biswas, 2003). Ingestion of Arsenic through drinking water has been associated with skin diseases and even cancers. High fluoride content in water has been known to cause discoloration of teeth and crippling skeletal defects due to fluorosis.

1.3 Impacts of Pollution and Associated Risks

Environmental pollution adversely affects the quality of life and different aspects of human and ecological activities. The pollutants introduced in the catchments by the indiscriminate land uses cause various environmental problems. These include the following:

Eutrophication: Enrichment of water with nitrates and phosphates results in proliferation of algae and plants which then die and decompose in the water (Plate 8). It depletes the oxygen present in the water resulting in death of the aquatic life and consequent loss of biodiversity. It also results in increased cost of purifying the water.

Plate 8. Kibera slum village whose sewage flows into the Nairobi dam, in the foreground, now overgrown with water hyacinth (*Eichornia crassipes*) and other aquatic plants. The dam was used for aquatic sports before the slum village extended to the site.

Stalinisation: High salinity is another serious form of water pollution. The increased content of inorganic ions such as sulphates present in Acid Mine Drainage (ADM) increases the purification costs of water. Saline water is unsuitable for domestic use and crop irrigation and it has a negative impact on biological diversity in the receiving water. Poor drainage, fine grain size and high evaporation cause concentration of salts in the irrigated soils of arid and semi-arid areas. In some cases, salinity ingress takes place from the landscape due to clearance of vegetation and increased infiltration (Biswas, 2003).

***Organic pollutants*:** Increase in organic pollutants due to faecal contamination of the water or leachate from landfill sites raises its BOD (Plate 9). It also increases health risks to the water consumers by exposing them to water borne diseases such as cholera and certain types of hepatitis.

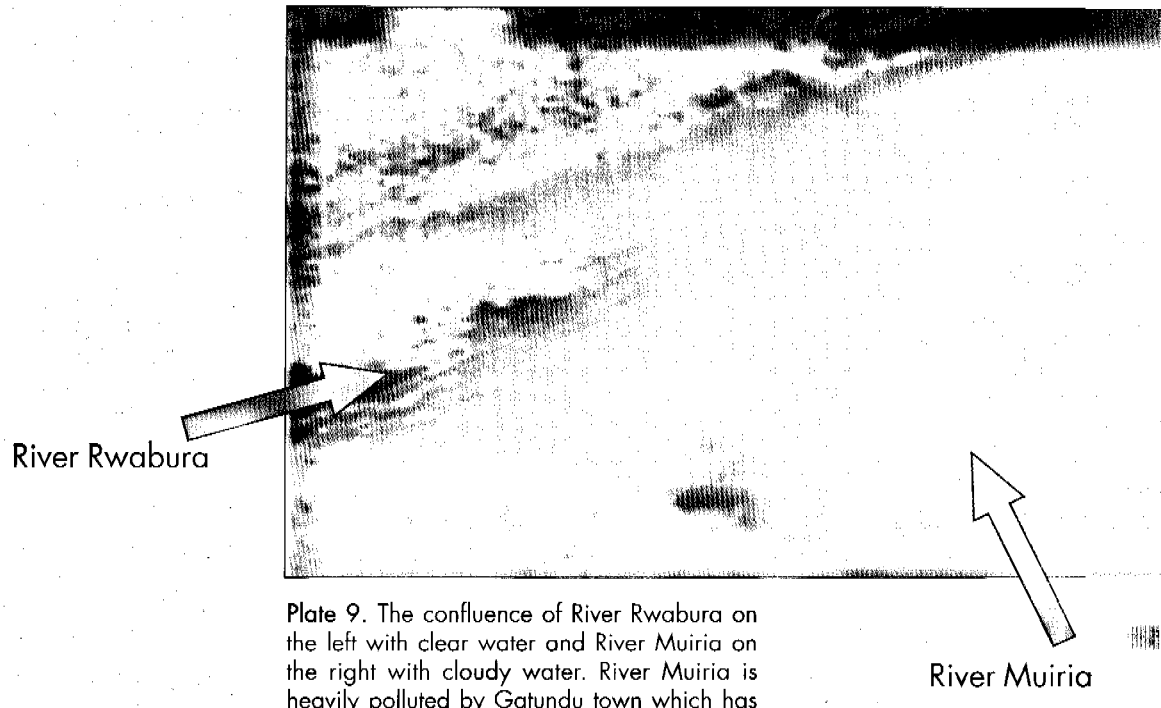

Plate 9. The confluence of River Rwabura on the left with clear water and River Muiria on the right with cloudy water. River Muiria is heavily polluted by Gatundu town which has no sewerage network.

***Erosion*:** Soil transportation to the rivers especially by rain water is commonly encountered where riparian areas and wetlands have been interfered with. Degraded lands which have lost vegetation cover due to logging, clearing, overgrazing or open quarrying are prone to soil erosion. These are also known to cause increased turbidity of the water and silting of rivers and dams in catchments.

***Increased acidity or alkalinity*:** This is caused by discharge of industrial effluents that are strongly acidic or alkaline. It results in the degradation of the water resource and it may cause the total loss of biological diversity at the effluent receiving site. It also increases heavy metal pollution of the water due to increased solubility of metal ores and makes the water unsuitable for use.

***Toxic spills*:** Toxic chemicals washed into rivers cause loss of biological diversity due to death of many aquatic animals and plants. Such chemicals include fluids from electrical transformers, pesticides and other hazardous chemicals.

***Solid waste*:** Dump sites are sources of various toxic compounds which eventually find their way to the water sources posing health risks to water consumers and aquatic life.

***Alien vegetation*:** Invasive foreign vegetation may threaten the existence of local biodiversity and may cause ecological imbalance. For instance, introduction of *Eucalyptus* tree species has been associated with significant losses of water in catchments.

1.4 Community Action for Problem Solving

Environmental problems arise due to failure of communities in recognizing their role to utilise the natural resources in a sustainable manner or to observe environmentally sustainable practices. Hence, at community level, it is necessary to identify the problem, formulate the action plan, with agreed goals and execute the plan with active community involvement. An example of a scheme for action planning for problem solving at the community level is shown in Fig. 2.

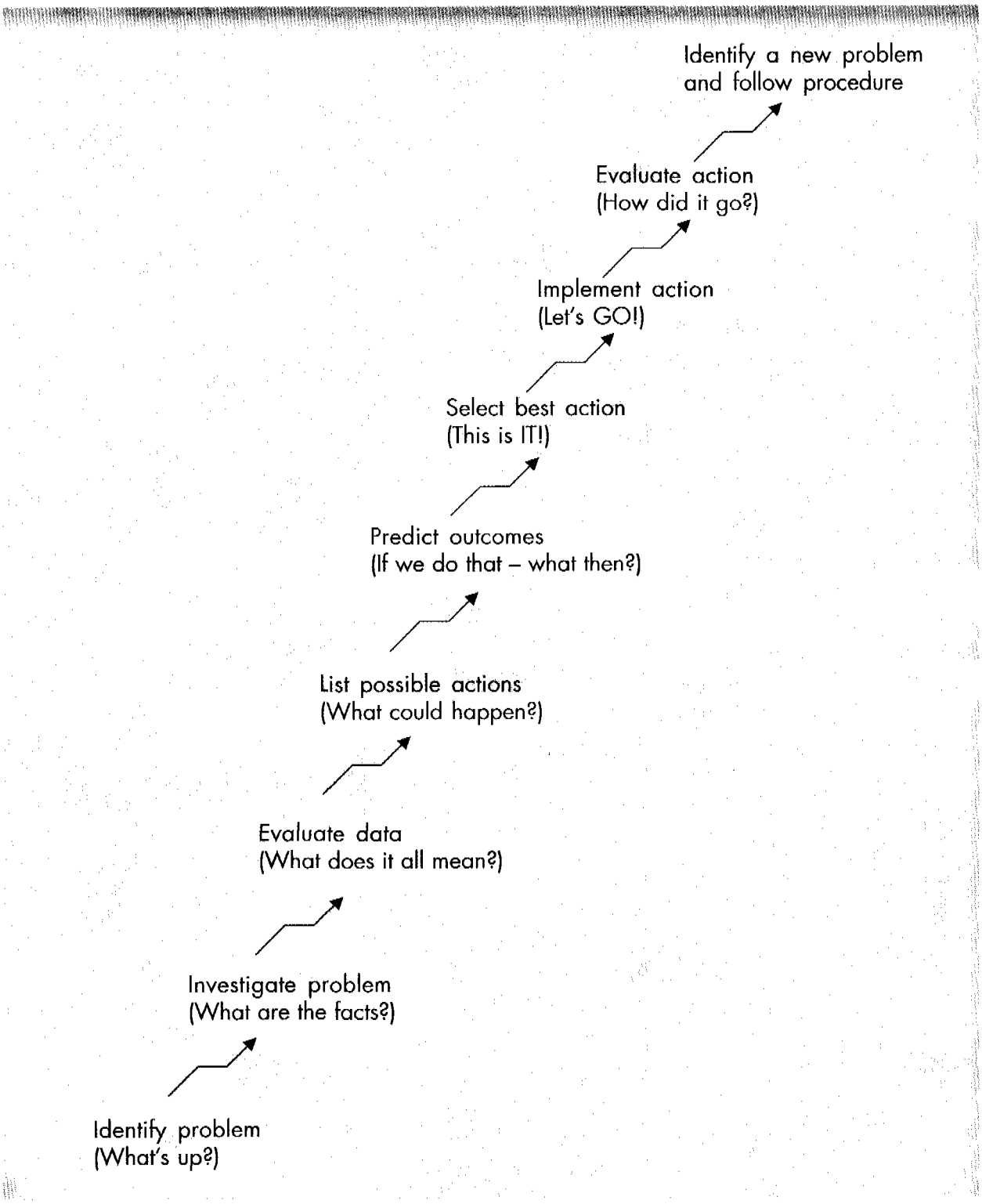

Fig. 2. A scheme for action planning for problem solving at the community level. (adopted and modified from http://www.nrm.qld.gov.au)

1.5 Community Involvement for Catchment Management

With the indiscriminate economic activities and land use, the urban areas are facing the problems of environmental stress and related risks. The symptoms of stress and risks are evident in increasing pollution and water scarcity. To ensure sustainable availability and quality of water, it is necessary to find ways and means for management of catchment areas. Conventional sectoral approaches for pollution control, water supply and sanitation have served limited purpose. Community involvement for catchment management can serve as a useful instrument for addressing the problems in a holistic manner. The approaches and action points for catchment management are elaborated in the following sections of this Guidebook.

2.0 Catchment Management: Lessons Learnt

A catchment is the area from which the rainfall drains into the watercourses through surface runoff. In a catchment, much of the surface is land and a smaller portion consists of the river channel. Catchment management or river basin management is therefore viewed as land – water management and it involves the management of the river and the surrounding land (Krhoda, 2000). It is a process of strategic decision-making about the allocation of land and water resources within a water catchment area. The proper management of water resources is of critical importance to the twin issues of pollution control and sustainable development.

2.1 Past Approaches to Urban Catchment Management: Case Studies

Lack of a catchment-based approach in water resources management has been a serious omission in modern urban systems (Biswas, 2003). Let us now look at some case studies of urban areas in which the sectoral approaches to catchment management have been followed and these have largely failed to provide the desired result.

Case Studies

1. *Accra: The Densu River Basin*

Various institutions from the national level down to the community level have been established to regulate the use of natural resources. Programmes and strategies have been developed; however, these have not been effective in arresting environmental degradation in the Densu River Basin. This is attributable to institutional inability to: i) coordinate and integrate plans at the local level; ii) offer alternative means of livelihood or incentives for arresting degradation and overexploitation of natural resources; iii) remove weaknesses in local level institutions and iv) effectively link up with the relevant local institutions and implement the programmes for the benefit of the local communities. The performance of the various institutions is further hampered by lack of trained staff, logistics and funding. It is patently clear that a formula has to be worked out to address the key issues so that a participatory and integrated approach can be adopted for effective management of the environmental problems in the Densu River Basin (UN-HABITAT, 2000; Adom and Ampomah, 2003).

2. *Johannesburg: The KLIP River Catchment*

In a study of the water quality of the Klip River whose catchment is in the Johannesburg Central Business District (CBD), the concentrations of various pollutants were reported to be above the target range of water quality in the catchment (UN-HABITAT, 2002). High faecal coliform, high concentrations of ammonia and Chemical Oxygen Demand (COD) levels were detected at many sampling stations close to residential areas or waste water treatment works. This was attributed to ingress of sewage effluent into the rivers. In the Klip river catchment, high levels of electrical conductivity, pH and acidity were associated with pollution from the open mines and also industrial effluents. Phosphates and nitrates present in the water samples were linked to sewage effluent and also non-point sources pollution due to application of agricultural fertilisers and their subsequent leaching by runoff from the fields (Miller 1998).

The City of Johannesburg is prone to pollution risk of surface water in high density areas due to inadequate water and sanitation infrastructure. In the Klip river catchment, vandalism of sewer networks and poor maintenance of existing infrastructure in the catchment are major causes of faecal contamination of the water. In the unplanned or informal settlements of Johannesburg, seepage from pit latrines and lack of access to basic sanitation is major causes of surface water pollution. This exposes the human population living downstream to health risks due to water borne diseases. Water borne infections are reported to be a common cause of morbidity and mortality in the area due to consumption of untreated water. In the Johannesburg catchment area, pollutants include acid mine drainage resulting in very low pH and death of aquatic life in the water. The acid dissolves heavy metal ores present in the rocks thus introducing heavy metal pollutants in the surface water. Increased salinity is also due to high sulphate levels making the water unsuitable for domestic and agricultural use.

In the past, there was no coordinated effort to manage the catchment area. As a result, there were overlaps, duplication of efforts, gaps and even conflicts in the management of the catchment.

Recognising the deficiencies in the earlier efforts, a new strategy has been proposed. It aims to achieve the overall goals of protecting local biodiversity; promoting sustainable use and conservation of the land and water resources by optimising their utilisation on a sustainable basis. The protection of the riparian zone and wetlands in the catchment are among the important components of the proposed strategy for mitigating the effects of flooding.

Catchment Management Unit (CMU): It is proposed to set up a Catchment Management Unit to implement the Catchment Management Strategy. The roles of the Unit will include coordination of all management activities in the catchment; monitoring of all water resources in the catchment; developing and coordinating Memoranda of Understanding (MOU) with all stakeholders and coordinating and reviewing Environmental Impact Assessment (EIA) of development activities.

Institutional Arrangements: For involvement of all stakeholders in cooperative governance of the catchment, the CMU is required to establish formal lines of communication with each stakeholder impacting on the environment; develop action plans with specific and achievable goals in concert with the stakeholders; ensure acceptance of rights and obligations by all stakeholders and establish a Catchment Information Exchange that is accessible to all.

3. *Addis Ababa Water and Sewerage Authority (AAWSA)*

According to its mandate, AAWSA has the responsibility to develop a system for monitoring and protection of the surface water resources. In Addis Ababa, inadequate capacity for solid waste management, seepage from pit latrines and lack of basic sanitation are major causes of surface water pollution in the catchment (UNHABITAT, 2003c). The problem of faecal pollution is worsened by overflowing pit latrines due to inaccessibility of some areas to evacuation vehicles or inadequate service. In some parts of the city with no sewerage system, many residential and business premises have illegally connected their flush toilets to the storm water networks. Together with the illegal practice of dumping, evacuated faecal matter from cesspits in watercourses adds to water pollution in Addis Ababa.

The built up areas of the city leads to increased surface run off from the paved areas which contributes to flooding and associated problems. The wastes from the sizable population of livestock and other animals are washed into river courses during the rains thus causing organic pollution of the water sources and the risk of infectious diseases.

The high pollution risk in industrial zones is due to discharge of industrial effluents into storm water networks. The effluents contain various hazardous chemicals due to failure by industries to comply with the effluent standards. In Addis Ababa, majority of factories discharge their untreated effluents into water courses without due regard for the environment.

Lack of a common strategy, poor waste management, institutional weakness and failure by the various institutions to integrate their action plans and programmes at the City level has resulted in massive pollution of the surface water resources in Addis Ababa. This has resulted in negative impacts on the sustainable utilisation of surface water resources in the catchment, increased risk to human health and increased cost of water treatment before it can be rendered suitable for use in various development activities.

2.2 Integrated Approach to Urban Catchment Management: Case Studies

From the case studies, one can appreciate that successful urban catchment management is hard to achieve through a sectoral approach. The issues are far too many and too complex due to the large number of stakeholders with varied interests. Although national level management institutions and local authorities have been established in many countries to regulate the use of natural resources as also programmes and strategies have been developed to implement their mandates, these are unable to arrest environmental degradation in their areas of jurisdiction. This is mainly due to:

- Lack of coordination and integration of their plans and activities at the local level;
- Inability to offer alternative means of livelihood to the local inhabitants;
- Inability to give incentives to the local communities for restraining from over exploitation and degradation of natural resources;
- Failure to address the weaknesses in local level management institutions; and
- Failure to effectively link up with the relevant local institutions through which they are to implement their programmes for the benefit of the local communities.

In addition lack of trained personnel, logistic problems and inadequate funding also hinder the performance of the various institutions. The solution lies in addressing the key issues and in adopting a participatory and integrated approach (Adom and Ampomah, 2003).

In Australia, catchments have long been the focus of natural resources management since water shortages were experienced in Sydney in 1790s. More recently, these have emerged as the focus of land and water management to protect urban water supplies (Hooper, 1999a).

The integrated approach to catchment management has been defined as 'The co-ordinated management of land and water resources within a region, with the objectives of controlling and/or conserving the water resource, ensuring biodiversity, minimising land degradation and achieving specified and agreed land and water management and social objectives (Hooper, 1999a).

Let us now look at some case studies of urban environmental management using integrated catchment management approach.

Case Studies

1. *Cajamarca: A Provincial Municipality in Peru*

The interdependency between urban and rural development in developing countries is well illustrated in Cajamarca. In the rural part of the municipality, the main social-economic activities are cattle ranching and agricultural production. The encroachment by cattle owners on marginal land is reported to have caused serious environmental degradation to the region's watershed due to deforestation. The result was increased soil erosion, reduced water quality and quantity and loss of biodiversity. This was the cause of increased poverty levels and rural unemployment which resulted in the migration of large number of people to the urban centres leading to rapid and unplanned growth in Cajamarca and other municipalities in the area. The Kilish River which is the main source of drinking water is said to have been heavily polluted due to mining activities in the rural areas and lack of a sewerage system in the town. As a result, water borne diseases were on the increase and there was also a persistent flooding problem in the town due to poor management of storm water run-off.

Lack of coordination between agencies responsible for planning and implementation, demographic changes and environmental degradation severely undermined the municipal government's ability to deliver quality services to the local inhabitants. To address the situation, the municipality decided to implement a participatory regional development planning process to coordinate development activities and to improve the delivery of community services. This involved decentralisation of the local administrative structure and the creation of a consensus building forum bringing together all social and political stakeholders to address a wide range of issues. It resulted in the establishment of a number of specific initiatives in the urban and rural areas of Cajamarca.

Lesson learnt: Local governments can create partnership structures to open lines of communication to gain consensus and commitment for long-term projects that meet the needs of citizens and other stakeholders (Global Water Partnership: http://www.gwp.ihe.nl).

2. *Colombia*

Colombian legislation and competence for the use, management and protection of the water resources are scattered in different sectors which frequently result in conflicts between state officials, duplication of efforts, gaps in the development of activities and ultimately failure by the state to deliver services to its people.

In 1999, the Ministries of Environment and Health signed a Common Agenda to open lines of communication to enable them deal with issues of common interest such as water resource conservation and legislation on pollution levels. Other Ministries also signed a Joint Working Agenda to improve governance and quality of delivery of water and sanitation services.

Lesson learnt: The participation of all sectors, public and private, can contribute to the success of the process. Support by high level representatives of each institution / ministry was found to be essential to the success of the initiative (Global Water Partnership: http://www.gwp.ihe.nl).

