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ABBREVIATIONS AND ACRONYMS

AED	Agroecological Division
CEP	Community Engagement Programme
CITES	Convention on International Trade in Endangered Species
DFID	Department for International Development
DoE	Division of the Environment
EIA	Environmental Impact Assessment
EMES	Environmental Monitoring and Evaluation System
EMP	Environmental Management Plan
GIS	Geographical Information System
GPS	Global Positioning System
HIMA	Hifadh ya Mazingiri (DANIDA-funded project)
ILFEMP	Institutional and Legal Framework for Environmental Management
LRGP	Local Government Reform Programme
MoW	Ministry of Water
NEAP	National Environmental Action Plan
NEMC	National Environmental Management Council
NEMP	National Environmental Management Programme
NEP	National Environmental Policy
NLP	National Land Policy
NLUCP	National Land Use Planning Commission
RBMSIIP	River Basin Management and Smallholder Irrigation Improvement Project
RBWB	Rufiji Basin Water Board
RBWO	Rufiji Basin Water Office
RLR	Rural Livelihoods Research
RUBADA	Rufiji Basin Development Authority
SRMP	Subcatchment Resources Management Programme
SMUWC	Sustainable Management of the Usangu Wetland and its Catchment
TMV	Timu ya Maendeleo Vijijini

1. INTRODUCTION

1.1 Environmental management programme

Environmental management in most development projects is a clearly defined project component responsible for the environmental integrity of that project. SMUWC, however, is in itself essentially an environmental exercise aimed ultimately at developing a sustainable resource management strategy. The role of environmental management in SMUWC, therefore, is to integrate the many aspects of the project that are directly or indirectly environmentally related, thereby providing a systematic environmental overview and a consistent and comprehensive check that no environmentally significant factors or aspects have been omitted or inadequately covered.

The main environmental management activities in SMUWC (figure 1.1) are:

- initial environmental screening and scoping for the preliminary identification of key environmental issues (completed during the Inception Phase);
- establishment of the environmental baseline in the SMUWC Project Area to identify current environmental status and trends and hence the critical environmental issues (prepared during the Interim Phase and updated here for the SMUWC Final Report);
- preparation of an Environmental Monitoring and Evaluation System (EMES), presented as Supporting Report 25 in Volume 11 of the Final Report.

Originally it was proposed for the Senior Environmentalist to undertake Environmental Analysis (as defined by DFID, June 1999) of resource management options to identify potential impacts and relevant amelioration measures. However, the current phase of SMUWC, terminating in March 2001, will not attempt to define strategy options in terms of management activities. Consequently there is no call during the current phase of SMUWC for formal environmental appraisal of options.

In the Inception Report it was anticipated that the Environmental Analysis of strategy options would be accompanied by an outline of an Environmental Management Plan (EMP), including within it an Environmental Monitoring and Evaluation System (EMES). However, it has become evident that the management strategy and its constituent activities ultimately emerging from the long-term participatory planning process defined by SMUWC will constitute the EMP for Usangu.

Whatever the ultimate EMP it will include a comprehensive monitoring programme which because of the nature of the project will be an EMES for Usangu. It was therefore proposed that the Environmentalist should direct his final input to preparing an initial framework for the EMES, ensuring that the monitoring programme is sufficiently comprehensive, aptly targeted and realistic (i.e. effective in terms of the funds, staff and equipment available). In effect the EMES will aim to maintain continuous update of the Environmental Baseline during and beyond the participatory strategic planning seen as the next step in achieving sustainable development of the Usangu Catchment.

1.2 Environmental resources

It is important to emphasise that environmental management relates to more than simply the ecological concerns of a project. The **physical** (including chemical) and **biological** (or biotic) issues together comprise the ecological component but in addition a range of **human** issues must be taken into account (social, economic, institutional, human use, cultural). DFID (June 1999) emphasise the importance of human resources, issues and impacts in the environment. The environmental resources examined in this report therefore include both ecological and human resources.

Human environmental resources comprise both people and their activities. People form different **impact groups**, often on the basis of their socio-economic status and activities. In Usangu these might include: women, the aged, children, irrigation farmers, rainfed cultivators, pastoralists, fishermen, large and small landowners, the landless, government officers, etc. Each impact group will often have differing assessments of the effects of a particular form of development.