2.3 Pre-requisites for Integrated Catchment Management (ICM)

For integrated catchment management, it is necessary to ensure coordination of government programmes across and within government and between the management actions of individuals, water organisations and utilities, industry and other private sector organisations. However, coordinated participation of the stakeholders is often difficult to achieve (Hooper, 1999b). The weaknesses in implementation of ICM are caused by:

- Lack of coordination between and within government and communities;
- Poorly understood need for an integrated approach;
- Using a standardized approach due to failure to understand the importance of the local context;
- Confusion between bottom-up consultation and community participation and top-down policy and governmental investment;
- Lack of integration of economic development with ecosystem management;
- Institutional barriers to effective integration;
- Lack of integrated information management systems to support catchment management;
- Disagreement over need for additional legislation for enforcement of management plans;
- Poorly structured financial arrangements; and
- Limited use of conflict resolution methods.

2.4 Catchment Management Agency (CMA)

The weaknesses in effective implementation of collaborative catchment management (Hooper, 1997; 1999a) are likely to be typical of situations where integrated catchment management is being introduced for the first time. In the rapidly urbanising areas, planning is a major challenge due to the multiplicity and complexity of the issues and interests involved. To be able to identify and address all the critical issues pertaining to development activities and their impact on the environment, the involvement of all stakeholders in the cooperative governance of the catchment is required. The Local Authority for the area or the concerned agency of the Local Government should constitute a Catchment Management Agency (CMA) to manage the affairs of the urban catchment area. The CMA should be run by a Board comprising senior members of the Local Authority, key public institutions, community based organisations and umbrella organisations in the private sector. The CMA should establish formal lines of communication with all stakeholders whose activities impact on the environment. The CMA is expected to perform the following functions:

- Coordinate all management activities in the catchment;
- Monitor all water resources in the catchment;
- Develop and coordinate Memoranda of Agreement (MOA) with all stakeholders who impact on the catchment;
- Develop joint action plans with specific goals for implementation with the stakeholders;
- Ensure acceptance of rights and obligations by all stakeholders;
- Coordinate and review all environmental impact assessments (EIA) carried out in the catchment; and
- Establish a Catchment Information Exchange that is accessible to all.

The Catchment Management Agency is to be charged with the responsibility of implementing the integrated catchment management strategy in an urban area. As a member of the agency, one needs to be fully aware of the problem areas and to address them at the opportune time. A well thought out and integrated catchment management strategy, if well coordinated and implemented, can help achieve the desired goal of striking a balance between environmental protection and sustainable development. This guidebook strongly advocates a coordinated and integrated approach to urban catchment management in order to promote resource use optimisation, minimise duplication of effort, gaps and frequent conflicts of interests inherent in the management of catchments from a sectoral approach. It is the role of the Catchment Management Agency to implement the Catchment Management Strategy.

2.5 Catchment Management Strategy (CMS) and Its Imperatives

CMS is a process for integrating the environmental, economic and social considerations in the management of catchment areas (Biswas, 2003, refer Appendix 1). It is an organized course of actions aimed at attaining specified objectives in a given water management area. In developing a CMS, all the relevant facts must be analysed well so that the most appropriate decisions about managing the catchment can be made.

The main objective of CMS should be to facilitate the management of the water resources in the area so as to achieve equitable, efficient and sustainable use of water for the benefit of all users (DWAF, 2001).

To attain a good balance between protection and use of water resources in the catchment area, it is necessary to consider the following:

- The prevailing local conditions i.e. local context;
- The legitimate needs of water users in the area;
- The role of the public in the management of the water resources;
- The reserve, classification etc.; and
- Preparation of a water use allocation plan.

There is a pressing need to amend the way in which water resources have been managed in the past using a sectoral approach. There is also an urgent need to address the lack of social equity in the provision of water especially to the urban poor, the majority of whom have to pay several times more to the kiosk vendor than the well-to-do who are connected to the city's water supply system (Water & Sanitation, 2003).

The demand for a new approach to water resources management has been heightened by the need to achieve a sustainable balance between use and protection of the resource despite the shrinking resources and the enormity of the pollution threat. An integrated approach linking *water management, land-use,* the *environment* and *human activities* and involving cooperative governance by the Government and other stakeholders has been proposed as the logical way forward (DWAF, 2001). For this to become a reality, it is necessary to develop enduring partnerships based on a common approach between the participating institutions.

The Catchment Management Agency (CMA) will be responsible for developing and implementing the CMS for a particular catchment area. Where a CMA cannot undertake a task due to lack of expertise or the capacity to do so, it should outsource the expertise of a lead agency or the services of a consultant.

2.6 Key Issues related to Legislation and Water Resources Management in a Catchment

Right from the start, it is important to carefully examine and interpret correctly the country's water related laws and other initiatives that may influence or affect the development of the CMS. In some countries, water related legislation is scattered in several statutes (Okoth and Otieno, 2000). Hence, it may be necessary to engage a legal expert to extricate the relevant legal issues affecting the use, protection, conservation, control, development and management of water resources at the national level and at the catchment level. This should form the basis of the legislative framework for the management of water resources in the catchment. The following issues are of immediate relevance to CMS:

1. Establishment of the Catchment Size and Boundaries

The catchment area for which the CMS is to be developed should be clearly delineated on the official map of the geographical area in which the local authority is situated. The power to define boundaries for water management areas in a country is normally vested in the body charged with the responsibility of formulating the national water policy.

The catchment size should include the urban area under the city's jurisdiction and its environs. The political or administrative boundaries should not be a factor in determining the catchment area. However, the catchment size being a water management issue should be determined by the authorised body in accordance with the laws of the land. The boundaries drawn on a map are defined more correctly by water extraction and disposal (Showers, 2002). The boundaries of the catchment area must be clearly delineated on the official map of the area.

2. Procedure for developing a CMS

The CMS should be developed through wide consultations and its publication in a draft form for seeking comments from stakeholders. After the comments are taken into consideration, the CMS requires approval by the recognised authority before it is published in the official Gazette as an established. In developing the CMS, it is important that the following steps are taken to ensure its wide acceptance and appeal as well as facilitation of its implementation by the various stakeholders.

i. Approval must be sought and obtained from the responsible authority in the Ministry of Water Development so that policy issues can be clarified early enough.

ii. Consultations should be held with:

   a. All the relevant City Council Departments, Government Departments and agencies, District Development Committees in the neighbouring Districts (DDCs); and

   b. All other stakeholders including NGOs, CBOs, and umbrella organisations who have an interest in the content and implementation of the CMS.

iii. The draft CMS document should be made available to all stakeholders including the general public and their inputs included in the final document. The document should then be published as a notice in the Government Gazette, together with the physical address where it can be inspected. The CMS may be established in a phased manner over a period of time. It should be noted that a CMS is dynamic and should be constantly reviewed so that it remains relevant to the water management situation in the catchment. A period of 3-5 years is recommended.

3. Need for Avoidance of Conflict

The CMS should outline the strategies, plans and methodologies for managing water resources in the specified area. However, due attention should be given to ensure that it is not in conflict with the national water resources policy and development strategy.

4. Water allocation

A comprehensive plan is required for water allocation in the catchments taking into account the national strategic uses, existing and prospective users. To exercise fairness and social equity, the approved CMS should set principles for allocating water in the catchment and abide by them. The capacity of the recipient water resources to assimilate wastes should be taken into account when allocation volumes are determined.

5. Water pricing strategy

Exemption from billing, for example, for water allocated to basic human needs in some countries, ecological reserve, and international obligations should be implemented in accordance with the Act. In other cases, lower water tariffs as a pro-poor strategy may be applied for economically disadvantaged communities where this is provided for in the Act.

Apart from raw water, the pricing strategy should also include a charge system for waste water discharge.

6. Guidelines

Guidelines dealing specifically with improving water use efficiency in the various sectors such as agriculture, water services and industry should be developed. This should be done in conjunction with the respective sectors and should include best practices in each sector.

7. Registration

A register of all water users who do not receive their supplies from the local authority or other registered suppliers should be opened and continuously updated. Details of the locality, the source and amount of water withdrawn and the purpose should also be included. This will enable a more comprehensive database of water users to be made and it will also facilitate better protection, management and development of water resources in the catchments.

8. Water Quality Management

Initiatives relevant to the development of water quality aspects of CMS and catchment management plans (CMP) include: Guidelines for Water Quality Management components of the CMS and Procedure for Water Quality Catchment Assessment studies (DWAF, 2001).

9. Other issues

These include limitations imposed on the amounts of water that may be abstracted from a source, water quality of return flows, water use efficiency and protection of water resources. Parameters such as ecological reserve determination, resource classification and determination of resource quality objectives should be determined based on the national strategy. Issues related to the various Development Plans prepared by the Local Authorities and the Strategic Environmental Assessment entailing the physical and social-economic environment should also be considered.

3.0 Framework for Development of Catchment Mangement Strategy

3.1 Situation Assessment

A CMS involves the implementation of a water management process in an integrated and a participative manner and should be reviewed periodically to make it relevant to changes in the catchment. A period of five years has been proposed for such review (DWARF, 2001). The CMS process has several steps, viz

- Data collection
- Investigation
- Information assimilation
- Planning
- Implementation
- Monitoring and control
- Auditing and review

In developing a generic framework for a CMS for the effective management of water resources in South Africa, a model with three components has been proposed viz. Situation Assessment, Foundation Strategies and Supporting Strategies (DWAF, 2001). An institutional framework is necessary so that the various steps can be implemented in an integrated manner.

To formulate a catchment management strategy and plan aimed at finding the right balance between protections and use of the water resources, it is necessary to make a thorough assessment of the existing situation so that the necessary baseline data and information are available to facilitate decision making.

Important characteristics of the catchment include: physical features, demographics, the surface and ground water resources, hydrological and geological characteristics, vegetation and wildlife resources, land uses, water use profile and economic overview. To gauge the water stress level in the catchment, an accurate analysis is to be made of the water quantity, quality and the available ecological data.

Data on water usage by various sectors and the total available yield in the catchment should be compiled. An effort should also be made to capture in the databases any relevant data that may have been collected by researchers from other Government agencies and Universities.

Familiarity with the administrative units such as divisions and their heads within the catchment area is important for the approval as well as smooth implementation of the catchment management strategy. Establishing communication lines between the Catchment Management Authority and the relevant Government offices will provide channels through which information may be quickly passed to the general public.

Physical Features

An inventory of the following features for the catchment area should be prepared and the relevant maps obtained from the concerned Department.

a. *Position and size*: A brief description of the geographical position on the map giving the latitude and longitude in degrees and minutes and the catchment area in square kilometres.

b. *Climate*: Average temperature, seasons and rainfall pattern, average annual rainfall.

c. *Topography*: A description of the surface features of the region such as the hills, valleys and rivers and a topographical map of the area.

d. *Geology*: A description of the earth formations in the catchment area and a geological map of the area.

e. *Hydrology*: A description of the distribution, conservation and use of the water resources and a hydrological map of the area should be obtained. The map should show details of wetlands, the river system, location of lakes, dams and other impoundments in the catchment.

Data on the vulnerability of the area to floods or other extreme meteorological events should be recorded.

Natural Resources Inventory

a. *Soils*: A brief description of soil types (e.g. loams), well drained volcanic soils, and clay soils should be prepared. The nutrient status of soil e.g. highly leached or fertile soils, bare or with vegetation cover etc. should be included.

b. *Vegetation:* A brief description of vegetation types e.g. grassland, wooded savannah, indigenous forests, plantation forests, scrubland, and wetlands should be prepared. It needs to describe the status e.g. extent of forest clearance for development projects, overgrazing and human encroachment in riparian zones and wetland areas and give details of any alien species, their invasiveness and impact on the riverine ecosystem.

Areas of Ecological Importance

River sections of high ecological importance due to factors such as habitat diversity, presence of threatened plant or animal species should be gazetted as protected areas. This factor should be considered in any future developments along the river.

A checklist of the aquatic plant and animal species present and their relative abundance along the various stretches of the river system including any pristine sections for comparison is required for this purpose.

c. *Wildlife:* A brief description of wildlife present in the area is needed.

d. *Surface water resources*: An inventory to be made of the streams, rivers, lakes and other impoundments e.g. dams in the catchment. Details of mean monthly and annual rainfall and the volume of water discharged at the outlet which could be obtained from the Meteorological Department and other agencies. Information and data on the available water resources in the catchments should be compiled.

e. *Ground water potential.* Potential for ground water resources in terms of expected yield should be determined.

Water Resources Utilisation and Demand

i. The water supply schemes and associated infrastructure. Preparation of an inventory of the reservoirs and water treatment works and the distribution system.

ii. Preparation an inventory of the major water users and the amounts abstracted for authorised uses per year. The present and the projected demand over the next 20 years or so should then be computed based on the population and economic growth trends.

iii. Other data such as the per capita annual water consumption and the breakdown of sectoral withdrawals (%) viz. domestic, industry, agriculture, recreation and the environment should be worked out.

iv. The water balance status should be prepared bearing in mind the ecosystem needs.

v. Determination of the water user quality requirements for domestic, agriculture, recreation, industry, and ecosystem. This should be done in consultation with the national water agency or ministry and other water experts where the benchmarks have not been gazetted.

Social Inventory

Demographics: The following data should be collected.

- Total population of the area
- Breakdown of the population in the various administrative units of the City
- Population density of the area (persons /km2)
- Population growth rate
- Life expectancy of males and females in the population including survival rate for children <5years of age
- Occurrence of water-borne diseases and their relative importance on morbidity and mortality and the health budget
- Primary health care level in the catchment.

Economic Overview

Collect the following data and information.

- The main economic activities in the catchment area. The percentage of people engaged in various economic sectors viz. agriculture, manufacturing and cottage industries, service industry, forestry, fisheries, sand harvesting and stone quarrying and any other income generating activities.
- Levels of income and cost of living indices.
- Unemployment and poverty levels in the population including inability to pay for water and sanitation services.
- Impact of HIV-AIDS and water-borne diseases on the economy.

Land Use, Pollution Sources and Environmental Degradation

Undertake a survey of the land use activities and their impact on the catchment by field surveys, consultations, questionnaires and interviews with the various stakeholders. In carrying out the survey a representative sample of respondents should be interviewed i.e. males and females, various age groups, educational backgrounds, service providers and professionals.

a. *Residential*

Urban

- Housing estates and the state of associated infrastructure i.e.
- Water and sanitation infrastructure including liquid and solid waste disposal.
- Extent of forest clearance for development projects, overgrazing and human encroachment in riparian zones and wetland areas.
- Unplanned human settlements and available infrastructure:
  access to safe water and basic sanitation and methods of waste disposal.
- Proximity of informal settlements to rivers and lakes and impact on the environment especially the riparian zones and the water quality.

Rural

- Agricultural activities: cropping system, tillage methods, use of chemical fertilizers and pesticides, irrigation methods, disturbance of riparian zones and wetland areas.
- Forests: Logging for fuel wood and sawn timber.
- Livestock keeping, overgrazing and disposal of manure.
- Alien species, their invasiveness and impact on the riverine ecosystem.
- Impact of the agricultural and livestock-keeping activities on the land and water resources.

b. *Sewerage network and waste water treatment works*

- Inspection of the sewerage network noting blockages and overflows and the schedule of preventive maintenance if any.
- Location and capacity of the Waste Water Treatment Works and proximity to water courses.
- Siting of sludge-drying beds in relation to the water courses. Evidence of effluent discharge permit and compliance with the emission standards.
- Impact on the land and water resources.

c. *Manufacturing / agro-processing Industries*

- Inventory of the industries, their raw materials and products and their location in relation to the water courses.
- Categorization of the industrial wastes into hazardous and non-hazardous components.
- Method of solid waste disposal and effluent treatment before discharge into sewerage system or water course should be examined.
- Evidence of discharge certificate and compliance with emission standards should be confirmed.
- Assessment of the receiving water to determine impact on water qua.

d. *Transport* system

- Brief description of transport infrastructure including road and railway networks, bridges etc.
- Details of the length of road network and classification: bitumen, gravelled.
- The paved area and effect on water infiltration during rains should be examined.
- Environmental effects of dumping hydrocarbons particularly used engine oils and other lubricants on the environment should be investigated.
- Effectiveness of the storm water drainage system especially during rainy seasons should be evaluated.
- Impact of the infrastructure on flooding conditions in the catchment should also be investigated.

e. *Commercial*

- Paved surfaces (%) of built up areas and provision for water infiltration into the ground and/or water harvesting.
- Solid waste collection and disposal.
- Water and sanitation infrastructure in Municipal Council food markets.
- Impact on the land and water resources in the area.

f. *Mining*

- Quarrying and sand harvesting activities in the catchment.
- Evidence of pollution due to use of explosives and worsening of soil erosion.
- Evidence of increased siltation of the river channel due to increased soil erosion.
- Impact on the land and water resources in the area and the necessary restoration methods.
- Alternative income generation activities for the communities.

g. *Landfill sites*

- Solid waste collection and disposal system.
- Inspection of the solid waste dumps sites and their proximity to water courses.
- The types of solid waste and their relative toxicity should be determined.
- Impact on the land and water resources in the area should be recorded.

h. *Water pollution due to natural causes*

Investigate whether apart from human activities, geological conditions in certain areas of the catchment may be the cause of water pollution. In the Klip River in South Africa, water polluted by acid mine drainage was found to have a pH of 1.5 which is acidic enough to cause grievous harm to anyone coming into contact with it (UN-HABITAT, 2002).

In some areas ground water contains high levels of Arsenic whose long term ingestion in drinking water is associated with skin disease and even cancers in the human population (Biswas, 2003). Ground water in other cases has been found to contain high levels of fluoride whose excessive intake is associated with skeletal defects.

i. *Social-economic activities and their impact on the environment*

Information gathering and data collection should be undertaken from a cross section of residents in the catchment.

Methods to be used include: Field surveys, Remote Sensing Data/Imaging/ Vegetation Mapping to identify degraded sites; focus group discussions (FGDs) with groups of residents; in-depth interviews (IDIs) with administrators; opinion leaders, natural resource managers and professionals in the area.

Impact of human settlements, agricultural practices, types of industries and their practices, logging activities, quarrying and sand winning, other mining activities and their respective impacts on the environment and surface water quality in the catchment should be assessed. The prevailing natural resource use and trend should be closely monitored. Knowledge of local environmental problems and willingness of the local community members to participate in finding lasting solutions to environmental degradation in the catchment should be assessed

j. *Community outlook assessment*

Undertake a survey of the knowledge, awareness, perceptions and attitudes of the catchment inhabitants to the causes of environmental degradation and the restoration measures necessary.

- Awareness about water issues and environmental degradation.
- Willingness to participate in interventions.
- Proposed solutions by residents e.g. tree planting, banning cultivation on riverbeds.

Other Relevant Issues in Situation Assessment

Situation assessment also requires that certain key issues be addressed. Investigate the following:

- Whether the reserve and resource quality requirements are being met.
- Whether the water resource is well managed, so that upstream users do not abstract more than their allocation to the detriment of downstream users.
- Status of water demand management or water use efficiency.
- Status of water quality in the catchment and the trend.
- Current and future investment in water resources infrastructure and catchment management activities.
- Significant events relevant to water resource management such as floods and droughts.

3.2 Institutional Framework

As part of the situation assessment, engage a consultant to carry out in-depth investigations by conducting interviews with resource managers and referring to government documents. The consultant's findings should identify the institutional strengths and weaknesses, the causes of the weaknesses and how they can be overcome; the need to amalgamate them or create new ones. The aspects which need to be looked into include the following:

1. Institutions and their respective mandates.
2. Roles and responsibilities of the institutions as understood by the chief officers and their subordinates.
3. Capacity of the institutions to discharge their responsibilities with regard to:
   a. Budgetary allocations
   b. Manpower needs including training
   c. Logistics
4. Successes and failures of the institutions to fulfill their stated mandates and the lessons learnt.

Watershed Development Project in Darewadi, Maharashtra, India: NGO-Community Partnership

Not so long ago, Darewadi, a remote and drought prone village in the rain shadow region of the State of Maharashtra, India, was a picture of despair: isolated from the mainstream, without any assurance of drinking and irrigation water and depleted natural resources- especially those necessary for rural livelihood such as biomass and soil. Villagers had to migrate to resource – endowed areas for earning a livelihood. They toiled in sugar fields of rich farmers or in brick kilns of the contractors. Some of them took to herding sheep, which further depleted the already fragile ecosystem. Poverty of the environment, coupled with the absence of any alternate sources of livelihood, had caused the community to lose its vibrancy, and become withdrawn and fatalistic. Agricultural production – even in a year of reasonably good rain – was not sufficient for even 3-4 months, labour opportunities were scarce, and the possibility of the very basic education for the children was remote. Women had to toil hard, either in the places they had migrated or in their village to fetch water, fuel and other basic needs. In order to redeem this desperate situation and to transform despair into hope, the only solution possible was resource mobilization and judicious utilization of the conserved resources by the community through locally evolved practices, institutions and management structures.

At this point, the Watershed Organization Trust (WOTR), which is a support organization helping Non-Governmental Organizations (NGOs) and Village Self Help Groups (VSHGs) to undertake participatory natural resource management along watershed lines, came into the picture. The challenge was to win confidence of the people and make them aware of the inter-relationship between the environment and quality of life. Awareness generation was achieved through constant interaction, audio-visual aids; exposure visits to areas where people had conserved resources for betterment of their life. The next stage was to mobilize and capacitate the entire community to undertake the responsibility of managing their resources and life. People agreed to contribute voluntary labour and follow the social fencing principles such as ban on free grazing and tree felling. A simple but scientific and people oriented technology was adopted

The status of existing institutional arrangements among water management institutions should be closely examined with a view to:

- Developing mechanisms of coordination between and within government institutions and communities
- Developing a shared vision among them
- Creating a better understanding of the need for an integrated approach to water resources management
- Overcoming institutional barriers to effective integration
- Developing workable methods for coordination and collaboration

for soil conservation, rainwater harvesting, as well as greening the mountains and wasteland. A series of technical treatments (such as, contour trenches, gully plugs, farm bunds and contour bunds and check dams etc.) along with bio-regeneration (plantation, grass seeding etc.) were undertaken. The once degraded landscape was slowly transformed, providing adequate drinking and irrigation water with increased soil moisture for better crop production and sufficient fodder and fuel.

The transformation of Darewadi would not have been possible without emergence of effective local institutions, which were willing to discharge their responsibility and legitimacy conferred on the by the village community. The formation of the Village Watershed Committee (VWC), giving representation and voice to all sections that had earlier been marginalized (e.g. women and landless labour) was the backbone of the village development. They interfaced with the civil society organizations – WOTR as well as government departments for holistic watershed management. They planned, implemented and monitored all the activities and evolved systems and procedures for management and conflict resolution.

Darewadi, which was once a remote and isolated village, is now a hub of activities. Visitors come from far off places to get an insight of the success story and many of them go back with the resolve to replicate this effort in their own areas. The villagers themselves explain to the visitors and some of the VWC members and women group members' even work as resource persons for creating awareness in other villages. Due to the 'demonstration effect' of Darewadi, many villages in the vicinity have also taken up natural resource management along watershed lines.

In order to conserve the developed natural resources, the VWC has taken some difficult decisions like ban on direct lifting of water from storage structures, digging of bore wells, cultivation of water intensive crops and other social fencing measures. A firm resolve, necessary institutional structures and ownership of the project coupled with unity among all stakeholders are the important pre-requisites for success of this NGO-community partnership.

- Helping community catchment management groups mature
- Integrating economic development with ecosystem management
- Developing effective communication channels among them
- Developing an integrated information management system to support catchment management
- Agreeing on methods of conflict resolution to be used in case of disputes among them
- Agreeing on how to share the costs

Modalities for Participatory Urban Catchment Management

The mechanism of community participation in a development project to be undertaken in a catchment area will depend on the project environment and the nature of the project. This is because of variations in entrenched social structures which have a bearing on community relations The village chief and council of elders are still recognised, even in urbanised areas, as centres of power in enforcing Government directives, conflict resolution and other matters at the village level. Knowledge of the social set up will therefore be important in creating mechanisms of community participation that are acceptable at the local level so that they are both effective and sustainable. In addition, the community mobilisation will depend on its level of understanding and appreciation of the project goals and whether these are in harmony with the community's goals and aspirations. The models of community participation in catchment management proposed below and outlined in Appendix 3 have largely been developed from the experiences and lessons learnt in the Great and Little Lotus Rivers Catchment in Cape Town, South Africa and the Densu River Basin in Ghana respectively.

The first major step is to identify all major stake holders in the catchment. The second major step is to develop a working model for stakeholder participation in the management of the catchment. The community participation strategy should involve identified community-based stakeholders and representatives of the relevant local government departments directly in the process of developing a model for community involvement in urban catchment management. Due to the wide knowledge gaps, it is important to bring the community sector to an appropriate level of understanding of the concept, the process and the key components of Integrated Urban Catchment Management. This will enable the community to negotiate with the local authorities and other stake holders. The specific objectives to the strategy are to:

1. Identify all relevant stake holders whose activities are having impact on the catchment area
2. Develop a database of the stake holders
3. Introduce ICM concept to the community representatives
4. Facilitate discussions and co-operation between stake holders
5. Identify the key issues of importance to stake holders in relation to ICM
6. Identify the level of decision making at which the issues would be considered
7. Gain acceptance of the broad principles of community management
8. Explore appropriate mechanisms of community input in the decision-making process

The strategy can be divided into three phases viz. a database development phase, a phase involving analysis of local interests and needs and a platform building phase. The process

should start with the identification of organised community groups such as civic organisations, local and school based environmental groups, local Councillors and influential individuals such as business and church leaders in the Catchment area.

Implementing the strategy

i. Hold discussions with community representatives.

ii. Organise group tours to important sites in the catchment and along the river corridor.

iii. Organise workshops to identify stakeholder interests and needs relevant to the ICM process.

iv. Organise a series of open meetings involving community and local government representatives to discuss issues of principle in terms of community involvement in the ICM process.

Integrated projects such as ICM are better placed to find more enduring solutions due to the willingness to accommodate divergent views, needs and interests which can then be put into generic categories and because of the holistic manner in which the issues are addressed. Effort should be made during the implementation of the community participation strategy to develop specific categories that can accommodate the needs and interests identified by the various stakeholders so as to promote an environmental ethic and a sense of ownership among them.

Examples of such categories include:

1. Integrated service delivery and management linking stormwater management to other services such as street cleansing, solid and liquid waste collection and disposal, environmental conservation and improvement. The planning and deliverly of the services should be integrated.

2. Integrated development planning and implementation should also facilitate and promote an environmental ethic and a sense of ownership. This can be effected by:

   a. Linking environmental education and management programmes to social and economic development projects such as the provision of housing and appropriate infrastructure; promoting income generation opportunities and supporting organisational development and skills transfer. Programmes which assist people to develop a deeper understanding of the connections between the biophysical and the economic elements of development should get priority.

   b. Catering for the needs and interests of farmers, livestock keepers, wood cutters, sand harvesters and quarry workers while addressing the impact of their activities on the environment. The plan would therefore have to facilitate the development and introduction of better or alternative technologies, alternative products to promote efficient and environmentally sustainable income generating methods.

3. Developing long-term environmental awareness programmes that are linked to implementation projects related to local needs and interests. The programmes should target learners in local schools, people in local organisations, environmental advocacy groups and the general public.

4. The existence of urban informal settlements must be acknowledged and upgrading programmes implemented. Any process that is meant to promote an environmental ethic in

poor communities will simply fail if people continue to live in squalid conditions, without decent housing and basic services.

5. Community participation and integrated service delivery should work hand in hand. Participation should be supported through meaningful capacity building and skills development programmes. The issue of tangible benefits resulting from community participation in ICM by implementing local projects that improve the physical environment is of great importance to the community representatives. Community benefits should include employment opportunities, training opportunities and local infrastructural development such as sports facilities and bus shelters.

Lotus River Project, Cape Town, South Africa: Participatory Urban Catchment

The catchment area of the Great and Little Lotus Rivers presents a microcosm of South Africa's urban development. The Lotus River project was envisioned to create a vehicle whereby people from diverse communities could come together with a common desire to improve the environment and quality of life within the catchment in which they live. The project proposed to develop a "blueprint" for managing the urban catchments at a local level, which could be dovetailed with the work of the much larger Catchment Management Agencies as set out in the National Water Act of 1998.

One of the major objectives of the Lotus River Project was to identify all major stakeholders and to develop a working model for community management of the catchment. The community participation strategy was designed to involve identified community-based stakeholders and representatives of the relevant local government departments directly in the process of developing a model for community involvement in urban catchment management. It was important to bring the community sector to an appropriate level of understanding of the concept, the process and the key components of Integrated Catchment Management (ICM), to enable them to negotiate with the local authorities and other stakeholders. The specific objectives of the strategy were as follows:

- To identify all stakeholders who had an interest in the development of the Lotus River;
- To develop a data base of the stakeholders;
- To introduce the concept of ICM to community sector and their representatives;
- To facilitate discussions and cooperation among the stakeholders;
- To identify key issues of importance to stakeholders in relation to ICM;
- To identify the level of decision making at which the issues would be considered;
- To gain experience of the broad principles of community management; and
- To explore appropriate mechanisms of community input in the decision making process.

Case study: An institutional framework for environmental management in Kenya

The enactment of an Environmental Management and Coordination Act or similar Act establishing an institutional framework for the management of the environment can provide an enabling environment for integrated catchment management. In Kenya, the Act provided for the establishment of a National Environmental Management Authority (NEMA) whose principal function is to coordinate environmental management activities in the country. Environmental management activities have previously been carried out on a sectoral basis by various institutions each governed

The strategy was divided into three phases consisting of the data base development; local interests and needs analysis and platform building. The process started with identification of organized community groups such as civic organistions, local and school based environmental groups, local councillors and influential individuals such as business and church leaders in the Lotus River Catchment area. The strategy was implemented through an on-the-ground approach consisting of:

- One-on – one discussions with community representatives;
- Group tours to important sites in the catchment and along the river corridor;
- Workshops to identify stakeholder related interests and needs relevant to the ICM process; and
- Series of open meetings involving community and local government representatives to discuss issues of principles in terms of community involvement in the ICM process.

Through the abovementioned process, it was possible to pull together divergent views, needs and interests in a holistic manner. During implementation of the community based participation strategy, it was also possible to develop specific categories of tasks that accommodated the needs and interests identified by different stakeholders. Community participation and integrated service delivery are two sides of the same coin. Participation should be supported through meaningful capacity building and skills development programmes. It is important to note that community representatives consistently raised the issue of tangible benefits resulting from people's participation in ICM, by implementing local projects that improve the physical environment and open the opportunities to local organisations and individuals. The examples include the following:

- Outsourcing special services like the collection of garden waste and building rubble to local entrepreneurs. Such services are currently not provided in some areas of the catchment.
- Providing public sanitation and waste disposal facilities in areas such as informal settlements, trading and sport areas.

by its own statutes. For example, water management under the Water Act by the Ministry of Water Resources and waste management under the Local Government Act by the Ministry of Local Government. A central coordinating body can bring order to environmental management in the catchment (Okoth and Otieno, 2000). Many concerns and fears expressed about such a body include the view that it would only add to the bureaucracy, wastage and conflict or take away duties and responsibilities of the existing institutions. However it has been shown that many of the fears are largely unfounded (Mumma, 2000). This is because NEMA's primary responsibility is coordination of environmental management activities of the various institutions which will however continue to exercise their mandates.

- **Environmental Impact Assessment (EIA)**

  The Environmental Management and Coordination Act provides for introduction of EIA as a statutory requirement. This is the procedure for prior assessment of the environmental impact of a proposed development project under the country's laws. The Act empowers the local authorities to require an EIA when they are considering an application (for planning permission under the Physical Planning Act or any other relevant Act.) for implementation of the proposed development project. The Act provides a schedule setting out the list of activities for which an EIA is required and the procedure to be followed by the applicant for an EIA license from NEMA. Details of the regulations to be followed by EIA licenses including fees and other relevant terms need to be worked out.

- **Environmental Quality Standards**

  In the absence of local environmental quality standards, many Local Government authorities adopt WHO guidelines which are health based. There is therefore need to develop local environmental quality standards so as to strengthen the role of enforcement in pollution control. The Environmental Management and Coordination Act provides for establishment of a Standards and Enforcement Review Committee as a subcommittee of the Environmental Management Authority or body. The committee recommends national quality standards for water quality, air quality and waste management which are then issued in a gazette notice. Implementation of the standards however remains the responsibility of the respective environmental quality control bodies. A schedule to the Act also sets out the membership of the committee including members from parastatal organisations and central Government as well as the private sector.

- **National Environmental Tribunal**

  The Environmental Management and Coordination Act provides for a Tribunal to be set up to resolve disputes administratively rather than through court processes which are often protracted, time consuming and expensive. The Tribunal will rely on non-legal expert knowledge to resolve factual disputes. The Tribunal is made up of legal and non-legal experts and may also hire various experts on environmental matters. The High Court is only left to hear appeals against convictions.

- **Incentives**

  The Environmental Management and Coordination Act empowers the Minister for Finance, Commerce or Industry as the case may be to develop a scheme for rewarding industries which invest in technologies required for good manufacturing practices and are environment friendly. Such schemes could involve tax rebates or other financial benefits to the industries commensurate with the cost of the introduced technology.

- **Penalties for Offences**

  Penalties meted out for environmental crimes aim at deterring potential offenders. The Environmental Management and Coordination Act provides for the naming and shamming of offenders,custodial sentences and fines or both depending on the extent of damage to the environment and the risk exposure to the inhabitants. Of equal importance is a professionally trained,well-eqoipped and highly motivated enforcement team that is highly committed to environmental protection.

- **National Environment Council**

  The Environmental Management and Coordination Act provides for the setting up of an Environmental Policy making body such as the National Environment Council (NEC). The membership of the Council includes senior Government officials and representatives from the private sector and NGOs. A provision is also made for the Minister responsible to co-opt other members if and when necessary.

- **Public Access to Information**

  The Environmental Management and Coordination Act provides access to environmental information held by the National Environmental Management Authority unless there is reason to believe that such disclosure would violate or compromise state security or commercially sensitive information. The availability of environmental information to the public is to enable individuals or organizations to challenge perpetrators of environmental crimes in court where such provisions are made in the Environmental Management and Coordination Act.

4.0 Monitoring and Data Management System

4.1 Water Quality Monitoring System (WQMS)

The overall objective will be to provide the information and data necessary for the management of the surface water resources including their protection and conservation. Reliable data are especially important in decision-making and a long-term monitoring programme will be necessary before effective and sustainable river management policies can be developed (VWQMN & SBMP, 1999).

The sampling plan should aim to cover the river from the source where the water is pristine to the outlet so that the necessary baseline data as well as the whole river profile are captured. Sampling points along the river courses should be selected on the basis of the likelihood of identifying point and non-point pollution sources; effects due to tributaries by sampling 20 m upstream and downstream of each tributary; potential sinks and the complete river profile from source to outlet. Collect and analyse river water samples during both wet and dry seasons for comparison. During the dry season, there is reduced river flow and no surface runoff to carry pollutants from solid waste dumpsites, filled pit latrines and rain-fed agricultural fields among other sources to the watercourses. A laboratory dedicated to water quality assessment is recommended so that the analytical methods can be standardised and quality control assured.

It is important that river-bottom sediments and other catchment sediments be sampled and analysed to study the behaviour of sediment-bound trace elements in the river (Horowitz, 1991).

Rivers and streams

Sampling frequency: monthly

Selection of sampling sites

Choose the monitoring sites on the basis of:

- Ease of access
- Variety of habitats
- Potential for locating point-source pollution sources e.g. proximity to a factory
- Potential for locating non-point pollution source along the river course
- Potential for identifying tributary effects on the water quality (20m upstream and downstream of a tributary)
- Channels adjacent to irrigated fields with intensive cropping

The selected sites should be representative of the entire catchment.

Methodology

Determine the following field parameters in *situ* at the sampling site.

- Electrical conductivity (EC) (ms/cm)
- Turbidity (NTU)

- pH (pH units)
- Temperature (°C)
- Total dissolved solids (TDS)
- Dissolved oxygen (mg/L)
- Discharge (m3/s)

Equipment: Calibrated field meters

It is important to take all measurements directly with the highest possible level of accuracy. If in *situ* measurements cannot be taken due to safety considerations or any other reason, determine the parameters in a water sample immediately after collection from the river in a well-rinsed bucket or similar container.

Parameters to be determined in the laboratory:

Colour (Filt.) (Pt/Co Units)

Filterable reactive phosphorus (FRP) (mg/L P)

Total phosphorus (TP) (mg/L)

Oxidised nitrogen (mg/L N)

Total Kjeldahl Nitrogen (mg/L)

Suspended solids (SS) (mg/L)

Metals: Zn, Pb, Cu, Cr, Cd, Ni, Hg, As.

Major ions: Na, Mg, SO4, Ca, K, Cl., alkalinity (CaCO3)

Fertilizers

Pesticides e.g. DDT, Ambush, Ridomil, and Malathion

Volatile organic compounds e.g. Petroleum hydrocarbons.

BOD

Total and faecal coliform bacteria (counts /100ml)

Sampling

Ensure that collected water samples for laboratory analysis are representative of the water body. The samples should be collected directly beneath the water surface using polyethylene bottles directed upstream but sub-sampling from a bucket or another clean container is also acceptable. All bottles should be labelled with a reference number giving details of the sampling site; type of analysis; date and time of collection and initials of the sample collector.

Sample preservation

Collected water samples may undergo some changes due to biological and chemical activity before they are analysed in the laboratory. To control such changes, various methods of sample

preservation are followed depending on the intended laboratory analysis. The water samples should first be filtered through 0.45µm pore filters immediately after collection and stored in a refrigerator or cool-box at +4°C. Water samples for determination of heavy metals are preserved by acidification with nitric acid to pH 1 – 2 (VWQMN & SBMP, 1999). Bottles containing water samples in which the major ions i.e. K, Na, Mg and Ca are to be determined should be filled completely to exclude air and stored at +4°C.

Laboratory analysis

The water samples are to be preserved as detailed above and transported to the laboratory for analysis. The major ions i.e. K, Na, Mg and Ca can be determined using an inductively coupled plasma emission technique (VWQMN & SBMP, 1999). Metal ions such as Zn, Pb, Cu, Cr, Cd, Ni and Mn can be determined by mass spectrometry after sample digestion with nitric acid and hydrogen peroxide. Filtered reactive phosphorus, nitrate and nitrite are determined colorimetrically. The total suspended solids (TSS) can be determined by filtering a measured volume of sample through a pre-weighed filter and drying the non-filterable residue at 105°C. The biochemical oxygen demand (BOD) of the water samples is determined as detailed in Colwell *et al.* (1975). Pesticide residues in the water samples can be determined using several methods (Simoneaux and Marco, 1987; Greathead and Ashcroft, 1987).

Bacteriological tests: Water samples for microbiological analysis should be collected in sterile glass bottles and transported to the laboratory in a cool box. The samples should be tested for total and faecal coliform bacteria which are indicators of faecal contamination using the membrane filter technique (Evans *et al.*, 1981).

Equipment Calibration Requirements

The manufacturer's recommendations and procedures should be followed closely to obtain a high level of precision and accuracy in the measurement of both field and laboratory parameters.

Recording of results

The data should be consistently recorded in field sheets using indelible ink. A copy of the results should always be prepared.

Analysis of the results

Construct profiles of the pollutant concentration (in mg/l) and pollutant mass flux (in mg/s).

4.2 General Guidelines on Surface Water Quality

pH

Most natural waters have pH values between 6.0 and 8.5 i.e. neutral to slightly alkaline waters. pH values along rivers are similar, but tend to become slightly acidic at stations immediately downstream of industrial plants.

Conductivity

In general, conductivity values of river waters exceed 1000 S cm-1 if the waters are polluted or receiving large quantities of runoff (Chapman, 1992). Sampling during a dry period when runoff inputs are at a minimum captures the effects due to non-runoff related pollutants.

Total Dissolved Solids (TDS)

These constitute the non-filterable residue that passes through the standard filter.

Total Suspended Solids (TSS)

Suspended matter consists of silt, clay, and fine particles of organic matter, soluble organic compounds and microscopic organisms. High TSS concentrations are associated with relatively high discharge rates and high levels of human activity.

Biochemical Oxygen Demand (BOD)

Unpolluted waters have low BOD values (2mg/1 or less). Raw sewage has a BOD of about 600mg/1, whereas treated sewage effluents have BOD values ranging from 10 to 100mg/1, depending on the treatment (Chapman, 1992). Higher BOD values are associated with a combination of pollution by raw sewage and industrial effluents.

Coliform Counts

The total number of coliforms in drinking water should not exceed 10 cells/100ml and faecal coliform counts should be nil (WHO, 1984).