A convenient and systematic grouping of environmental resources is indicated in table 1.1. This is the framework adopted throughout the SMUWC environmental management programme. The aim is to make certain that all environmental aspects are systematically identified and considered, individually and in relation to each other.

Environmental resources and their utilisation clearly will vary within the very wide range of conditions that exist within the Usangu catchment. Chapter 2 establishes an **environmental spatial framework** to facilitate the evaluation and discussion of environmental resources and trends.

1.3 Current environmental status and trends

The current condition of the various components of the environmental resources framework summarised in table 1.1 can be defined as their **current environmental status**. In simplistic terms, this is the **environmental baseline** against which potential future changes caused by the strategic management options can be forecast and against which actual future changes can be audited. However, environmental conditions are rarely static, especially in an area such as Usangu where a wide range of human interventions are occurring and the effects of most of them are accelerating. Thus it is important also to establish the ongoing changes in environmental resources (i.e. the **current environmental trends**) as these provide the real comparison base for future changes. In a **without-project** scenario (i.e. no management strategy designed and implemented in Usangu – the **"business-as usual"** scenario defined by SMUWC) these current trends can be expected to continue. Almost always such unplanned and uncontrolled development will accelerate environmental resource degradation. It follows that the trends identified here give rise to the current **environmental issues**. It is these issues that SMUWC's management strategy options have to address.

The baseline analysis in Chapters 3-5 (summarised in tables 6.1-6.3) identifies 69 issues: 23 related to physical resources, 13 to biological (or biotic) resources, and 33 to human resources. Current trends affecting these issues have been broadly assessed as positive or negative and scaled as negligible, weak, medium or strong. The timeframe of the different trends varies: long-term trends that are continuing today have been considered over their duration, which might be up to 50 years (the period in which irrigation development and pastoralist in-migrations in particular have occurred). Other more recent trends might have been established in the last two or three years, notably those related to the establishment of the Usangu Game Reserve. These are reviewed briefly in Chapters 3-5, with particular emphasis on those currently perceived as key issues

In updating the Environmental Baseline as presented in the SMUWC Interim Report (March 2000) the main changes relate to the dramatic impacts of the very low wet season rainfall recorded in 2000 – the lowest on record. Following on the poor rains in 1999 this shattered the complacency regarding the immediate future of the Eastern Wetland and the Ihefu. In March it was felt that while the Western Wetland was clearly deteriorating the Eastern Wetland and Ihefu would continue to be filled for some years at least. In 2000 only half the Eastern Wetland was flooded and the Ihefu was reduced to perhaps half of its previously perceived "permanent" extent of 80 sq km.

In effect, the identification and evaluation of current environmental trends constitutes an Environmental Analysis of the present (without-project) situation in the Usangu Catchment. Current trends are therefore assessed on the same broadly quantitative basis as an Environmental Analysis. Thus weak, medium and strong trends, in a positive or negative direction, are comparable with minor, moderate and major environmental impacts identified by an Environmental Analysis. Nil/negligible trends are similarly recognised, where effects are very weak. Moderate and especially strong negative trends are regarded as representing key environmental issues.

In many cases where precise data are lacking, trends are inferred from existing knowledge and understanding of current environmental conditions based on whatever information does exist supported by field observations, discussions with local people and with SMUWC colleagues, and experience of comparable conditions elsewhere in the world. For example, no data exist regarding dust, but it seems evident that dust must be increasing as land is cleared and development proceeds. Local people say this is the case and experience elsewhere suggests it should happen.

The current status and trends for physical, biological and human environmental resources are presented here in Chapters 3-5 respectively. Again, the nature of SMUWC as an essentially environmental project means that most of the key environmental resources are dealt with elsewhere in this report in much greater depth and detail. The baseline as presented here aims only to give an overview and to highlight critical points, especially those primary interrelationships between different environmental resources which have created existing trends.

Finally, Chapter 6 summarises the critical environmental trends, positive and negative, that at present are affecting the Usangu catchment and its off-site impact areas (i.e. outside the catchment).

The value of this comprehensive and systematic approach to identifying and assessing current environmental trends is that it produces check lists and related discussion on all aspects of the Usangu Catchment. Where omissions and/or errors in the assessment occur, they can be quickly identified by others and corrected. The approach also highlights those aspects about which our current knowledge and understanding are inadequate, enabling future effort to be directed towards them. It also summarises in one place, albeit at a very general level, SMUWC's ideas concerning the physical, biological and human baselines in the Usangu Catchment. Finally, it provides a comprehensive and systematic supplement to the discussion of changes in the Usangu Catchment provided in Annex 2 of the Main Report.