Major Cations (Na, K, Ca, Mg)

The dominant factor controlling these ions is the geology of the area. However localised changes may reflect anthropogenic inputs especially due to industrial effluents. Ca may be precipitated from solution leading to lower concentrations. K and Ca could also be introduced into the river system from agricultural activities.

Anions (Cl and F)

The geology, ceramic plants and glass etching industries are likely sources of high F concentrations in rivers (Kithia, 1992).

Phosphate and Nitrate

The major sources of Nitrogen (N) and Phosphorous (P) in water bodies are agricultural fertilizers, animal manures and municipal sewage. N and P content in water samples collected during the dry season, when there is low surface runoff from cultivated fields into the river system, is representative of minimal levels mainly due to animal waste and sewage ingress. Natural levels of N are normally less than 0.1mg/1. Higher N values in the water are associated with sewage ingress and intensive use of nitrogenous fertilizers.

Heavy Metals

It is difficult to indicate the safe levels of heavy metal ion concentration because it may vary with the metal, the exposure and the state and toxicity of the metal (UNEP/GEMS, 1991). However, the question of bioaccumulation in food crops grown and irrigated with polluted water continues to be raised. It has also been found that the concentrations of these trace elements in suspended sediments and in the top few centimetres of bottom sediment tend to be far greater than their concentration in the water column (Horowitz, 1991). Likely pollutants from small-scale industries and large informal settlements include Mn, Cr, Cu, Zn, Pb, and Cd. Effluents from various industries involved in electroplating, leather tanning, textile dyeing, battery and paint manufacturing and welding contain high levels of these metal ions. Pb is also used as an additive in petrol and is emitted in vehicle exhaust fumes.

4.3 Biological Monitoring

The presence, condition and number of the types of fish, insects, algae and plants can provide accurate information about the health of a particular river, stream or wetland. The types of animals and plants present in an undisturbed or pristine aquatic environment are its biological indicators. A polluted site in the same environment will have different biological characteristics from the undisturbed site which is used as a reference for comparison. The use of biological indicators in evaluating the health of a river, stream or another body of water is referred to as biological assessment.

Site selection

Monitoring sites may be chosen on the basis of factors such as:

- Ease of access
- Variety of habitats
- Proximity to a local point-source of pollution e.g. a factory, a drainage canal
- Proximity to a non-point source of pollution e.g. a farm

The selected sites should be representative of the local catchment characteristics.

Sampling frequency

It is recommended that sampling should be carried out twice yearly especially when macro invertebrate diversity and abundance is high. A period of at least five years of continuous data is required for statistically valid and meaningful trend analysis to be undertaken (VWQMN & SBMP, 1999).

Sample collection

Sampling of the biological monitoring sites should only be undertaken when the water is clear or four weeks after floods have subsided. It is recommended that a team of at least two people should carry out field sampling.

4.4 Rapid Bio Assessment Method (RBA)

Physico-chemical measurements should always be carried out *in situ* using field equipment before biological sampling at any site. This ensures that the parameters, such as turbidity and dissolved oxygen, are not altered by biological sampling.

The aim of RBA is to sample the widest diversity of macro-invertebrates within a set period of time for a representative stretch of the river. At each site, a number of habitats such as pools and riffles may be sampled. Each sampling is to be carried out by making several sweeps with the net over a specified period or area. This is to be followed by a specified period of live sorting.

An experienced biologist is required to pick representative macro-invertebrate samples from the sorting tray. The samples are labelled both internally and externally and preserved in 70% ethanol for identification in the laboratory. Samples preserved in this manner can be stored for up to 12 months before processing provided the samples do not dry up.

Equipment

ISO Standard Hand nets

These are qualitative sampling nets used to sample macro-invertebrates in aquatic habitats. The design and mesh size of the nets should be in accordance with the international specifications (VWQMN & SBMP, 1999).

Laboratory preservation of the macro-invertebrates

Preserve the macro-invertebrate samples in 70% ethanol containing 5% glycerol. Sample containers sealed with Para film or waxes are ideal for long term preservation of the specimens.

Include details such as the date, site name and description, habitat type and method of collection in the labels. It is advisable to keep a register of the collected samples. The samples should be stored in well labelled boxes to facilitate their identification and handling.

Habitat Assessment

The following habitat variables are to be assessed at each sampling site on each sampling occasion:

- Mean width of river
- Depth of river
- Substrate composition
- Altitude
- Riparian and aquatic vegetation
- Stream morphology
- Benthic and filamentous algae
- Any other general observations

Quality Assurance and Quality Control

Quality assurance and control should be conducted on field procedures to ensure a high level of consistency and accuracy in all operations i.e. *in situ* field measurements; sample collection and field processing and habitat assessment.

The quality assurance programme for sample collection and field measurements should include:

- Regular calibration of field equipment.
- Inter-laboratory comparison (e.g. analysis of quality control samples; use of identical sampling procedures at same site by different field teams).

Safety

In all operations of the water quality monitoring programme, pay close attention to the safety of the personnel. All field teams are required to be familiar with the Code of Practice for First Aid at their work place; Occupational Health and Safety Regulations and any other relevant Acts or regulations.

4.5 Data Management

The data collected may be categorised into physical and social data and stored in the following formats:

- *Statistical* data in tabular format

  These data can be manipulated in various ways and can even be exported to other databases and converted to charts using graphic software.

- *Descriptive* data

  These data are in the form of brief or detailed descriptions as may be necessary.

- *Graphic* presentations and maps

  These data are stored in pictorial and graphic formats to enhance understanding and interpretation especially among the general public.

- *Modelling*

  Installation of a data conversion facility is necessary to help in the manipulation of statistical and other data for worst case scenario studies and other simulations necessary for decision making.

4.6 Categories of Datasets

River Water Quality

- Water Quality Tables
- Fertilizer residues Table
- Pesticide residues Table
- Heavy Metals Table
- Environmental Data Table
- Rainfall and Flooding
- Year, rainfall and extreme weather conditions e.g. drought and flooding incidences
- River characteristics i.e. width, depth and course
- River Flow Data Table
- River siltation data

Social datasets

Health information

- Water borne and other infectious diseases
- Number of cases attended to annually
- Prevalence of water borne diseases and trend over the years
- Mortality rate children < 5years of age
- Disease control measures
- Budgetary implications of health care programmes

Water and Sanitation

- Existing water sources and supply rates
- Water supply schemes and associated infrastructure
- Reservoirs and water treatment works
- Water users and amounts abstracted for authorised use per year
- Consumption patterns and charges
- Current water demand
- Water demand projections
- Types of toilets and their distribution
- Toilet access and use survey
- Sewerage network coverage and associated infrastructure
- Storm water drainage system coverage

Solid Waste

- Collection system coverage in formal and informal settlements
- Handling of solid waste
- Disposal including management of disposal sites

Population

- Population distribution in planned settlements
- Population distribution in unplanned or informal settlements
- Population density (persons /km2)
- Population growth rate
- Life expectancy of males and females in the population including survival rate for children <5years of age.
- Occurrence of water-borne diseases and their relative importance on morbidity and mortality and the health budget.

Economic Overview

- Main economic activities
- The percentage of people engaged in various economic sectors viz. agriculture, manufacturing and cottage industries, service industry etc.
- Levels of income and cost of living indices
- Unemployment and poverty levels in the population
- Household characteristics
- Impact of water-borne diseases on the economy

Human settlements

- Land tenure system
- Housing characteristics
- Infrastructural development
- Administrative and community structures
- NGOs and CBOs operating in the area

Land use

- Urban Residential: housing estates
- Rural residential: agriculture and livestock keeping
- Sewerage network and waste water treatment works
- Manufacturing Industries
- Transport sector infrastructure including road and rail network
- Bridges and culverts
- Central Business District (CBD)
- Other uses

The database should be updated on a continuous basis so that the Catchment Management Strategy can be reviewed more accurately. Additional data should also be sought from Government institutions including Universities so as to build a more complete database.

4.7 Mapping of the catchment

To appreciate the complexity of the pollution problem in the urban catchment, the pollution data, drainage data and the social and land use data sets should be integrated. A base map covering the whole urban catchment and its environs showing the river system, transport infrastructure and landforms should be obtained from the concerned Department. Informative maps should then be prepared to help create awareness and highlight the pollution problem of surface water in the urban catchments.

5.0 Strategies for Water Resources Management in Urban Catchments

The key strategies for effective management of water resources in the catchments are well outlined by (2001). The main aspects of water management include the quantity, quality and the ecology or environment. The finance and the modalities of integration of plans and programmes are also important aspects in enabling the process.

- Develop a management strategy involving both quantity and quality of the water aimed at striking a balance between resource protection and utilisation on a sustainable basis.
- Develop a strategy for the maintenance of the ecological integrity of the environment with the aim of conserving biological diversity.
- Develop a financial strategy so as to limit dependency on external sources.
- Develop a strategy for integrating action plans aimed at protection, use, development, conservation and control of the water resources in the catchment.

5.1 Water Resources Protection Strategy

Water Quality (Groundwater and Surface Water)

- Develop strategies for achieving the set target water quality range (TWQR) over a specified period. The target water quality range (TWQR) is the ideal range of the specific parameter (Appendix 4).
- Establish the nature and extent of point sources and non point sources of pollution (ground and surface water).
- Investigate success and merits of implementing existing standards and the need to develop new ones.
- Identify suitable remediation plans for water stressed sub-catchments and specific sites.
- Develop incentives for pollution reduction and use of best available clean technology.
- Establish acceptable limits for pollutants.
- Establish monitoring and review system.

Ecologically Sensitive Areas

- Develop a database of sensitive areas where there is impact on water e.g. wetlands and estuaries.
- Establish current and desired status and the water related implications of maintaining this status.

5.2 Water Use Strategy

Licensing and Authorization

- Devise a scheme for evaluating license applications, general authorizations and for reviewing licenses.
- Determine when and where licensing should be compulsory.

Water Allocation and Use

- Develop strategy for water allocations to address the issue of social equity
- Investigate groundwater potential and limitations of sustained use
- Develop water allocation principles and allocation strategy taking quantity and quality issues into account
- Establish mechanisms for monitoring and review of water allocation
- Develop incentives for reducing water usage by major users such as industries
- Develop strategy for trading water allocations.

5.3 Water Resources Development Strategy

Existing Water Supply Schemes

- Develop a database of supply infrastructure viz. reservoirs, water treatment plants, distribution system; the ownership, location, and capacity and area covered by schemes, the operating rules, efficiency and financial status (Plate 10).

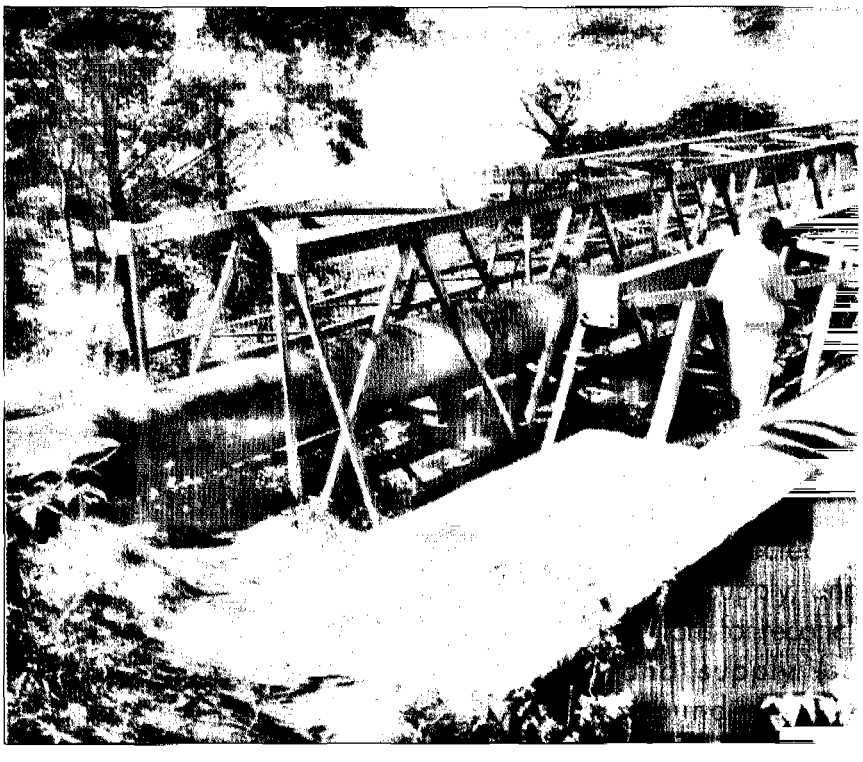

Plate 10. Nairobi City water supply pipes from the Ndakaini reservoir.

Augmentation of Water Supply

- Identify areas with current and projected shortages of water supply, and investigate options for reconciling demand and supply (surface and ground sources), their associated costs, social and environmental impacts
- Develop strategy for evaluating new water supply development proposals
- Assess potential for intra-catchment transfers from water-rich catchments
- Develop criteria for evaluating merits of transfers including cost/benefit analyses and socio-economic impacts
- Identify water conservation/demand management potential.

5.4 Water Conservation Strategy

The need to develop a water conservation policy is based on four key principles (UN-HABITAT, 2003):

1. That water is a valuable resource essential for individual and community health and for maintenance of the environment.

2. That water resources are limited and vary according to geographical distribution and other factors.
3. That water is a renewable resource and is part of the hydrological cycle.
4. That water is a shared resource.

Urban demand-side water management is set to gain importance as an IWRM tool since it aims at meeting increasing service demands without increasing water supplies or compromising the quality of service (UN-HABITAT/Rand Water/WRP, 2003). Thus, it is possible to achieve a reduction in water demand in the catchment area by increasing the water use efficiency by the urban population. The Water Demand Management (WDM) programme, if effectively managed, could improve the availability of water to many more of the urban residents including those in informal settlements. By lowering the water demand and minimising unaccounted for water due to leakage and illegal connections more water will become available for development activities in the urban centres. In the recently published "Water Demand Management Cookbook" (UN-HABITAT/Rand Water/WRP, 2003), comprehensive details are provided on effective urban demand-side water management for catchment managers and others with interest in Integrated Water Resources Management (IWRM). For water resource conservation strategy, the key requirements are to:

- Develop guidelines for demand management strategies for user sectors e.g. agriculture, industries.
- Develop a system of identifying water-stressed areas or areas where water use is not efficient.
- Investigate appropriate intervention mechanisms.
- Develop strategy for incorporating public participation programmes.

5.5 Water Resources Control Strategy

- Evaluate the existing monitoring system for water quantity and quality.
- Develop a strategy for reviewing, upgrading and maintaining a satisfactory monitoring system.
- Develop an Early Warning System and strategies for flood control, droughts and pollution disaster management.
- Develop Environmental Risk Assessment methodologies.
- Establish a database of dam safety; carry out regular safety inspections and preventive maintenance.

5.6 Establishing a Catchment Management Plan

Once the situation analysis report is ready, the information should be assimilated and a draft Catchment Management Plan (CMP) prepared by the Catchment Management Agency. The draft action plan should contain the activities to be carried out and a time frame (e.g. one year), clear objectives and implementation strategies, mechanisms of monitoring and control as well as auditing and review processes. The action plan should also have funding priorities for the activities. In drafting the catchment action plan, the existing natural resource management plans for the area should also be considered. The CMP should comply or strive to enhance the laid down national natural resource management standards or targets. The CMA should produce an annual report detailing the progress made in achieving results set out in the action plan.

Case Study: Integrated Water Resources Management in Singapore

Singapore has taken significant steps towards integrated water resources management. Being a small island State, Singapore has limited freshwater resources. With annual renewable surface water resources of 0.6 cubic kilometres and negligible groundwater, it is in the lowest band of water scarce countries in the world (UN World Water Development Report, 2003). Singapore imports water from Johar, Malaysia to supplement the local water resources.

To optimize water supply, about half of Singapore's total land area is set aside as water catchment. Although the local catchment water and imported water are adequate for its needs, Singapore has leveraged on new technologies by developing alternative sources of water in reclaimed wastewater (NEWater) and desalinated water to diversify its water resources. The entire population in Singapore is served with potable water, drinkable from the taps and the water is treated to a quality well within the World Health Organisation's guidelines for drinking water quality.

The management and control of water resources is essentially the responsibility of the two statutory bodies under the Ministry of Environment. The Public Utilities Board (PUB) is responsible for managing Singapore's water, sewerage and drainage services. It manages, in an integrated

Organise a workshop for the relevant Government Departments and agencies, representatives of DDCs from the neighbouring districts and representatives of stakeholders including private sector organizations, NGOs and CBOs concerned with the water quantity and quality in the catchment. The objective of the workshop should be to acquaint the stakeholders with the situation analysis reports and the draft CMP so as to chart the way forward for more effective management of the land and water resources in the catchment area on a sustainable basis. To achieve this, the following strategies whose details are provided in Appendix 2 can be employed:

1. *Co-operative governance strategy* : To engender effective co-operative governance.
2. *Communication and public relations strategy* : To identify all stakeholders, disseminate general information to promote proactive participation, provide forum for stakeholder participation.
3. *Public participation strategy* : To optimise stakeholder involvement and public participation in the development and implementation of the CMS and the action plan.

5.7 Institutionalising Cooperative Governance of the Catchment

The participants at the workshop should address the following known weaknesses of collaborative catchment management and devise ways of overcoming them by:

- Developing mechanisms of coordination between and within government institutions and communities
- Developing a shared or common vision for the catchment
- Creating a better understanding of the need for an integrated approach to water resources management

manner, the water resources such as reservoirs, water works, rivers, drainage system, water reclamation plants and sewerage system. The National Environmental Agency (NEA) is responsible for ensuring that the environmental concerns are incorporated in land use planning, development and building control of new development, and control of water pollution, hazardous substances and toxic chemicals.

Singapore has adopted a two-pronged approach to manage its water supply through addition of the available water resources and greater emphasis on control of demand. New projects are in the pipeline to increase the catchment areas to two-thirds by tapping run-offs from urbanized catchments. With the advancement of technology, desalinization of seawater has now become a viable source of water supply. In 2002, the Public Utilities Board awarded a contract for supply of 136,000 cubic metres of desalinated water per day through a Design-Build-Own-Operate (DBOO) project. A two-pronged approach has also been adopted for demand management of water through implementation of water conservation measures and efficient distribution system. As a result of such initiatives, it has been possible to maintain the per capita domestic consumption of water at 165 litres per day for the past five years and reduce the unaccounted for water loss from about 10 per cent in 1990s to around 5 per cent in 2002, which is amongst the lowest in the world.

- Overcoming institutional barriers to effective integration
- Developing workable methods for coordination and collaboration
- Helping community catchment management groups mature
- Integrating economic development with ecosystem management
- Developing effective communication channels among them
- Developing an integrated information management system to support catchment management
- Agreeing on methods of conflict resolution to be used in case of disputes among them
- Agreeing on how to share the costs

5.8 Devising Management Plan for Stressed Catchments

Stress in a catchment may be related to water quantity, quality or the ecological conditions. However socioeconomic, political and other factors could also have an indirect impact. The remedial action prescribed will depend on the severity of the stress following information assimilation of the situation assessment and should be outlined in a catchment management plan (CMP), which should be part of the CMS.

Elements of the CMP include the following (DWAF, 2001):

1. **Process initiation.** Identify the key issues and the relevant institutions to handle them.
2. **Characterisation.** Information and data from the situation analysis should be assimilated and the requirements for managing the key issues identified. These should be guided by the expected outcomes.

3. **Setting the goals**. Identify and prioritise the strategies and actions needed so as to achieve the expected outcomes.

4. **Implementation**. Execute the identified strategies and action plans in a coordinated manner with the aim of achieving the set objectives.

5. **Monitoring and evaluation**. Monitor and review the process so that necessary changes can be made to ensure realisation of the expected outcomes.