2. ENVIRONMENTAL SPATIAL FRAMEWORK

2.1 Rationale

Environmental resources, issues and impacts will vary from one part of the project area to another, so to facilitate the identification, analysis and discussion of these an **environmental spatial framework** comprising **agroecological divisions (AEDs)** has been devised (table 2.1). These represent a synthesis of natural land or water units and the uses made of them by people. In broad terms, they will often reflect land cover units within **geomorphic regions**. Thus the environmental spatial framework here has been devised on the basis of the land cover and geomorphological findings presented in Supporting Report 1. The AEDs in table 2.1 are also grouped initially into basic **ecological regions** (figure 2.1), to facilitate discussion on a broader scale, especially within the various wetlands.

It should be noted that the AEDs are not seen as local subdivisions of **Agroecological Zones**. The latter are usually mapped on a regional, national or continental scale, often primarily reflecting significant climatic zones, and are mainly used to define agronomic potential.

2.2 Uplands Geomorphic Region

It is apparent that most of the AEDs in the Uplands correlate directly with the geomorphic units, primarily reflecting slope and elevation. Further subdivision is possible, notably on the basis of variations in geology (acid granitic and basic volcanic rocks) and land use (forest, grassland, cultivation). The **Northern Hills AED** is separated out because cultivation is much less widespread than in much of the southern Low Plateau and the generally dense miombo vegetation (with tsetse) dominates.

2.3 Lowlands Geomorphic Region

The “dry” Lowlands are occupied largely by alluvial fans, often with large sand hills on their upper and middle slopes. Three fan AEDs have been defined to reflect major differences in land use and soils.

The **Northern Fans AED** has very typical *Acacia kirkii* and is used almost wholly for grazing, with mainly small, scattered patches of cultivation; the soils on the lower slopes are typically hardpans with a distinctive pale pink appearance. Unlike the Alluvial Fan AEDs in the south the alluvium here seems to be significantly older and hence more leached and compact. The small but distinctive “new” Kimbi Fan east of Upagama, however, is superimposed on a much larger “old” Kimbi Fan and is more like the Southern Fans.

The **Southern Fans AED** includes all non-irrigated alluvial fans in the south, although again finer divisions could be made on the basis of land use, slope and soils, especially in the south west corner at the foot of uplands formed by the Rungwe volcanics. Generally the natural woodland vegetation decreases downslope on the upper fans and rainfed cultivation increases on what are generally light and easily managed soils. On the middle fan slopes, woodland vegetation thickens again, although in places it is thinned by wood-cutting and the creation of grazing areas.

The **Irrigated Fans AED** mostly occupies the lower slopes of the southern Alluvial Fans where extensive tracts totalling some 40,000 ha have been drastically modified from their natural condition for rice irrigation. They are not separated on figure 2.1 because of their spatial complexity relative to the map scale. They occupy parts of all the major fans from the Kioga Fan westwards. Alluvial Fans in the south differ from the NFn AED in that they consist mostly of grey-brown young alluvium deposited on older material. The latter seems likely to correlate in age with the general pale-coloured alluvium of the Northern Fans.

The remaining Lowland AED is the Sand Hills AED, formed by sandy alluvium deposited where streams descending the steep escarpments slowed immediately on reaching the old lake. Water and wind have both resorted this alluvium to form distinctive slightly elevated tracts of brown, fairly sandy soils on the upper parts of fans. The easy workability and high infiltration characteristics make this AED a favourable location for rainfed cultivation.

2.4 Wetlands Geomorphic Region

The Wetlands geomorphic region has been considered in more detail because these are the focus of SMUWC. Eight Wetland AEDs have been defined, six of which combine to form the main Usangu Wetlands. In considering these six, however, it is important to recognise that the Usangu Wetlands form two distinct wetland sub-basins: the **Western Wetland** and the **Eastern Wetland**, each of about 600-700 sq km in extent. All the perennial rivers except the Ndembera/Mwima enter the Western Wetland and all its outflow leaves via the Great Ruaha River through a narrow neck of wetland formed by the "old" Kimbi Fan impinging from the north and the Kioga Fan from the south, in the vicinity of the Nyaluhanga crossing. Thus the Eastern Wetland receives inflows from only two "perennial" rivers, the Great Ruaha and the Ndembera/Mwima, although the former and possibly both now have periods of no-flow before reaching the main perennial swamp (the **Ihefu**). The **Great Ruaha River** is considered an AED in its own right as the main drainage artery for the Usangu Wetlands.

The two wetland sub-basins have been divided further on the basis of soil. The main wetland soil is typical *Black Cotton Soil*, well-known from many parts of the subhumid and semi-arid world. It results from alternate seasonal wetting and drying, forming large cracks when dry but following initial huge intakes of water when flooded, it seals to become impermeable. As it dries again, the surface soil forms a distinctive crumb structure by a process termed *self-mulching*. These are the characteristics of *Vertisols*. They are vital because they imbue the black soils with strong resilience, so long as wetting and drying occur. Soil colour is important because there are certain extensive marginal seasonal wetland soils which are grey in colour and lack the vertisol characteristics and so are much less resilient. Seasonally flooded grassland soils are known in Tanzania as *mbuga*, so that here **Black Mbuga** and **Grey Mbuga AEDs** have been defined in each of the two wetland sub-basins. Strictly speaking, the BMw AED is mis-named because it includes some fairly extensive tracts of *Acacia seyal* woodland along drainage lines, but at this level of study it is not necessary to separate these off..

The Black Mbuga are much more extensive and form a continuous tract in each sub-basin. In the Eastern Wetland the Black Mbuga encircles the **Ihefu AED**, a perennial swamp about 80 sq km in extent. The Ihefu consists mainly of two sub-units: open water dominated by water lilies (*Nymphaea sp*) and floating vegetation dominated by wild rice and tall grasses (notably *Echinochloa sp*). Two main tracts of Grey Mbuga occur, in and around the Kapunga Rice Scheme in the Western Wetland and in and around the Madibira Rice Scheme in the lower Ndembera valley upstream of the Ihefu.

The **Fan Swamps AED** comprises small patches of swampland thought to be perennial, around the periphery of the Kapunga Rice Scheme, notably the remnants of the Ifushiro Swamp. They probably relate to the extensive Grey Mbuga tract in this area. It seems unlikely that they have major ecological importance, given their very small extents.

The **Ndembera Wetland AED** was characterised in the Project Memorandum as a major upland permanent swamp some 100 km distant from the Ihefu. The extent of some 80 sq km shown on various maps was said to comprise perennial swamps predominating over seasonal wetland. The swamp was thought to have high vegetative biodiversity flourishing, relative to the Ihefu, in quasi-natural conditions. In practice Ndembera "Swamp" is a Y-shaped wetland, almost wholly seasonal, formed by the two uppermost valleys of the Ndembera Catchment which merge south west of Lumuli Village into one valley extending south almost to the Ndembera Bridge on the Mapinga-Madibira road.

SMUWC field traverses found only one genuine sizeable extent of permanent swamp, covering about 1 sq km below the village of Ikungwe. Adjoining reed swamp and two separate patches of perennial bulrush (*Typha sp*) and Papyrus swamp occurring just to the south and north of this give a total extent of perhaps 3 sq km. This would be more aptly named the *Ikungwe Swamp* to avoid the impression of an extensive river basin swamp. Small linear tracts of permanent wetland were seen at sporadic points along the Ndembera River and in tributary valleys, estimated to total at most another 2-3 sq km. The valley bottoms clearly flood extensively in the wet season and this is essentially an upland seasonal wetland. Far from being ecologically pristine, it is widely grazed and burned in the dry season and is in many stretches flanked by roads/tracks, villages and cultivated strips, often intensively irrigated from springs at the foot of the steep valley sides.

It is possible that the original identification of an extensive upland permanent swamp in the north east of the catchment resulted from confusion with the extensive perennial swamps on the headwaters of the Little Ruaha River seen along the Iringa-Mbeya highway in the Sao Hill forest plantations. Apart from the fact that the forests are planted rather than natural, these swamps appear to be almost undisturbed, cover large uniformly wet extents, and seem unaffected by settlement, cultivation, livestock, etc.

2.5 Off-site Impact Areas

Table 2.1 also identifies four potentially important **off-site impact areas (OIAs)**.