5.9 Strategies for Pollution Control in Urban Catchments

General Guidelines for Pollution Control

Guidelines for improvement of surface and ground water quality by reducing environmental impacts due to human activities should be developed. These should include codes of practices in the respective sectors. These should be developed in collaboration with concerned agencies such as the Ministries of Agriculture, Forestry, Water Development, and Environment and with

Total Catchment Management in New South Wales, Australia: Community and Government Working Together

Total Catchment Management (TCM) is defined in the New South Wales Catchment Act (1989) as "the coordinated and sustainable use and management of land, water, vegetation and other natural resources, on a water catchment basis, to balance resource use and conservation". It provides the structure for integrated Natural Resource and Environmental Management (NREM) in New South Wales (NSW). In practice, TCM has three elements:

- The Philosophy – based on stewardship. In essence, holding natural resources in trust, having a duty to care, and leaving them in first-class order for the next generation (intergenerational equity).
- The Process – achieving ecologically sustainable development (ESD) through effective and efficient government partnerships. In this system, the surface water catchment is a basic, but not exclusive, unit of management.
- The Administrative Structure – as set out in the NSW Catchment Management Act, it recognises the value of community input, such as localised catchment Management Committees (CMCs), which play a key role in working towards effective and sustainable catchment management outcomes.

Although TCM is still a relatively new approach, it has already achieved significant increase in cooperation and coordination of community and government effort resulting in highly beneficial environmental outcomes. In particular, Catchment Management Committees working in partnership with the local community groups, environmental groups, industry, Local and State Government have been at the forefront of attracting significant State and Federal Government funding and achieving an integrated management system.

any other agency concerned with natural resources management in the catchment. The guidelines/ codes of practices should deal with the procedures for introduction or promotion of environment-friendly technologies e.g. 'conservation tillage' which involves minimal ploughing; use of bio-fertilisers and minimal use of chemical fertilisers for crop production; application of Integrated Pest Management (IPM) approaches to pest control which employ minimal use of chemical pesticides (Plate 11).

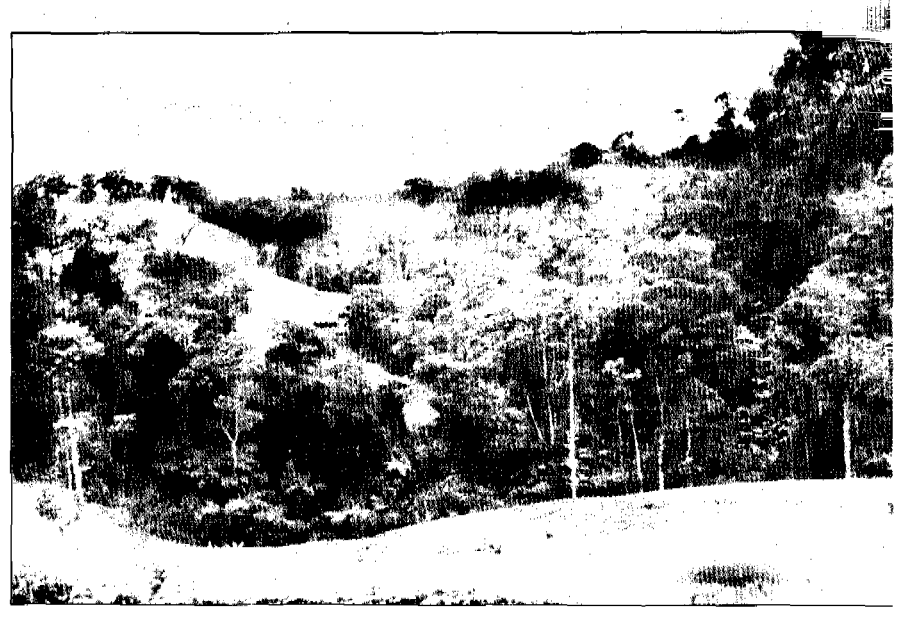

Plate 11. A tea crop – forest interface in a catchment area North-West of Nairobi. The farmland is a non-point source of pollution due to chemical fertilisers and pesticides that are carried in surface runoff to the rivers.

In the case of urban environments such as the Sydney Region, covering an area of nearly 2000 square kilometres and supporting a population in excess of 3.7 million people, TCM is playing a critical role. It is essential to repair and maintain the surviving ecosystems to ensure their continued ability to support and sustain the natural and built environments and large population. Ecological sustainability must be a major focus of any NREM strategies and outcomes. TCM is helping to deliver those outcomes, particularly for ecosystems and habitats recognised as being under extreme environmental pressures.

Under the TCM umbrella, there has been extensive development and implementation of:

- Opportunities for community consultation and participation in the NREM process;
- Knowledge of specific on-ground mechanisms to address NREM issues;
- Prioritisation of NREM issues and strategic actions through community consultation;
- Identification of pollution sources and level of significance, and facilitating actions to address causes and not the symptoms;
- Development of relevant NREM education programmes, materials and actions that result in measurable on-ground change;
- Development of urban storm water management strategies including management plans involving Local and State Agencies; and
- Influence in the development process for effective and sustainable State and local level policy, procedures and requirements.

'Community Contracts' or 'Statements of Joint Intent' have also been developed by some CMCs to provide a strategic approach to catchment management. For example, the 'Community Contract' developed by Hacking River CMC resulted in relevant Councils, Government agencies and local community groups committing to progress specific strategies and actions to address community issues.

Many factories release the effluents into the rivers without any treatment. This may cause anoxic conditions to develop downstream and serious deterioration of the water quality. Guidelines on the treatment of effluents before their release into the environment should be provided to the factories.

Interaction with the forestry sector is needed to promote alternative income generating activities such as harvesting of honey and other non-timber products as well as ecotourism. Use of alternative sources of energy such as Liquefied Petroleum Gas (LPG) and kerosene should also be promoted by lobbying for tax reduction on the items and the related devices such as gas cookers and stoves to make them more affordable and thus minimise demand for charcoal and fuel wood from the forests (Plate 12).

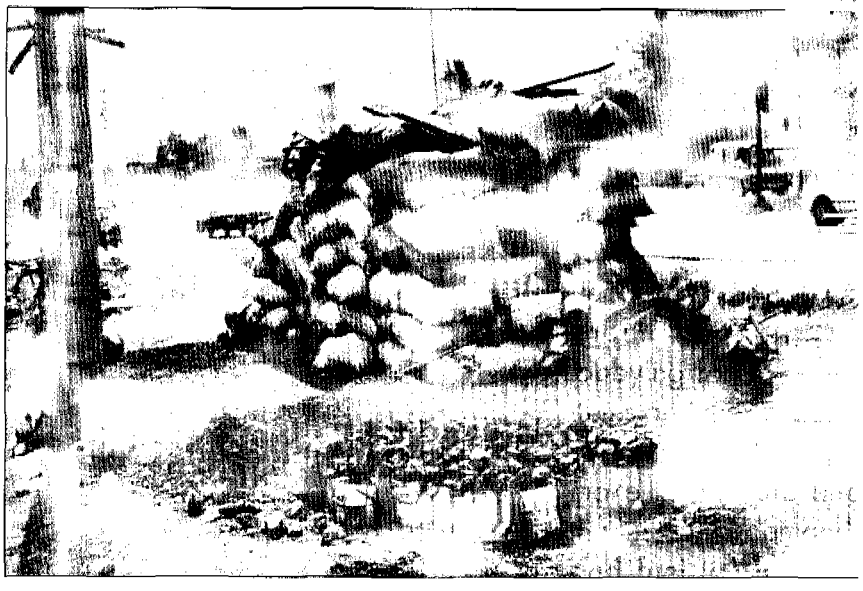

Plate 12. Charcoal on sale in small tins and in gunny bags on a street in an urban area. It is the only affordable fuel for many of the urban poor.

Liaison with the extension staff from the relevant ministries should be ensured to implement the transfer of appropriate technology to the farmers in the catchment.

For the industrial sector guidelines for waste minimisation approaches by avoiding generating waste in the first place and waste recycling should be developed. Other guidelines that should be prepared by the CMA include those outlining the best practices in liquid and solid waste management.

The catchment can be divided into two or three sub-catchments depending on the river system and the geographical size. In each sub-catchment, the highly polluted sites or 'hot spots' need to be identified from the water quality data. Appropriate remediation measures should be selected to suit the site-specific situation. Some of the commonly recommended remediation measures are enlisted below:

Pollution control at source

This is the preferred method of controlling pollution. It involves establishing institutional arrangements for pollution monitoring and control at source rather than developing mitigation measures. The approach is to prevent or minimise the release of pollutants by setting standards of air and water quality and acceptable limits of pollutants so as to avert the environmental impact before it occurs. Controlling pollution at source is effective for both point and non-point sources of pollution. It requires the establishment of monitoring and control mechanisms to enforce compliance.

Waste storage

Lagoons or oxidation ponds may be constructed to hold liquid effluents from small communities and wastewater from agro-processing factories and other manufacturing industries until they

are less toxic. The wastewater is released into the watercourse when the assimilative capacity of the receiving land or water is high. The benefit of this approach is the low cost since it relies on natural degradation of the pollutants. In case of hazardous wastes, more stringent storage requirements such as burial in secure landfills and deep well injection into permeable layers of rock bounded by impermeable strata have been recommended (Krhoda, 2000).

Waste recycling

Solid wastes such as bottles, paper, plastics, should be recycled and the organic wastes should be rendered harmless through aerobic or anaerobic decomposition. Sorting the waste will minimise its total volume, provide raw materials for other industries and create jobs for many urban poor. Encourage entrepreneurs to fill this gap rather than scavenging at the dump sites (Plate 13).

Plate 13. A man scavenging for valuables at a burning city dump site.

Wastewater treatment

Effective sewage effluent collection, treatment and safe disposal are particularly important in densely populated areas. In areas having no sewerage networks, cesspits are commonly used. High cost of construction, regular inspection to clear blockage and maintenance of the wastewater treatment plants are among the issues, which need to be addressed in waste water treatment (Plates 14 and 15).

Plate 14. Waste water treatment in the primary oxidation ponds at Ruai showing floating scum.

Plate 15. A part of the large secondary waste water treatment ponds at Ruai. The water has a reduced BOD and lower coli form count than that in the primary pond.

In-stream aeration

In-stream aeration to increase dissolved oxygen in the water enhances the assimilative capacity of the river. This can be done by putting weirs to increase surface turbulence and thus promote oxygen transfer into the water (Plate 16).

Plate 16. A weir constructed across an urban river to promote oxygen transfer to the water for enhanced degradation of pollutants.

Low flow augmentation

This strategy is required when the pollution load exceeds the assimilative capacity of the river due to reduced flow. To implement the strategy, the cost of building reservoirs and the effect of diverting water from other users including down stream users have to be considered.

Wetlands and impoundments

Wetlands are effective biological purification systems (Plate 17) and these should not be indiscriminately encroached and commercialised (Plate 18).

In addition to removing silt, pollutants such as nitrates and phosphates are taken up as nutrients by the plants. Wetlands also promote water infiltration and recharge of ground water resources. These may serve as wildlife or bird sanctuaries and promote local tourism to generate some revenue for operation and maintenance.

Plate 17. A papyrus (*Cyperus papyrus*) swamp in a wetland area North of Nairobi. Swamps are known to be highly effective in cleaning polluted water.

Plate 18. Papyrus reeds are harvested and woven into mats which are sold along the highway.

6.0 Expected Outputs & Specific Interventions

1. Output: Enhanced Public Awareness and Education

It requires development of a programme for dissemination of information and for raising community awareness for conservation of the water resources. The community's role in the sustainable management of the water resources is influenced by the individual perception and the ability to make informed and appropriate decisions. Murals with clarion calls such as "Water is life, conserve it! Waste not want not!" and other awareness enhancing measures may help to drive the message home.

Activities

a. Appoint a public relations consultant to:

- Review public awareness and environmental education programmes and strategies of the various natural resource management organisations in the area.
- Prepare public awareness programmes and mobilisation strategies targeting various stakeholder audiences i.e. government officials, industrialists, farmers, women and the general public (Plate 19).

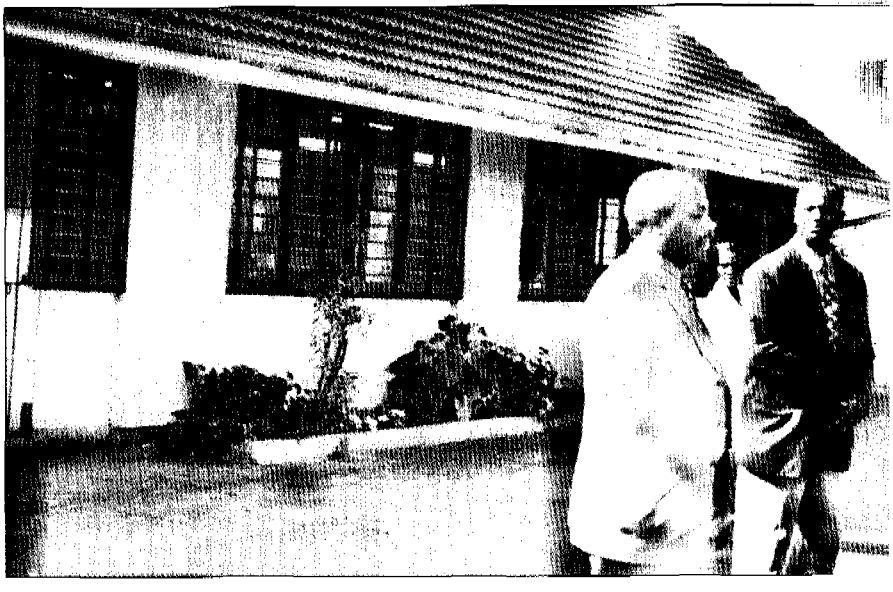

Plate 19. A member of staff at the Ruai Sewerage Treatment Works explains to visitors the operations at the plant.

b. Identify the most effective channels of reaching the target audience through effective use of print and electronic media, animation etc.

c. Prepare a Work Plan for implementation

d. Cost the implementation of the agreed programme

e. Submit Draft Report

f. Present the draft report to a stake holder's workshop for consideration

g. Finalise the document

h. Mobilise funds from Government and donors

i. Implement programme to create awareness and mobilise social and political will.

j. Carry out periodic reviews of public awareness and education programmes and social and political mobilisation strategies.

Verifiable indicators

- Well sensitised communities with a deep appreciation for clean and healthy environments at an early age.
- Less degradation of the land and water resources.
- Community support in the rehabilitation of degraded sites.
- Restoration of degraded sites.

2. Output: Incorporation of Environmental Education in School Curricula

Although some general aspects of environmental education are taught in schools these are not specific to the urban catchment situation. The misuse and destruction of water resources is closely linked with the attitudes and values of water users (UNCHS, 2001). A value-based approach to water education has been strongly advocated to highlight the role of the individual community members in conserving water and in protecting the environment. The aim is to impart information on water, sanitation and hygiene to young members of the society and thus inspire attitudes that promote wise and sustainable use of water. It is important to sensitise members of the community and influence their attitudes and behaviour at an early age when they are in the formative stage.

Activities

i. Appoint a consultant to:
   a. Review the primary and secondary school syllabi with a view to making the environmental education component more relevant to the local situation.
   b. Prepare draft syllabi and teaching aids such as flip charts incorporating the environmental problems experienced in urban catchment areas.

ii. Present draft to stakeholders including Education Department officials in-charge of curriculum development for schools.

iii. Finalise document

iv. Mobilise funds

v. Run a pilot trial in selected schools

vi. Review results and update syllabus for final approval

vii. Introduce Environmental Education in schools

If there are difficulties in imparting the environmental health information through the school syllabus:

i. Appoint a consultant to:
   a. Develop informative materials on environmental problems such as posters for distribution to schools.
   b. Design learning materials for environmental clubs in schools.
   c. Design competitions such as essay writing for schools to promote water conservation and environmental health.

ii) Mobilise funds

iii) Launch the promotion in schools

Verifiable indicators

- Early sensitisation of community members to appreciate clean rivers and environments.
- Communities more knowledgeable in environmental issues.
- Communities that are better equipped in waste management methods.

3. Output: Regulation of Water Quality

In case of point source pollution due to discharge of industrial effluents or water from Waste Water Treatment Works (WWTW), regulate the quality of surface water in the catchments by:

- Controlling discharges at source.
- Managing the receiving environment.
- Waste minimisation.

Activities

1. Set specific discharge standards in individual permits based on the TWQR for the given area. The water quality standards could also be based on the best available clean technology. Stricter standards should be applied depending on the sensitivity of the environment that is receiving the effluent. Specific regulatory instruments can be applied to protect aquatic ecosystems, riparian habitats and in the rehabilitation of water resources.
2. In the case of non-point source pollution such as agricultural fertilisers carried in runoff from farmland, discharge standards are difficult to apply and enforce. The best environmental practice approach providing guidelines for the application of fertilisers and pesticides may then be adopted. The guidelines can be agreed upon with the Ministry of Agriculture (MOA) and implemented by the agricultural extension staff in cooperation with the farmers.

Other types of regulatory instruments that may be useful in controlling surface water pollution include:

3. Liase with the umbrella organisation of local pesticide manufacturers to set product standards for pesticides and other agrochemicals
4. Liase with the Ministry of Agriculture for introduction or promotion of Integrated Pest Management (IPM) methods of pest control which employ minimal use of chemical pesticides. MOA staff to implement technology transfer methods to the farmers in the catchment.
5. Liase with the Planning Department, Environmental committee, community leaders and other stakeholders on strategy to impose zoning or land use controls so as to protect the sensitive environments.
6. Develop and issue safety regulations and procedures for handling accidental pollution.
7. Regular monitoring of receiving water by inspection team to ensure compliance.

Verifiable indicators

- Improved water quality in the catchment.
- Increased stakeholder participation in catchment protection and water resources management.

4. Output: Measures for Conservation of Ecologically Sensitive Habitats

Protection of riparian and wetland areas is necessary to preserve the diverse flora and fauna characteristic of environments and the integrity of these ecosystems. Human activities such as farming, grazing of livestock, logging, sand harvesting and stone quarrying remove the vegetation cover leaving the ground bare and prone to soil erosion. The loose soil is transported to the rivers and wetlands where it interferes with the water flow resulting in increased frequency of flooding or its magnitude and has a negative effect on biodiversity.

Activities

i. Launch a media campaign for public awareness raising and education to mobilise the political will of leaders to protect sensitive habitats such as riparian and wetland areas by creating buffer zones of at least 50m. This will lead to the movement of people squatting on the river banks to areas away from the rivers.

ii. Develop a database of sensitive areas where there is impact on water e.g. wetlands and estuaries.

iii. Establish current and desired status and the water related implications of maintaining this status.

iv. Undertake a survey to count and register the number of families that will be affected by the ban on squatting in the designated buffer zones.

v. Hold discussions with the community leaders and local administrators and agree on a timetable for the families to relocate to areas away from the buffer zones.

vi. Mobilise funds to help the needy cases to relocate to the new sites.

vii. Ban farming on the riverbeds and overgrazing of the riparian zones and wetland areas by large herds of animals.

viii. Stop the clearing, drainage or diversion of water from wetland areas and ensure complete protection of wetland sites with unique flora and fauna from any human interference.

ix. Ensure complete protection of wetlands in which effluents from human settlements flow.

x. Ban sand winning activities on the river beds and open stone quarrying in the area if river flow is interrupted or the ecosystem is threatened by the activities.

xi. Initiate a programme to restore the land degraded by sand winning or stone quarrying activities. This involves re-establishment of the ground cover by planting local grasses and indigenous trees to stabilise the soil.

xii. Ban the introduction of any foreign species that may later threaten the existence of local biodiversity.

xiii. Mobilise workers to remove any introduced invasive species especially those that threaten local biodiversity.

Verifiable indicators

- Restoration of degraded river banks, riparian areas and wetlands.
- Increased plant cover in riparian zones, reduced erosion and silting of the river channel.
- Improved water quality with respect to physical, chemical and bacteriological properties.
- Removal of threat to human life and property when the rivers are flooded.
- Improved biological diversity and ecosystem function.

5.Output: Degraded Sites Restored and Buffer Zones established along Catchment Areas

Small woodlots may be established on degraded sites of river banks to provide buffer zones and to protect the river corridors from farming and other land degrading practices. Local tree species should be planted because they are already well adapted to the soils and are unlikely to disrupt the ecosystem. These woodlots serve as buffer zones and protect the riparian areas from direct erosion and other degradation effects.

Activities

i. Conduct awareness raising and education campaign to sensitise the communities.

ii. Contact and hold discussions with the Department of Forestry and NGOs actively involved in establishment of shelterbelts or re-forestation programmes.

iii. Involve the community in decision making from planning to implementation of the programme. The communities will need to take care of the plants by weeding and watering before the trees are well established. The participation of women should be ensured for the programme to succeed.