Three of these relate to reduced flows from the Usangu Catchment. The main adverse impacts of development projects often occur outside the project area, and especially downstream when water is concerned. All three OIAs are downstream of the point where the Great Ruaha River leaves the project area at Ngiriama village. In fact the SMUWC Project has its origins off-site in the concerns over dry season river flows past the **Ruaha National Park (RNP)** and into the **Mtera** and **Kidatu Reservoirs**, where much of Tanzania's electricity supply is generated. The **Lower Rufiji Basin** is included for completeness but at present changes in the Usangu Catchment seem not to influence this area significantly.

To these can be added a less easily defined group of OIAs, namely any other grazing areas in Tanzania, especially those adjacent or close to Usangu. These will be adversely affected, possibly severely so, if the recent establishment of the Usangu Game Reserve leads to the large-scale emigration of livestock out of Usangu.

3. PHYSICAL ENVIRONMENTAL RESOURCES BASELINE

3.1 Water

Eleven potential environmental issues have been considered as possibly arising from current trends affecting water resources:

- surface run-off
- river discharges
- river water quality
- siltation
- seasonal wetlands recharge/extent
- perennial swamp recharge/extent
- wetlands water quality
- groundwater levels
- groundwater quality
- drainage
- flooding

More detailed discussion and data presentation relating to many of the issues covered here are to be found in Supporting Volumes 1 and 4-8.

3.1.1 Surface run-off

There has been much discussion of surface run-off in Usangu, especially in the upper catchment. SMUWC has pointed out that many studies around the world show that reduced forest cover in upper catchments increases *total annual run-off*. Against this, of course, is the fact that reduced vegetation cover often results in accelerated run-off during rains, decreased water storage in the upper catchment, and longer periods of low (or no) flow in catchment streams during dry seasons. A further complication is that the type of vegetation cover in the upper catchment is also important.

Substantial areas within the Usangu upper catchment (the Uplands ecological region in table 2.1) have been cleared of forest cover or have had forest and woodland thinned by selective cutting of economically important species. However, hydrological monitoring shows that flows and flow patterns in the Usangu rivers at the point where they emerge onto the Lowlands have either not changed significantly over recent decades or the changes are very small. This indicates that either the area of depleted tree-cover is not sufficient to greatly affect river flows or that it has been replaced by vegetation or cultivation practices that continue to retain rainfall as effectively as the forest. This may well be the case for the perennial rivers in the south west because upland cultivation, mainly on the medium plateau, has benefitted from soil and water conservation advice and assistance provided by the HIMA Project. Another factor is likely to be the often deep, permeable basalt soils with their high moisture-holding capacities that occur in the south west upper catchment, derived from the Rungwe Volcanics geology.

Further east the upper catchment is lower and less steep, consisting largely of the MPl and LPl AEDs, with only minor escarpments. This topography means greater accessibility and in large parts

extensive agricultural development, with much decreased natural vegetation cover. Rainfall, however, is much lower than the annual 1500 mm in the south west and surface run-off accordingly less, as illustrated by the generally non-perennial rivers that emerge from this area. Only the Ndembera River in the extreme north east of Usangu is perennial, fed by perennial springs.

In the NHi AED there has been relatively little disturbance of the natural vegetation and changes in surface run-off seem unlikely.

Within the Alluvial Fans in the SFn and IFn AEDs changes in land cover and use have been radical over recent decades. In the SFn AED widespread clearance of woodland for rainfed cultivation and grazing has occurred, often exposing the soil surface, and run-off has accelerated as a result. This diminishes soil moisture and groundwater on the fans and often initiates or accelerates erosion over what are still significant slopes, especially on upper and middle fans. In the IFn AED surface run-off is largely controlled by the levelled paddy fields flattening topography but is still susceptible to human actions in directing and releasing unwanted water. Occasionally the latter lead to very concentrated run-off and local flooding and erosion.

It is widely believed locally that significant acceleration of surface run-off can also occur in the Seasonal Wetlands as a result of soil impaction by cattle, leading to reduced flooded area and soil erosion. Discussions in Sections 3.1.5 and 3.2.1 indicate that there may be a current trend towards decreased extent and increased degradation in the Western Wetland but this has still to be confirmed and cattle are unlikely to be the original cause. Black Mbuga has four key characteristics that counter surface run-off.

- When rains start the vertisol soils are dry, very deeply and widely cracked and hence extremely receptive to any surface flow – large amounts will be absorbed before the heavy, clays swell and seal the cracks.

- Topography is usually near-level, with almost no slope to encourage accelerated run-off.

- However trampled the soil surface may be, it is restored annually by the self-mulching and cracking characteristics implicit in the montmorillonitic (2:1 lattice) clay mineralogy of the soils. Unless seasonal wetting and drying ceases, this strong resilience will persist indefinitely.

- During the wet season it supports a dense carpet of luxuriant grass cover, which for much of the wet season is only lightly grazed (certainly in the Eastern Wetland) because cattle have moved upstream and onto the Alluvial Fans.

The key, of course, is that alternate wetting and drying must occur. In the Western Basin wetting is likely to result more from seasonal flooding than directly from the relatively low rainfall in situ. Reduced extent of wetting seems to be degrading the vertisols there and encouraging run-off. Two areas of marked gullying noted between Utengule and Ukwahera suggest accelerated run-off where steepening of slope occurs along the margins of drainage lines within the Black Mbuga, said to have been initiated quite recently during the excessive *El Nino* rains of 1997-98. This is precisely the area where significant changes in soil appearance have occurred even in the last two years, with Black Mbuga seemingly already modifying into Grey Mbuga (Section 3.2.2).

The Eastern Wetland appears to exhibit no evidence of significant accelerated run-off, although it may be that conclusions drawn from the Western Wetland have been automatically ascribed also to the Eastern Wetland.

The current overall trend in accelerated surface run-off is probably no more than weakly negative but could deteriorate in certain parts of the Usangu Catchment, possibly exacerbated by the movement of livestock out of the new Game Reserve into much more vulnerable and already slightly affected areas.

3.1.2 River discharges

Much of the discussion above in Section 3.1.1 applies to river discharges. As noted, no significant change in flows and flow patterns have been noted in the monitoring data collected where the main streams and rivers enter the Lowlands from the south, while human interference in the northern upper catchments seems very limited.

However, river discharges, and particularly that of the Great Ruaha as it exits Usangu, are the central focus of SMUWC, reflecting the fact that major changes in river discharge have occurred **within** the lowlands and wetlands. The key question facing SMUWC is why the Great Ruaha dry season flow has ceased in at least the last nine years, for what seem to be increasing periods of time.

Although this is clearly a major environmental issue it is also an emotive one. Flow records show that at present there is no statistically significant decrease in the Great Ruaha annual or wet season discharge from Usangu. The critical issue is that of dry season flow, in which there has been a steady decrease over at least the last 30 years, accelerating since the mid-1980s. However, the dry season flow was historically extremely low, so the real impact of current trends is the change from an almost negligible dry season flow to drying up completely, combined with increasing delays in the recovery of flows in the early wet season (November/December/January).

The other important environmental trends are the greatly reduced dry season and early wet season flows in the perennial rivers which seem likely to be the cause of the Great Ruaha drying up and the greatly diminished wet season discharges of rivers entering the Western Wetland.

Dry season irrigation is not extensive (2,500 ha estimated by SMUWC) but even so it is significantly reducing the naturally low dry season river discharges (current SMUWC estimates are by 28%). This is greatly exacerbated by the uncontrolled diversion of river flows through the many government and smallholder rice areas, either through laziness or a desire to maintain supplies for domestic uses. Some of this latter water returns to the river channels downstream but much is likely to be lost to spillage into local swamp and wet areas. It is estimated that 87% of dry season stream flow is diverted.

Another critical trend is the apparent absorption of about one-third of wet season river discharge by the 40,000-50,000 ha of rice irrigation. This is almost certainly a main cause of the drying up of the Great Ruaha downstream during the late dry season and early wet season, when flows are still low but are increasingly used for rice field preparation and planting. These activities are taking place earlier and earlier as farmers compete to be first into the markets when prices are higher. Subsequently, as the wet season progresses, the loss of the 25-35% water used for rice in a “normal” year must be reflected elsewhere in the regional hydrology, since the Great Ruaha wet season discharge at the exit has not significantly decreased. The obvious answer is that flooding in the Western Wetland must be greatly and increasingly diminished – an extremely ominous trend (see Section 3.1.5) underlined in 2000 by the virtual absence of any inundation in the Western Wetland.

Even more threatening was the failure of inundation in the Eastern Wetland to exceed more than about half its extent and the reduction of the 80 sq km of supposed perennial swamp by half. This contradicted the confident assertion made in the Interim Baseline that outflows from the Western to the Eastern Wetland seem to be maintained.