Verifiable indicators

- Restoration of degraded sites
- Improved water quality
- Shelter belts established

6. Output: Significant Reduction of Water Pollution by Sewerage Effluents

Poor sanitation is a major cause of surface water pollution in many cities. It will require cross-sector planning and coordination to address the problem comprehensively. This will need time and financial resources that may not be immediately available. However there are short-term actions that may not require a lot of funds but which if implemented or enforced may prove significant in the immediate improvement of water quality at the sites. To this end, exhauster services for evacuation of cesspits and pit latrines in residential areas not served with sewage networks should be made readily available and affordable (Plate 20).

Activities

1. Hold discussions with the Water and Sewerage Department, Housing, Planning and other relevant Departments of the City Council, community representatives and other stakeholders and agree on a joint plan of action to undertake the following:
    - Retrofitting of the existing sewer networks to replace broken and vandalised sewerage infrastructure.

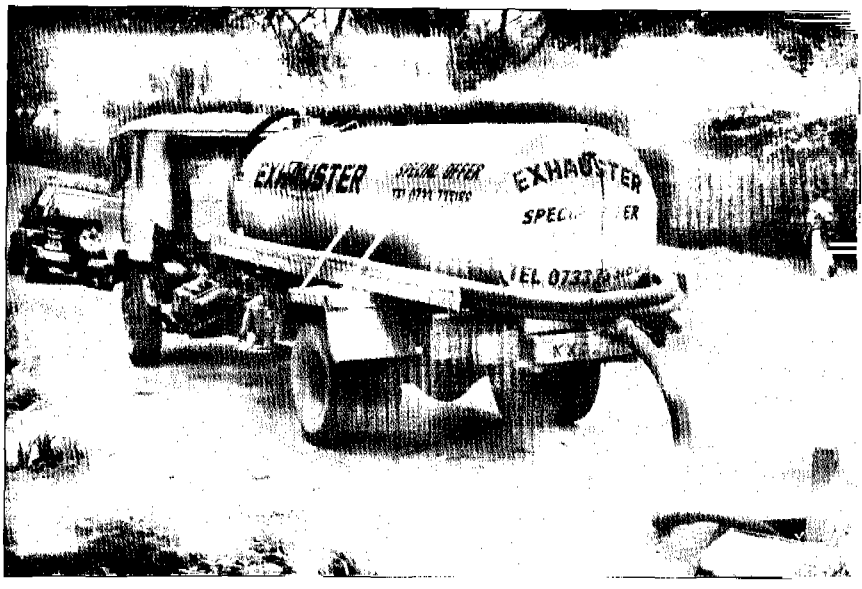

Plate 20. A cesspit evacuation tanker or exhauster vehicle emptying raw sewage in a main sewer line through an open manhole. Exhauster services are in high demand in areas without sewerage network.

- Regular inspection and maintenance of sewer lines to clear any blockages and to repair broken sewers. This will enable early detection of problems in sewer networks so that the necessary repairs can be undertaken before much damage is done to the environment. It will require additional funds, personnel and equipment.
- Immediate identification and prosecution of all owners of business and residential premises whose WC toilets are illegally connected to the storm-water networks. The connections should be demolished, the premises closed and the owners required to construct cesspits where there are no sewer networks.
- Immediate cessation of dumping faecal matter in water courses by cesspit cleaning vehicles. Information regarding emptying points, provided with airtight manhole covers, along the sewer lines should be provided to all registered service providers. Stiff penalties including fines and/or jail sentences should be imposed on those found guilty of contravening the order.
- Regular inspection and preventive maintenance of WWTW to improve the efficiency of wastewater handling.
- Regular monitoring of water discharged by WWTW into rivers to ensure compliance with the requirements of the discharge permit, the Water Act and other relevant Acts.
- More private investors to be contracted to increase capacity for cesspit evacuation services if the existing capacity in the city is inadequate.
- Enhancement of public awareness and community responsibility in taking care of the water and sanitation infrastructure to minimise vandalising and blockages of the sewerage system.

2. Draw a priority list for the action plans.
3. Cost the programme.
4. Present the estimates to stakeholders for approval.
5. Mobilise funds.
6. Coordinate implementation of the programme.

Verifiable indicators

- Improved river water quality: lower coliform counts.
- Enhanced community involvement in water management.
- Reduced surface water eutrophication.
- Increased biodiversity.

7. Output: Improved Access to Basic Water and Sanitation for the Slum Dwellers

Every year, over 5 million people mostly in developing countries, die from illnesses caused by unsafe drinking water and poor sanitation (WHO, 2001).

It has been observed that a sense of community responsibility and a stable economic base are necessary ingredients for the provision and maintenance of basic services in low-income and unplanned communities (Global Water Forum, Case 101).

Activities

i. Organise meetings with the Water and Sewerage Department, Housing, Planning and other relevant Departments of the City Council, local administration, local community leaders and NGOs active in the area to review the state of basic infrastructural services covering mainly access roads, water and sanitation and solid waste management in the informal settlements.

ii. Agree on a Strategic Management Plan (SMP) for the settlements to improve community access to piped water, toilet facilities, garbage collection and disposal and provision of access roads.

iii. Review the proposed SMPs for the settlements with the local residents to ensure that they coincide with the needs of the communities. This may involve construction of several community water and sanitation blocks offering services at cost on a prepaid basis. It may be easier to limit wastage of piped water and maintain a good standard of hygiene under such an arrangement than by increasing the number of standpipes and pit latrines accessible to the squatters in informal settlements. The collected funds would cater for the operation and maintenance of the facilities on a sustainable basis.

iv. Outline the minimum necessary changes that may need to be effected in the area before the residents can enjoy the improved services. The communities should provide labour as their contribution to the programme so that they develop a sense of ownership.

v. Improvements such as installation of solar panels to provide lighting at night to improve security should also be considered. The communities should also demonstrate their willingness to provide security for the project materials and to protect the facilities from being vandalised once completed.

vi. Finalise the SMPs.

vii. Cost the various project inputs.

viii. Mobilise funds from government, Development partners and the community.

ix. Implement the programme.

Verifiable indicators

- Lower water bills and improved access to basic services by poor urban families.
- Less time spent by womenfolk and children looking for water.
- Less time spent on queues for basic sanitation services.
- Improved hygiene and lower incidence of water borne diseases in the area.
- Reduced infant mortality rate.
- Lower medical bills and improved quality of life.

8. Output: Improved Capacity for Solid Waste Management

Solid waste collection by the service providers should be well coordinated with the city residents so that the garbage does not remain uncollected for long thus providing breeding sites for rodents, flies and other vectors. The selection of the disposal sites and the management of the sites to prevent leachate from reaching the water course are the major concerns. The leachate may contain toxic chemicals which may contaminate the water. Other problems associated with open dumping of solid municipal waste include air pollution, threat to health of the scavengers and communities living close to the dumpsites.

Activities

i. Organise a workshop for stakeholders including Local Administration, Housing, Cleansing, Transport, Parks and Inspectorate Departments, service providers, Community Based Organizations (CBOs), neighbourhood networks and any other stakeholders. CBOs can organise solid waste collection at the household level. Each household should contribute a small fee to pay for waste collection bags and transportation of the garbage to collection points. Contracted service providers should issue identifiable waste collection bags so that companies which illegally dump garbage in unauthorised places can be easily identified and punished under the law. The City Council trucks or contracted service providers should then transport the solid waste to:

   a. Designated landfill sites where it may be compacted by bulldozers or incinerated.

   b. Garbage processing and recycling plants where the garbage should be sorted out. The vegetable matter mainly from the food markets should be fermented to produce biogas and bio-fertilizers while waste paper may be processed into paper tissues and other products of commercial value. Glass, plastics and metals could be sold to recycling plants. The City Council should offer incentives to private investors to set up garbage processing and recycling plants.

ii. The capacity for collection of solid waste in the city's residential and business areas should be optimised by providing more trucks or contracting more service providers if necessary so that solid waste does not pile up on the pavements attracting flies and rodents or get washed into the storm water drainage system. Companies operating businesses in the city should be encouraged to provide services such as litter bins in return for advertising their products and services (Plates 21 and 22).

iii. Discuss with road construction section of the Transport Department so that unused construction materials are not left on kerbsides from where they may be washed into the storm water network and cause blockage.

Plates 21 and 22. Litter bins at busy street intersections in an urban area. Corporate advertising of goods and services while providing a service to the urban residents should be encouraged.

Verifiable indicators

- Clean streets and residential areas
- Less frequent blockage of storm water networks
- Less litter washed into the river system
- Job creation for many urban poor in garbage recycling plants
- Income generation from garbage processing plants
- Improved surface water quality

Plastics waste materials

Plate 23. Litter mainly consisting of plastic bags discarded next to a low-cost housing estate in an urban area.

Plastics and polythene materials often constitute a large proportion of solid municipal waste in many urban areas (Plate 23) which litter the environment, block storm water drains and sewer lines and have been reported to cause livestock deaths when ingested. Additives contained in plastics include colorants, stabilizers, and plasticizers which often contain toxic constituents such as lead and cadmium. Reports indicate that plastics contribute 28% of all cadmium and 32% of all lead found in solid municipal waste (NEMA, 2003).

The sustainable development of the plastic and polythene industry requires that the adverse impacts of plastic waste on the environment should be significantly reduced without disrupting the production and use of the materials in commercial activities. A policy favouring reduction of plastic waste through recycling should be formulated.

Recycling of plastics waste will help to create employment opportunities for many urban poor people and avert the environmental pollution problems mentioned above.

Activities

i. Run a public awareness campaign to sensitise the plastics manufacturers, packaging industry and other industries in which plastics are extensively used, such as the communications sector with mobile phone scratch cards, municipal authorities, refuse handlers and other stakeholders

ii. Discuss and reach a consensus with the stakeholders including lead agencies on a timetable for implementation of the following actions:

   a. To develop guidelines for minimising plastics waste.
   b. To work with the city council to enact a bye-law barring indiscriminate disposal of plastics in the environment.
   c. To work towards harmonization of national legislation concerning plastics and plastics waste.
   d. Collection of discarded plastics
   e. To work with the stakeholders to ensure publication of draft standards for manufacturers of plastic packaging materials and their enforcement so that only recyclable plastics are manufactured, sold and used.
   f. Immediate phasing out of the production, sale and use of plastics that cannot be recycled.
   g. Plastics recycling by manufacturers or a private investor to start.

Verifiable indicators

- Plastics waste in the environment greatly minimised.
- Reduced blockages of storm water drains by solid waste.
- Job creation in plastics recycling industry.

9. Output: Safety Measures in Medical Waste Management

As the cities continue to grow there is increased demand for health services. The resulting expansion in health facilities has led to indiscriminate disposal of hospital waste including used dressings, syringes and needles, blood and tissues in municipal land fill sites without due regard to the high risk of infecting poor people who scavenge the dumps for valuables. Contaminated leachate from the waste disposal sites may reach and contaminate the ground water and rivers thereby posing a health threat to downstream users.

Activities

i. Ban the disposal of infectious hospital waste in the city's dump sites. Institute regular surveillance by law-enforcement agents to ensure that culprits are prosecuted and penalised in accordance with the law. The punishment for those found guilty of contravening the law should be severe enough to discourage potential offenders. Where the court sentences are lenient it may require the CMA board members and other stakeholders to lobby the law makers for the enhancement of the sentences.

ii. Enforce the requirement for all health facilities to incinerate their waste.

iii. Offending hospitals which fail to comply within a period of 3 months after official notification should be closed down until they make the necessary arrangements to incinerate their waste.

Verifiable indicators

- Proof of access to a functioning hospital waste incinerator by all open health facilities.
- No medical waste evident at the City's solid waste disposal sites.
- System set up in hospitals/health care facilities for segregation of infectious/harmful waste

10. Output: Minimised Pollution by the Transport Sector

1. Pollutant: Used oils and lubricants

Used engine oil is a hazardous waste and the Basel Convention binds the signatory countries to ensure its safe disposal. According to experts in the oil industry the recommended method of disposing off used oil is by recycling or by incineration in high temperature kilns (DN, 2003). Many garages operate close to petrol stations where arrangements can be made for collection of the oil drained from vehicle engines (Plate 24).

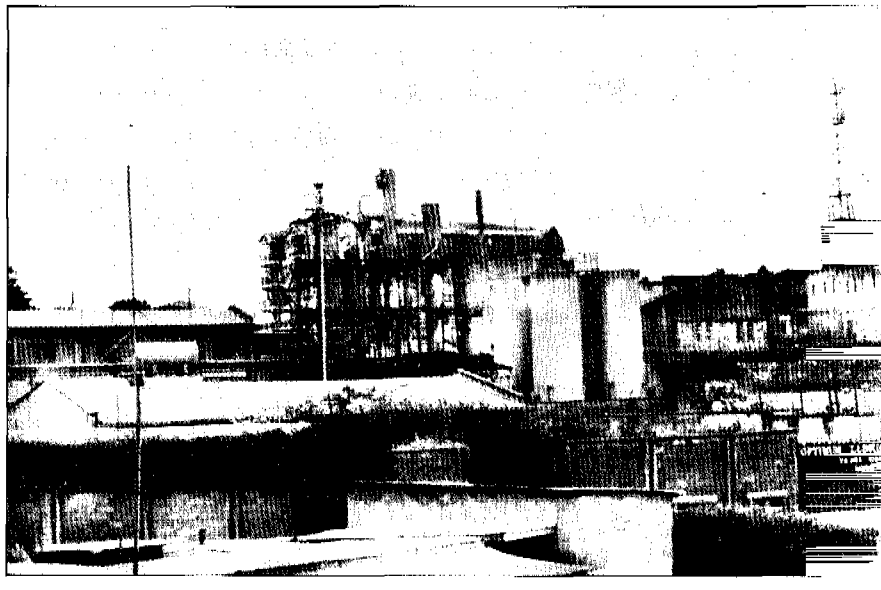

Plate 24. A recycling plant for used engine oil located in Kikuyu town west of Nairobi. The oil is collected from motor vehicle service stations in the city and transported to the facility for processing.

Activities

i. Run a public awareness campaign and education to sensitise vehicle owners, garage operators, petrol station operators and the general public to the dangers of washing vehicles in rivers and dumping used engine oils and lubricants in the environment especially in water courses.

ii. Hold discussions with all stakeholders in the transport sector and agree on a suitable course of action to stop dumping of used oils in storm water drains and the environment.

iii. Offer business opportunity with incentives to private investors to study the viability of setting up a recycling plant for used motor oil. The private investor to submit a proposal on the system of collecting used oil from vehicle servicing centres in the City.

iv. Discuss with the businessman and the stakeholders the proposed system of collecting the used oil and reach a consensus.

v. Formalise the arrangement with the businessman.

vi. If there are no willing investors, incineration of the used oil in high-temperature kilns may be the only alternative.

vii. Monitor and inspect garages to ensure compliance. Those found guilty of dumping used oil in the environment to be fined or punished in accordance with the By-law protecting the environment.

Verifiable indicators

- Reduced oil slicks in the environment and water courses in sites where vehicle service centres are located.
- Cleaner and healthier streams and rivers in urban areas.
- Biodiversity increased in river stretches adversely affected by the practice in the past.

2. Pollutant: Lead from leaded petrol

Emissions from vehicles using leaded petrol contribute to heavy metal pollution of the environment especially along the busy roads in cities. Although data on the magnitude of this problem is not readily available soil analysis has shown increased lead content in soils close to the highways than away from the highways.

Activities

i. Run a media campaign and lobby the political leaders for the government to phase out use of leaded petrol and only allow the sale of unleaded petrol.

ii. Lobby the Government to draw a time table for phasing out the leaded fuel so that vehicle owners can make the necessary engine modifications or seek other possible options.

Verifiable indicators

- Firm dates issued by the authorities for discontinuation of trading in leaded fuel.
- Increase of lead in the environment from vehicular emissions stopped.

3. Pollutant: Litter from Public Service Vehicles (P.S.V.)

In many urban centres, public service vehicles (P.S.V.) viz. buses, trucks and taxis do not have containers or receptacles for holding litter. Consequently, passengers throw litter out of passenger vehicles onto roads and road reserves. The litter especially paper wrappers, plastic bags and food and drink containers accumulate along the roads becoming an eye sore and reducing the aesthetic value of the environment.

Activities

i. Run a public awareness and education campaign to alert people on the need to maintain a clean environment. Call the attention of the people to the relevant city By-law against littering including stiff penalties for offenders.

ii. Invoke the provisions of the relevant By-law or Act to compel all public transporters including buses, trucks and Taxis to provide containers / receptors for litter in their vehicles within a period of three months. The local Environment Departments/ Committees, Local Authorities and the Police will be required to enforce the requirement once the notice expires.

iii. Lobby the City Council to enact a By-law requiring that all public service vehicles operating in the City provide litter bins inside the vehicles. A notice should be posted prominently in the vehicle warning the travellers not to throw litter outside the vehicles but to put it in the litter bin inside the vehicle.

Verifiable indicators

- Cleaner roads and road reserve areas.
- Less litter blockage of storm water drains and culverts.

11. Output: Minimised Pollution by Manufacturing Industries

Waste minimisation approaches by avoiding generation of waste in the first place should be the preferred method. "End-of-pipe" technologies tend to transform wastes from one form to another. To make treatment easier, industrial effluents should be separated at the factory level into hazardous and non-hazardous which can then be dealt with separately. Reduction of the volume, weight or hazardous nature of a waste during the production process can help to reduce impact on the environment. Pollution source reduction measures include substitution of materials with less toxic ones. Other approaches to waste minimisation include reuse and recycling of waste which may be used as a raw material by another industry. e.g. waste from a fibre factory can be used as a raw material by cushion making industries. Sorting of industrial waste materials for reuse and recycling can be an important income generation activity for many urban poor. Segregation of industrial waste from domestic waste by construction of separate collection and disposal facilities has also been proposed but may not be feasible in many developing countries due to the high costs involved.

Of particular concern are the date expired toxic chemicals which can no longer be sold or use of chemicals which have been banned by the state agencies e.g. the Ministry of Agriculture. All chemical manufacturers and stockists should be required under the law to belong to an umbrella organisation registered and recognised by the government. The organisation should have the responsibility of ensuring that its members are fully conversant with the codes of best practices governing the manufacture, storage, transportation and disposal of toxic substances.

Activities

i. Run a public awareness and education campaign to alert the general public and industrialists in particular on the dangers of industrial pollutants in the environment.

ii. Convene a stakeholder's forum with representatives of the formal industries, the informal sector, Government Departments and lead agencies as well as consumer organisations. Review the country's laid down water and air quality standards and any difficulties experienced in achieving them.

iii. Organise follow up meetings to discus how the stakeholders can implement the By-law or Environment Act by observing the rules and regulations on the disposal of industrial effluents in water courses. Agree on achievable targets that stakeholders should aim at over an agreed period.

iv. Establish a highly motivated well trained and equipped team to enforce the law through regular monitoring and inspection of the industrial effluents and ensuring compliance with the emission standards stated in the discharge permits.

v. Encourage manufacturers through incentives such as tax relief, well-publicised environmental commendations and awards etc. to adopt good manufacturing practices that are environment friendly. This can be achieved by city authorities working closely with the umbrella organisations to promote environmental awareness among their members. Special attention should be given to industries manufacturing pesticides and other toxic chemicals to ensure that the effluents are converted to less harmful by-products or detoxified before release into the water courses. Heavy metal ions such as chrome 6+ used as an anti-corrosive layer in vehicle body shells and known to be toxic can be converted to chrome +3 which is less toxic. Effluents that are strongly acidic should be neutralised by liming before disposal into the environment.

vi. Discourage irresponsible behaviour by manufacturers through naming and shaming of offenders and lobby the judicial system to impose heavy fines including custodial sentences for polluters.

vii. Lobby the country's parliamentary system to have an Act providing for a National Environmental Tribunal to give effect to the 'Polluter Pays Principle' to enhance environmental protection.

Verifiable indicators

- Reduced levels of toxic waste in industrial effluent and the city's storm water drainage system.
- Increased public awareness of the obligations of the chemical manufacturers not to pollute the environment.
- Increased biological diversity in receiving waters of industrial effluent.

12. Output: Management of Natural Sources of Pollution

Apart from human activities, natural geological formations in some catchment areas may be the cause of water pollution. High Arsenic concentration in ground water has been associated with skin diseases and even cancers in humans. Drinking water with high fluoride content has been known to cause discoloration of teeth and crippling skeletal defects in humans due to fluorosis

Activities

i. Appoint a consultant to:

   a. Review the health and environmental impact of natural sources of pollution such as Acid Mine Drainage (AMD), high levels of arsenic and fluoride in drinking water that may have been detected in the area by the Health Services system.

   b. Prepare a management plan for mitigation of the problem.

ii. Hold discussions with the mining industry to strengthen cooperation between the mine owners and the Government, the water utilities section and all stakeholders to discuss the recommended mitigation measures and agree on those to be implemented.

iii. Monitor the effects of implementation of the mitigation measures.

iii. Lobby the City Council to enact a By-law requiring that all public service vehicles operating in the City provide litter bins inside the vehicles. A notice should be posted prominently in the vehicle warning the travellers not to throw litter outside the vehicles but to put it in the litter bin inside the vehicle.

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iii. Monitor the effects of implementation of the mitigation measures.

Verifiable indicators

- Water quality improved
- Availability of water increased
- Improved health of the resident population
- Increased biodiversity in the ecosystem

13. Output: Institutionalised Environmental Impact Assessment (EIA) and Monitoring

Development activities often tend to impact upon natural resources and the environment in negative ways. A strategic environmental impact assessment is therefore necessary when a proposed development project is likely to have significant effects on the environment. Prior assessment and evaluation of the anticipated impact helps to minimize the economic and social costs of preventing damage as compared to restoring a degraded river system after development has taken place. Degradation of rivers and wetland functions and values have been known to occur without prior environmental impact assessment of projects (Pritchard, 1997). Data from the EIA may be used to help in the planning of the project so that management or control measures may be included in the project design when there is most flexibility.

Activities

i. Build capacity for EIA in the organisation.

ii. Subject all planned new developments which are likely to affect the flow of a river or have an impact on the riparian zone to an EIA process to determine the required environmental controls and mitigation measures.

iii. Monitor implementation of environmental safeguards during execution of development projects.

iv. Advise the Local Authorities to halt the development or operations of a particular project if the impact is detrimental to the environment until mitigation measures have been put in place.

Verifiable indicators

- Provision of opportunities for wider consultation of the public about the development proposals and their likely impacts.
- Significant reduction in the number and scale of adverse environmental impacts of the development projects.
- Maximisation of benefits for people affected by the development project including compensation in case of loss of land or livelihood.
- Availability of applicable management options for any negative impact that may arise as a result of the project.

14. Output: Coordinated and Integrated Institutional Mechanism

Failures to protect and conserve the natural resources as also degradation of the environment are to a great extent, attributable to the lack of information, effective regulation and coordination among the concerned agencies.

Activities

i. Appoint a consultant to:

   a. Study the rules and regulations governing the allocation, conservation and protection of the natural resources by the various government institutions.

   b. Compile traditional customs, rules and practices of natural resource utilisation, conservation and protection.

   c. Compile a draft set of the unified rules and regulations, and means of compliance for allocating, conserving and protecting natural resources at local level.

   d. Prepare cost of implementing the unified rules and regulations.

   e. Hold a workshop to discuss the draft document.

   f. Finalise draft with implementation strategies, schedules, resources and costs.

ii. Mobilise funds

iii. Pilot test in the field

iv. Update with lessons learnt

v. Apply in the catchment

Verifiable indicators

- Controlled exploitation of the natural resource leading to improved protection and conservation.
- Minimisation of the scale and frequency of conflicts among users of the resource.
- Restoration of the degraded environment.

15. Output: Strengthened Land Use Controls

Regulating land use is an important component of integrated water resources management. In rapidly growing cities, the increased discharges of liquid and solid wastes have significant impact on the surface and ground water resources. Logging activities in the forestry sector and intensive cropping in the agricultural sector also have adverse impacts on both the quantity and quality of surface runoff and ground water resources. Quarrying activities for building materials for the construction industry negatively impacts on the environment. The loosened soil is easily carried by wind and water to the nearby streams and rivers where it is deposited as silt and may interfere with the flow and also the water quality. For these reasons, land use planning is an important component of the implementation plans for integrated water resources management. It is especially important in protecting environmentally vulnerable areas such as wetlands and riverine ecosystems.

Activities

i. Appoint a consultant to prepare:

   a. Land suitability and capability maps for the whole catchment area identifying areas where specific forms of land use should be prohibited or restricted because of their likely impact.

b. Land capability and suitability maps for the heavily polluted areas

c. Water Master Plan for the catchment area for the next 20 years

d. Estimate the cost

ii. Mobilise funds

iii. Implement proposals

Verifiable indicators

- A well rationalised development plan for the urban area.
- Fewer environmental problems for the city managers to cope with.
- A better living environment for the residents.

16 Output: Improved Availability of Water in the Catchment

Water Harvesting

Water harvesting will provide more water to the catchment residents and also contribute to reduction of flooding and its attendant threats to life and property.

Domestic Users and Large Institutions

Encourage city residents to set up simple roof water harvesting infrastructure on their plots. The water collected during the rainy seasons should supplement the piped water supply and thus reduce piped water demand. A Bylaw requiring large institutions with expansive grounds such as universities and airports to set up water harvesting infrastructure on their premises should be enacted. The water should be used for cleaning operations including flushing toilets and irrigating gardens.

Irrigation and River Flow Maintenance

Small dams or reservoirs should be strategically located to collect the surface runoff during the rainy season. Increased water availability will provide more employment opportunities in irrigation agriculture to the urban poor.

The water may also be used to reduce water shortages and maintain or augment the river flows necessary for ecosystem function during the dry seasons. Planting more trees and grasses of the local species in road verges and degraded sites with no plant cover will help to improve water infiltration into the ground, reduce soil erosion and control flooding.

Manufacturing Industry and Other Users

Industries rank among water users with the highest allocation of piped water supplies in urban areas. Policies should be formulated to encourage industries to harvest rain water to supplement their piped water supplies.

Recreation

Expansive greens in golf courses require large amounts of water during dry seasons. City bylaws need to be enacted requiring such facilities to harvest the surface runoff during the rains for irrigating the grounds during the dry season.

Activities

1. Water harvesting:
    a. Encourage City residents to set up simple roof water harvesting infrastructure. The water collected during the rainy seasons should supplement the piped water and thus reduce the piped water demand.
    b. Small dams should be strategically located to collect most of the runoff during the rainy season. The water should be used to reduce water shortages and also to maintain the river flows necessary for ecosystem function in dry seasons.
    c. Plant more trees and grasses of the local species in road verges and degraded sites with no plant cover to improve water infiltration into the ground, reduce erosion and control flooding.
2. Appoint a consultant to prepare a proposal on:
    a. The capacity and location of the dams.
    b. Mitigation measures to be put in place for any foreseeable negative impacts.
    c. The cost of the dam infrastructure.
3. Review the proposal with the stakeholders to reach a consensus.
4. Mobilize funds for construction of the dams.
5. Implement the proposal.

Water Reuse

Wastewater from the sewage treatment works after satisfactory treatment could be reused for crop irrigation.

Industry

Manufacturing industries should be encouraged to reuse or recycle water. Engage the Ministry of Finance in discussions to provide financial incentives to industries which save water through recycling or reuse.

Urban and Peri-urban Agriculture

In the growing cities, waste water use for urban and peri-urban agriculture can provide many opportunities to bolster food security and income generation for poor families among other advantages (van der Hoek, 2000). However, urban agriculture is not recognised as a legitimate activity in many cities although it is widely practised in backyards, road reserves and open spaces especially by the urban poor. Waste water provides a reliable supply of irrigation water and plant nutrients all the year. The farmers grow cash crops such as vegetables which are in high demand in the local markets. The health risks commonly associated with use of waste water are due to the presence of disease-causing bacteria, viruses and parasites. It can be reduced by pre-treatment of the water before its use. Low-cost treatment facilities such as stabilization ponds have been successfully used in the Middle East (van Der Hoek, 2000). Efforts should be made to comply with the standards recommended by World Health Organisation (Mara and Cairncross, 1989) in the long term. In the short term however local standards for waste water use that are easily attainable can be developed.

Guidelines to minimise health risks from use of waste water for crop irrigation include:

- Use of irrigation canals and not overhead irrigation methods. This minimises foliar contamination of the edible parts of the vegetable crops such as cabbages, spinach and tomatoes with pathogens that may be present in the waste water.
- Irrigation of fruit trees in orchards with waste water is recommended.

Relevant research is urgently needed in the use of waste water to identify:

- Problems those are likely to arise in relation to water rights, land tenure and other pertinent issues once urban agriculture is legally recognised.
- Crops and plant parts which pose minimum health risk to the consumers.
- Irrigation methods which pose minimum health risk to the urban farmers.

Verifiable indicators

- Less pressure by city residents to cultivate along the riverbeds, in riparian areas and in wetlands
- Improved food security and income generation for many urban poor families
- Low cost disposal of municipal waste water
- Prevention of pollution of surface water resources
- Conservation of water
- Nutrient recycling

17. Output: Regulation of Water Abstraction in the Catchment

The ecosystem should be considered an important user of water. Excessive abstraction of surface water may significantly reduce the flow of the stream or river. thus raising the concentration of pollutants in the water and reducing the capacity of the river to assimilate the pollutants. Overexploitation of ground water resources may result in saline intrusion in the productive aquifers making the water unsuitable for domestic use or crop irrigation. A water abstraction and permit data base should be established and updated on a regular basis. The data base should be used by the managers for guidance in allocating water to users so that the minimum water flow can be maintained.

Activities

To effectively regulate water abstraction in the catchment you need to undertake the following:

1. Determine the available surface and groundwater water resources in the catchment.
2. Determine the current levels of surface and ground water abstraction in the catchment.
3. Determine the minimum or ecological reserve flow that should be maintained in the rivers.
4. Ensure the catchment's water allocation guidelines to water users including the environment are adhered to.
5. Build sufficient institutional capacity in the water sector to monitor compliance to regulations by the water users especially processing industries and irrigation agriculture that require large volumes of water.

6. Water permits should be issued to regulate ground and surface water abstraction by major water users such as industries and farms which are not connected to the city's water supply system.

The water sector should issue regulations specifying the following:

a. Volume of water abstractions for which a permit is not needed;
b. Volume of water abstractions for which a permit is needed; and
c. Conditions under which abstractions of specific waters is forbidden or limited e.g. during drought periods.

Verifiable indicators

- Ecological reserve flow maintained in the rivers.
- Maintenance of the rivers assimilative capacity and ecological integrity.
- Establishment of equity in the distribution of water resources to users in the catchment.

18. Output: A Catchment Information Management System

In place of the traditional catalogues, an electronic system capable of arranging, storing and exchanging data and information should be installed. An inventory of the natural resources of the catchment area should be prepared using a Geographical Information System (GIS) format. This system will enable the catchment managers to view and locate patterns of settlement, land use and natural resources in the catchment and to identify relationships between the data. The catchment managers can also view land systems, settlement features, land ownership and planning zones, demographic information and other socio-economic data and best management options. The GIS can also be used to study the relationships between pollution, land use, drainage patterns and socio-economic parameters. This involves integration of data of various themes to derive desired analysis and conclusions (Opiyo-Aketch and Kibe, 2000). Using the GIS system the manager can think of various scenarios and view the changes in land use or environmental conditions over time. This electronic system will also enable the manager to closely monitor the progress in the implementation of the IWRM strategy.

Activities

i. Appoint a consultant to:

   a) Set up an interactive Catchment Information Management System.

   b) Train the catchment management staff the applications, use and management of the GIS, Decision Support System (DSS) and modelling to catchment managers for more effective management of the land and water resources.

ii. Organise a workshop with stakeholders on how to access and exchange catchment information.

iii. Mobilise funds.

iv. Implement the programme.

Verifiable indicators

- A functional Catchment Information Management System.
- Enhanced participation of stakeholders in catchment management decision making process.
- Real time communication between the catchment managers and the stakeholders.

19. Output: Institutional Reforms in Public Water Sector

Viability of public – private partnerships in the water sector should be explored. In certain areas, residents rely on water kiosks, handcarts or even tankers for their daily water supplies. In other areas private companies are contracted to manage water billing and revenue collection from the water users. However, the high cost of water infrastructure and the need to keep water tariffs low to enable the poor to access the service discourages investment by the private sector (Stower, 2003). In Ghana, the proposed leasing of urban water supply systems to private companies, requiring them to invest in the water infrastructure, resulted in a dramatic increase in water tariffs and was strongly opposed by the civil society on the basis of equity and social justice (HARAMATA, 2003). Under the circumstances, the public sector will have to take the main responsibility for investment in water infrastructure.

Local authorities should establish independent companies to provide water services in urban areas. It has been seen to improve sustainability and efficiency in service delivery in several Kenyan Municipalities after starting their own water companies. The companies have been able to meet all their operation and maintenance costs and even remit annual dividends or lease fees to their respective Councils (Stower, 2003). In addition the increased water management efficiency by the companies has reduced the unaccounted for water by about 13% within a period of one year. It should, however, be noted that whereas the main objective of any private sector is to make profit, the motive of the public sector is to maximise efficiency and effectiveness of service delivery to the society (Singh, 2002). It is therefore appropriate that the profits should be shared with the consumers by lowering the billing rates charged especially against the poor. This approach is in line with the Dublin Statements aimed at improving the effectiveness of water governance.

Activities

i. Formation of independent water companies by the City Councils to manage water services in the cities more efficiently.
ii. Implementation of the Water Demand Management (WDM) programme to promote the efficient use of water in the cities, minimise loss due to leakages and unaccounted for water due to illegal connections.

Verifiable indicators

- Significant reductions in unaccounted for piped water in the supply system.
- Installation of efficient water saving devices in toilets and washrooms in public buildings including schools.
- Higher revenues collected enabling the companies to be financially self sustained.
- Improved water infrastructure and/or reduced water charges for the poor.
- Increased availability of water to users including the environment.

20. Output: Financing of the Water Quality Improvement Programme

Large capital intensive projects include the building and/or extending of sewer networks and Waste Water Treatment Works. The high level of funding will require donor support. Private investors may also provide initial capital to build Community Waste Water Treatment Plants, recoup their investment costs and turn over the ownership to the communities in 15 – 20 years. This will then become a source of income generation for the communities.

A water quality control levy should be established from the revenue raised from the sale of water, water abstraction and waste discharge permits to cater for water quality monitoring and rehabilitation of degraded sites.

Activities

1. Appoint a consultant to prepare a proposal on:
    i. Permit issuance and water tariffs for abstracted surface and ground water by water users who are not connected to the urban areas water supply system. A register of this category of water users should be opened and updated regularly. The water abstracted should be metered and the data included in the areas water balance sheet.
    ii. Appropriate water tariffs bearing in mind the local conditions such as the ability to pay for water by poor communities in the urban area. However, the rates payable by other communities should reflect the actual cost of the commodity to enable the water utilities to recover the cost of providing water services.
    iii. The monthly/quarterly or annual rates for waste water discharge permits for agro-processing factories and chemical industries operating in the urban area.
    iv. The projected revenue collection and the percentage of the funds that can be used for improving the surface water quality in the catchment. This should include a newsletter to educate the city residents and all stakeholders about important water issues in the catchment.
2. Discuss the proposal with City Council Departments, representatives of industries, all categories of water users and other stakeholders.
3. Proposals to be agreed upon, ratified and implemented.

Verifiable indicators

- Established levy to cater for:
- Routine water quality monitoring.
- Rehabilitation of degraded sites in the catchment.
- Increased level of environmental awareness among the population.

21. Output: Periodic Reviews of the Performance of the Catchment Management Strategy

Water management indicators are necessary to monitor the catchment management performance (Global Water Partnership: http://www.gwp.ihe.nl). They can also be used to set new targets and goals and in the reformulation of water policies and programmes. Indicators can also be

used for benchmarking to encourage better performance by catchment managers and for objective evaluation by others.

For the indicators to work without bias, the data collection system must be reliable. If comparisons are to be made between regions or water utilities, the data elements should be the same. Ideally, an annual report should be published giving details of the success of the catchment management action plan in achieving the set targets. The catchment management strategy should be evaluated every 3-5 years and changes made as necessary.

Activities

i. Assess water resources availability in the catchment (m/person/year)

ii. Determine water use (litres/person/day)

iii. Determine the numbers of households served with water

iv. Determine the cost of water treatment. (Cost/m)

v. Monitor the surface water quality by physico-chemical and microbiological methods

vi. Carry out a bio-assessment to determine the number of species of organisms/km or along a stretch of river compared to the pristine sections of the river.

Verifiable indicators

A successful catchment management plan should result in :

- Increased availability of water resources in the catchment
- Increased number of households served with water
- Decreased cost of water
- Improved surface water quality
- Increased biodiversity in the riverine ecosystem

Glossary

Biochemical oxygen demand (BOD). This is a measure of the amount of oxygen required by the biological process to break down organic matter present in the water.

Biodegradable. Capable of being broken down by micro organisms.

Biological diversity. The variety of living organisms in an ecosystem.

Coliforms. *Escherichia* coli and similar gram-negative bacteria that normally inhabit the colon or large intestines.

Contamination. Entry of unwanted organisms into water or some other material.

Ecosystem. A system which includes the organisms of a natural community together with their environment.

Incineration. Sterilization procedure by which contaminated materials are burned to ash.

Virus. Obligate intracellular parasitic micro organisms.

Water Stress. An area is experiencing water stress when annual water supplies drop below 1700m per person.

Water Scarcity. An area is experiencing water scarcity when annual water supplies drop below 1000m per person.

Sustainable Development. Meeting the needs of the present without compromising the ability of future generations to meet their own needs.

pH – A symbol for the degree of acidity or alkalinity of a solution.

Conductivity. This is a measure of the ionic concentration in water.

Dissolved Oxygen. This is the amount of oxygen dissolved in water and available for living organisms to use in respiration.

Habitat. The natural environment of an organism.

In situ. In the natural environment.

Turbidity – Cloudiness in water indicating the presence of suspended particles.

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Appendix

Appendix – 1
Developing Strategies for Urban Catchment Management & Pollution Control

Appendix – 2
Water Management Strategies by DWAF

Appendix – 3
A Toolkit for facilitating stakeholder mobilisation and participation in Integrated Catchment Management (ICM)

Appendix – 4
Water Quality Standards

Developing Strategies for Urban Catchment Management & Pollution Control

Introduction

The evolution of human civilization and urbanization has been centered around catchment (watershed, river basins) areas. As evident from the archaeological ruins of the earlier civilizations, the decision makers and planners recognized the importance of catchment areas as the physical planning units for urban development. Availability of water in the neighborhood and protection of natural systems were the prime considerations for urban management. The traditional water harvesting structures and drainage systems still bear the testimony of catchment-oriented approach for settlement plans. However, in the post-industrial era, with the availability of electricity for long distance transport, the practice of catchment management has often been ignored.

Over the years, cities in different parts of the World emerged as hubs of industry, trade and tourism in addition to the state and provincial capitals. With the increasing industrialization and transport network, the pace of urbanization has gained momentum. In the process, the urban centres have multiplied and small cities have grown in size while some of these cities have earned the distinction as mega cities. The cities, which were earlier created for specific functions and carrying capacities, are increasingly expected to meet the demands of multiple economic activities and growing population. The run-away growth in urbanization without commensurate backup infrastructure for civic amenities has taken its toll through increasing pollution. Pollution and associated problems are, to a great extent, attributable to lack of environmental considerations in planning and management of urban systems. The urban centres are confronted with various kinds of pollution, the nature and extent of which depend on the sources of pollution as well as physiographic conditions such as watershed and airshed. The present proper focuses on water pollution, which has a direct bearing on the urban catchment management.

Water: Availability and Quality

Unlike earlier settlements, modern cities are characterized by an endless sprawl beyond their densely occupied inner cores. To sustain the urban growth, the civic authorities have to face the challenge of providing water in required quantity and quality as also safe disposal of water borne wastes without adversely affecting the available sources of water. In many urban centres of developing countries, the existing system of water supply is unable to meet the growing demand of water. As a result, water is required to be tapped from distant sources, which involves sitable expenditure and energy besides the hydrological problems in the hinterland.

Yet another problem is the uneven supply of available water in urban centres. The distribution of population having access to safe water supply reveals wide variations in coverage. In some areas, while the overall reach may seem to be reasonably satisfactory, the availability of water

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to the poorer sections of the urban community is far from adequate. The urban poor, due to their low paying capacity and also due to peculiar conditions governing their settlement patterns are generally deprived of adequate sanitation facilities.

Besides surface water, the urban water supplies are abstracted from infiltration galleries and wells sunk on the riverbeds. These water sources are often polluted by discharge of untreated/ partially treated wastewater from the households, industries and run-off from agricultural fields. In several cities of developing countries, the city dwellers are dependent on water from bore wells without any treatment. Even in areas with piped water supply, contamination takes place due to leakage in the distribution system, which accounts for outbreaks of water borne diseases like hepatitis and cholera.

The developing countries are already facing the difficulty in ensuring the minimum annual per capita water requirement of 1700 cubic metres of drinking which is necessary for active and healthy life of their people. The situation is particularly grave in the cities of the developing world. This calls for alarm given the predictions of a 60 per cent world urban population by 2020. At present, half the population of developing countries lives in water poverty (UN World Water Development Report, 2003). Alongside, continuing deterioration in quality of available water has further aggravated the seriousness of the situation.

Water Pollution: Causes and Impacts

The common causes of water pollution in the urban centres of developing countries include the following:

- Poor sanitation conditions;
- Unchecked disposal of municipal sewage and solid wastes;
- Non-availability of minimum flow in rivers to utilize their assimilative capacity;
- Operation and maintenance problems in treatment plants for municipal sewage and industrial effluents;
- Outdated technology and scale of operation in small scale industrial units making it difficult to adopt effective pollution control measures; and
- Faulty land use.

The most frequent sources of pollution are human wastes, industrial wastes and chemicals, and agricultural pesticides and fertilizers. Directly as well as indirectly, the pollutants find their way to the watercourses thus affecting the quality of water in rivers, lakes and ground water resources. The water bodies are subjected to various forms of human induced pollution which include the following:

- Faecal coliforms containing pathogens from municipal sewage and effluents from certain categories of industries;
- Heavy metals and organic substances from industries;
- Acidifying substances from mining and industrial emissions;
- Ammonia, nitrate and phosphate intrusion from agriculture and human settlements; and
- Persistent and non-biodegradable agrochemicals like chlorinated pesticides from agriculture.

It has been estimated that half of the population of the developing world is exposed to polluted sources of water that increase the incidence of water borne diseases. The impacts of pollution

are observed through findings of water quality monitoring which reveal alarming statistics in terms of water quality indicators like Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), dissolved oxygen, faecal coliforms, suspended and dissolved solids and pesticides. Levels of suspended solid in rivers of Asia have risen by a factor of four over the last three decades. Asian rivers also have a high Biochemical Oxygen Demand (BOD) around 1.4 times the global average and bacterial contamination of 3 times the global average.

Besides anthropogenic pollutants, the natural geo-morphological conditions in some areas cause contamination of water. Millions of people in the gangetic belt of Bangladesh and India are affected by arsenic contamination of ground water. Long-term exposure to arsenic through drinking water causes cancer of the skin, lungs, urinary bladder and kidney as well as other effect on skin such as pigmentation changes and thickening. Similar problems with excessive concentration of arsenic in drinking water are faced in a number of countries. While the intake of fluoride in smaller concentration is desirable, higher doses of fluoride intake result in discoloration of teeth and crippling skeletal effects. It is reported that as many as 30 million people in China suffer from chronic fluorosis.

Increasing salinity is another serious form of water pollution. Poor drainage, fine grain size and high evaporation cause concentration of salts in the irrigated soils of arid and semi-arid areas. In some cases, salinity ingress takes place from the landscape due to clearance of vegetation and increased infiltration.

Improper land use and land use changes affect the hydrological cycle and consequently water resources in terms of quantity as well as quality. The findings of studies concerned with the impact of urban areas on the hydrological cycle reveal the following:

- Infiltration and recharge to aquifer systems are reduced and surface runoff is increased both in volume and rate;
- Groundwater mining leads to decline in water tables and land subsidence;
- Pollutant loads to water courses and surface water bodies increase due to surface run-off and sewage outfalls;
- Poorly maintained sewers lead to seepage of pollutants to the groundwater;
- Soil and groundwater are contaminated by pollutants from industrial activities and poorly planned solid and liquid waste disposal practices; and
- Habitats and biodiversity are reduced in the recipient waters.

Pollution Control Initiatives

For prevention and control of pollution, the countries have taken various initiatives which include the following:

- Augmentation of water supply and sanitation facilities within the available resources;
- Enactment of laws and regulations;
- Setting up of institutions for enforcement of laws and regulations;
- Laying down standards of water quality and acceptable limits of pollutants;
- Land use plans for human settlements, industrial operations, recreation and for other purposes;

- Demand side management for reduction of water consumption, reuse and recycling of waste water by some industries in water scarce areas; and
- Partnership with non-governmental organizations (NGOs) in selected areas.

More often than not, the initiatives for pollution control and water quality management failed to achieve the desired results due to lack of integrated approach and necessary coordination among the concerned agencies and stakeholders. Absence of catchment management concept has been one of the serious omissions in modern urban systems.

Imperatives of Integrated Approach

Proper management of water holds the key for sustainable development and pollution control. The water pollution control strategy should entail the following action points:

- Control of pollution at sources giving due regard to the techno-economic feasibility;
- Optimal utilisation of the assimilative capacity of recipient water bodies to minimize investment on pollution control;
- Maximization of reuse/recycling of wastewater;
- Judicious location of industries and human settlements based on environmental considerations;
- Introduction of discipline in water (surface and ground water) abstraction and wastewater discharge; and
- River flow regulation and protection of hydrological regime.

The action points for pollution control are closely linked with the effective management of water, which in turn depends on integrated approach for sustainable use of water resources. As envisaged by the Global Water Partnership (GWP), the integrated water resource management should promote participatory approaches, partnerships, subsidiarity and decentralization, the environmental, economic and social value of water and the basin or catchment management strategy. It is to be based on the principles of environmental sustainability, social equity and economic efficiency. It should provide an enabling environment through appropriate policies, legislation and governance system. The institutional framework needed for the purpose will involve central and local governments, public and private agencies and catchment (basin) management bodies with clearly defined roles and inter-linkages among the institutions.

Recognizing the importance of catchment management approach, some countries (e.g. Australia and South Africa) have taken initiatives for formulating the Catchment Management Strategy (CMS) and establishing the institutional mechanism for implementing the strategy. Countries like France, Sri Lanka and United Kingdom have established river basin authorities/institutions. It may be useful to learn from the experience of these countries and adopt the approach suited to site-specific situations in other countries.

Catchment Management Strategy (CMS)

Catchment is the area from which the rainfall drains into the watercourses through surface run-off. It constitutes an important component of an ecosystem and it serves as the life support system for human and other biotic communities within the ecosystem. The ecosystem and its catchment are of specific nature and size established through the natural process and these are

not necessarily confined within the administrative boundaries of urban jurisdiction. For proper management of the urban catchment, it is important to create catchment-based management systems which should serve the interest of urban inhabitants as also those living in the peripherial areas. The Catchment Management Strategy (CMS) is a process for integrating the environmental, economic and social considerations in management of catchment areas. It involves mobilization of human, financial and water resources for sustainable development.

Need for CMS

With the increasing population and economic activities, the urban areas are facing the problem of water stress, the symptoms of which are evident in increasing pollution, water scarcity and uneven distribution. While some areas receive inadequate rainfall others do not have requisite facilities for harvesting and storage of rainwater. To ensure sustainable availability and quality of water, it is necessary to find ways and means for management of catchment areas. Conventional sectoral approaches for pollution control, water supply and sanitation have served limited purpose. CMS has the potential of serving as a useful instrument for catchment-based management in a holistic manner.

CMS Objectives and Issues

The ultimate goal of CMS is to improve the quality of life through equitable and sustainable use of water for the benefit of all users. The objectives and issues to be addressed through CMS are:

- Striking a sustainable balance between utilisation and protection of water;
- Harmonious inter linkage between water and land use, environmental concerns and human activities; and
- Development of partnership among the stakeholders including government agencies, non-government organisations and local communities.

The CMS should specifically take into account the following issues:

- Legitimate need of water users;
- Water quality status and pollution control requirement;
- Resolution of conflicts between conflicting demands;
- Short and long term plans for catchment management and allocation of water use for different sectors;
- Modalities for stakeholder's involvement in decision making; and
- Legislative, institutional and financial mechanism for implementation of CMS.

Framework for Development of CMS

The CMS process broadly consists of the following steps:

- Data collection
- Investigation
- Information assimilation and analysis

- Planning
- Implementation
- Monitoring and control
- Auditing and review

As defined by the Department of Water Affairs and Forestry, South Africa in a document entitled "Development of a Generic Framework for a Catchment Management Strategy (January 2001)", the CMS is not an once-off plan for managing water resources in a catchment but rather a phased implementation of a dynamic, participative and integrated process that must be reviewed regularly (at least once every 5 years).

For development of CMS in South Africa, the following components are proposed:

- **Situation Assessment** to determine the profile of water resources, physical characteristics, hydrological and hydro-geological characteristics, vegetation and land use, water use and economic status.

- **Foundation Strategies** to promote the framework for water resource management. These strategies are to create the enabling framework for necessary human and financial resources and the institutional development to involve and deal with the stakeholders as well as to implement the strategies.

- **Supporting Strategies** to protect, use, develop, conserve, manage and control water resources. These strategies are considered as the minimum requirements for integrating different issues relating to water resource management.

The situation assessment involves creation of necessary data base on the basis of available information and studies where required. The key issues which need to be addressed in the situation assessment include the following:

- Status of existing institutional arrangements.
- Existing classification of water resources.
- Status of water abstraction.
- Status of water demand management.
- Status of water quality.
- Current and future investment in water resource management infrastructure and catchment management activities.
- Significant historic events or activities such as floods, droughts or change in status or role of key players.

The Foundation strategies help define the strategic directions and action points based on situation assessment. For instance, the action points for the purpose of capacity building may include development of a profile of existing capacity at different levels, development of plans for strengthening of existing capacity and creation of new capacity and assessment of education and training programmes. Similarly, for the purpose of institutional development, the action points may include evaluation of existing institutions, strategy for new institutional structure and establishment of communication mechanisms.

The Supporting strategies deal with the current management issues as well as expected scenarios. These strategies relate to the following:

- Water resource protection;
- Water use;
- Water resource development;
- Water resource conservation;
- Water resource management; and
- Water resource control.

The Foundation strategies and Supporting strategies are inter-linked and at times over-lapping. These need to be integrated in the CMS for articulation of specific management initiatives. In essence, the planning process for CMS involves the following steps:

- Identification of opportunities, problems and threats;
- Identification of objectives and targets; and
- Development of management options, strategies and actions.

For implementation of catchment management approach, some countries have set up legislative and institutional framework. For instance, the concept of catchment management was formalized through the Catchment Management Act (1989) in New South Wales, Australia. The local area catchment committees which were earlier set up have since been replaced by Boards and entrusted with the responsibility of preparing catchment management plans. In South Africa, the National Water Act recognized the need for catchment management and specified the elements for development of CMS. Several other countries have incorporated the concept of catchment management in their policies, laws and programmes. Projects for watershed (catchment) management in rural areas have been undertaken in different countries, the experience of which could serve as useful reference for development of strategies for urban catchment management.

To explore the possibilities and establish the contours of urban catchment management strategy and pollution control for sustainable water use, it will be useful to launch pilot projects for CMS in selected urban areas of different countries. The starting point for initiation of such projects would be situation assessment and creation of database for which techniques of remote sensing and Geographic Information System (GIS) could serve as useful tools.

Water Management Strategies by DWAF

Foundation Strategies

Some of the strategies outlined by DWAF (2001) which provide the structure and an enabling framework within which the water management strategies can be implemented.

Spatial/land use planning strategy

Identify existing land use and trends in land use patterns (on GIS) and liaise with the planning sections of other government institutions with a view to influencing the water related aspects of such plans. Identify related land/water development initiatives, assess their potential impacts on water resources and develop a strategy to integrate the initiatives with the CMS.

Co-operative governance strategy

Identify the various departments and officials at local government level who are actively involved in water resources management. Establish contact with them, and develop a communication strategy to promote joint planning and develop common approaches with them. It may be useful to sign a memorandum of understanding (MOU) with each partner stating their roles and responsibilities in the management of water resources in the catchment.

Communication and public relations strategy

Identify all stakeholders, select communication media and strategy developments to public and stakeholders, select programme of disseminating general information aimed at promoting proactive participation , create appropriate forums for stakeholders to verify basic information used in decision making processes and to give their opinions and views.

Data collection and information strategy

Decide on the additional data that needs to be collected and develop a database that is accessible via the internet and that can be updated as necessary. Relevant institutions such as Water Resources Planning, Water Quality Management, and Water Conservation should be involved.

Capacity building/education strategy

Undertake a community needs assessment with a view to improving its level of participation in the management of water resources. It is important to build on the community involvement that already exists. To build on their capacity, investigate and implement suitable options for education programmes at school and at tertiary level, other training programmes and pilot projects. The Education Department and other relevant institutions should be involved.

Auditing and review strategy

Decide on the aspects of CMS to be audited, the auditor, the standards to be conformed to and the type and frequency of reporting. Participating institutions in formulating the strategy will depend on the CMS aspects to be audited.

Conflict management strategy

Identify potential areas of conflict and appoint an advisory committee to develop a dispute resolution strategy.

Public participation strategy

In order to facilitate effective participation of the public, examine demographic profile and current institutional framework. Strategize on ways of involving interested stakeholders in the CMS process. Investigate possible constraints to participation and find ways of addressing them if appropriate. Participating institutions in formulating the strategy should include Water Resources Planning.

A Toolkit for facilitating stakeholder mobilisation and participation in Integrated Catchment Management (ICM)

Key Objectives	Activities	Methods	Relevance for ICM
Identification of all relevant stakeholders	Meetings, and FGDs with people at zonal levels.	Communication through newspapers and invitations.	i) Key stakeholders and their leaders identified ii) Fora and structures created for stakeholder interaction with CMO
Integrate management of water resources	i) Discuss benefits of ICM ii) Discuss how to achieve common goals and rules governing water use and conservation	Discuss with stakeholders and agree on most appropriate monitoring system and assigned roles.	i) Stakeholder roles identified. iii) Capacities of stakeholders established. iv) Information sharing on water usage and conservation
Mobilize stakeholders participation	i) Note activity routines of stakeholders iii) Sensitisation for decision making iv) Do a needs assessment of women and disadvantaged and identify strengths, and weaknesses.	i) Regular consultations with authorities and opinion leaders. Identify strategies for mobilizing people ii) Hold group discussions with women and agree on their participation strategy. iii) Agree on small committees to take care of specific tasks	i) Ways of mobilizing stakeholders identified. ii) Levels of participation identified. iii) Roles of stakeholders established iv) Social and environmental factors affecting community participation identified
Facilitate stakeholder assessment and prioritization of water resources issues	Organize local meetings, group discussions, workshops for: i) Individual stakeholders ii) All stakeholders	i) Assess stakeholder training needs ii) Use open discussions if stakeholders feel comfortable iii) Create small groups as in *adult learning to facilitate* inter-action, participation in discussions, and feedback among stakeholders iv) Let stakeholders list all options available for ICM	i) Stakeholders training needs assessed ii) Stockholder's assessment of water resource management is assessed iii) *Ideal groups necessary for* effective discussion established iv) Problems of stake-holders' assessments determined and corrective methods devised for subsequent interactions
Involve stakeholders in the decision-making process	Wide range of activities *including* meetings, workshops etc.	i) Identify all stakeholders ii) Organize specific stakeholder fora for discussions on ICM iii) Break discussions into smaller groups for effective interaction iv) Let groups select their chairpersons and recorders v) Separate women and other vulnerable groups for discussions	i) Principles of ICM moderated for *effective use in community.* ii) Several options for ICM derived from group discussions iii) Wide range of decisions made and feasible ones isolated for implementation. iv) Views of women and other vulnerable groups recorded and included in programme activities
Facilitate stakeholder participation in implementation and monitoring of local water resources.	Organize meetings to: i) Review decisions taken *and actual implementation* activities ii) Update aware-ness on ICM iii) Discuss and effect changes in socio-economic conditions iv) Hold workshops for disadvantaged to enhance their understanding of ICM issues and participation.	i) Set up local monitoring teams or committees ii) Establish regular meetings iii) Set up a communication system for regular reporting iv) Establish feedback systems so that information flows from bottom-up, and top-down v) Assign special meetings to mainstream gender for women's empowerment.	i) ICM becomes a sustainable process. ii) Women are equipped to participate in water resource use and conservation. iii) Meetings, communication channels, reporting and other monitoring activities become institutionalized. iv) Capacities are built at local levels for ICM. v) Women take keen interest in water issues.

A Tool Kit for ICM adopted with few modifications from Tool Kit for IWRM in Ghana (source: Anonymous)

Water Quality Standards

Standards for water quality have been developed for domestic, industrial, recreational, and agricultural use, as well as the requirements for maintenance of ecosystem integrity. The Target Water Quality Range (TWQR), the threshold range at which damage may occur and the levels at which concentrations are highly toxic are in the following Table. Each of these standards is provided for aquatic ecosystems, industrial use, recreational use and domestic use. The values for ecosystems are as follows (UN-HABITAT, 2002):

- The target water quality range (TWQR) is the ideal range of the specific parameter.
- The Chronic Effect Value (CEV) where the TWQR has been exceeded and remediation is required.
- The Acute Effect Value (AEV) where the aquatic environment is severely threatened.

Table: Target Water Quality Range for domestic, industrial, recreational and maintenance of the ecosystem (UNHABITAT, 2002)

Parameter	Aquatic ecosystem	Industrial use	Recreational use	Domestic use
Arsenic	Target <10µg/l Chronic 20µg/l Acute 130 µg/l			<0.010 0.05-0.2 >2.0
Cadmium Mg/l	Target<0.25µg/l Chronic 0.5µg/l Acute 6µg/l			<0.003 0.005-0.020 >0.050
Calcium Mg/l				0-10 32-80 >300
Chloride Mg/l	Target <0.2µg/l Chronic 0.35µg/l Acute 5µg/l	0-20 50-120 >120		<100 200-600 >1200
Copper Mg/l	Target<0.8µg/l Chronic1.5µg/l Acute 4.6µg/l			0-0.5 1-1.3 >15
Dissolved Organic Carbon (DOC) mg C/l		0-10 COD 30-50 COD >50 COD		0-5 10-20 >20
Fluoride Mg/l	Target <750µg/l Chronic 1500µg/l Acute 2540µg/l			<0.7 1.0-1.5 >3.5
Indicator organisms i.e. Faecal coliforms (count/100ml)			0-130 200-400 >400	0 10-20 >20

Contd....

Parameter	Aquatic ecosystem	Industrial use	Recreational use	Domestic use
Iron Mg/l	Should not vary more than 10%	0.0-0.1 0.3-1.0 >1.0		<0.1 0.5-1.0 >10.0
Magnesium Mg/l				<30 70-100 >400
Manganese Mg/l Manganese Mg/l	Ideal 180µg/l Chronic 370µg/l Acute 1300µg/l	0.0-0.05 0.2-1.0 >10		<0.05 1.0-4.0 >10.0
Nitrate/nitrite Mg/l as N	0.5-2.5 <0.5 2.5-10>			<6 10-20 >40
pH value	Should not vary from normal range by >0.5 or 5%	7.0-8.0 6.0-7.0 & 8.0-9.5 <6.0&>9.5	6.5-8.5 5.0-6.5 & 8.5-9.0 0-5.0&>9.0	6.0-9.0 4.0-6.0 & 9.0-11.0 >11.0&<4.0
Potassium Mg/l				<25 50-100 >500
Sodium Mg/l				<100 200-400 >1000
Sulphate Mg/l		0-30 30-80 >150		<100 400-600 >1000
Total dissolved solids mg/l	TDS conc. Must not change more than 15% of normal range	0-100 100-200 >450		0-450 1000-2000 >3000
Total hardness Mg/l		0-50 100-250 >250		0-25 100-150 >600
Turbidity NTU				0-1 5-10 >10
Zinc Mg/l	<2µg/l Chronic3.6µg/l Acute 36µg/l			<3 5-10 >20

Acceptable levels of substances in terms of the receiving environment (DWAF, 1998). In cases where no figures are provided, the parameter is not applicable to the specified use.