It is not currently clear to what extent the topping up of the Eastern Wetland is due to the other inflow source, the Ndembera/Mwima in the north east. Flows from this must have varied over the last 15-20 years because in about 1983 the Ndembera was diverted completely at Madibira by Baluchi rice farmers to continue flowing west rather than heading north across the valley to help form the Mwima River. Then in 1999 the Ndembera was returned to its old course by the new Madibira Rice Scheme, which at the same time diverted part of its flow into the 3,000 ha of rice irrigation it is establishing (although to date less than half has been taken up – see Section 5.4.2). Between 1983 and 1999 probably only a small part of the flow was used by the Baluchi rice, leaving the rest to flood into the valley bottom, with part able to make its way downslope to the Mwima River and hence to the Eastern Wetland. Once the new Madibira Scheme is fully implemented, and especially if it is then as poorly operated as Kapunga and Mbarali Schemes further west, it is likely that it will consume a large proportion of the Ndembera/Mwima inflow to the Eastern Wetland, at times possibly all of it. There are regulations which should maintain a minimum flow downstream of the Scheme but experience on the other Schemes suggests these might soon be ignored.

3.1.3 River water quality

The initial SMUWC water quality survey in November 1999 revealed no significant negative data regarding river water quality. This was at a time when flows were at a minimum and any concentration of pollutants might be expected to be at a maximum.

Two main concerns expressed in the past were with agrochemical pollution and with two gold-mining operations in the Usangu Catchment creating a mercury problem. In fact there is very little use of pesticides, herbicides, etc in the Usangu Catchment: they are too expensive, especially for smallholders, and the State-run rice operations at Kapunga and Mbarali have greatly reduced the area they cultivate, as well as the amount of agrochemicals used. The gold-mining areas are in the Upper Ndembera catchment near Ifunda and at Machimbo hamlet in Mabadaga village. Both are very small-scale rudimentary artisanal operations and the latter at least seems to be running down. The Ifunda operation sends the combined gold-mercury extract elsewhere for separation and Machimbo may do the same. The scale of operations and amounts of mercury involved led the Water Quality Specialist to deem sampling and analysis downstream of the sites to be pointless. It seems evident, therefore, that no significant negative trends are occurring in these respects.

Sewage pollution from the growing human population has not yet become a problem although if population growth continues to increase and river flows to diminish it could well do so in the future. A weak negative trend is identified.

3.1.4 Siltation

The increasing clearance of natural vegetation in many parts of the Usangu Catchment might be causing a slight increase in silt loads downstream. However, with so steep an upper catchment for the perennial rivers silt loads during the wet season must always have been high. The interruption of high silt-bearing wet season flows by extensive rice cultivation must trap much of the silt that once

flowed directly into the Great Ruaha along stream channels. Silt that was spread over the Western Wetland by overbank flooding from the streams will have diminished if such flooding has decreased (but this will often be the silt that now finds its way into the rice fields, where it is trapped).

The Madibira Rice Scheme has introduced an artificial silt trap and flushing system, so that silt disappears into a drain and may or may not be deposited in the Seasonal Wetland downstream.

The Great Ruaha always looks laden with silt, even at low flows, but unfortunately sediment load has never been monitored. In fact, under natural conditions the Western Wetlands would have formed a vast silt trap and even with today's reduced flooding there it must still absorb large amounts of silt from the floodwaters. Even so, the amount of suspended fine material continuing to be transported to the Eastern Wetland and the Ihefu appears high.

If sediment content is as high as it looks, it creates a further mystery regarding the Ihefu. Given that large amounts of water remain trapped in it during the long periods of extremely low or no flow over the exit, why has the Ihefu not silted up more rapidly? It is currently a very shallow body of water, so perhaps this is happening, and this is how the water level in it is maintained i.e. storage is decreasing. Siltation must have been the cause of the many past changes in the course of the Great Ruaha and presumably of the location of the Ihefu itself. The evidence of the topographic maps and local hearsay suggest this has happened, with the River and the Ihefu shifting southwards. In theory, of course, siltation should eventually - in the very long term - raise the whole Eastern Wetland plain above the level of the exit and so restore perennial flow there, unless wet season flows also disappear.

3.1.5 Seasonal Wetlands recharge/extent

Section 3.1.2 identifies major concerns about the Western Wetland recharge, extent and ecological integrity. These had been raised by SMUWC aerial estimates of the 1999 maximum inundated area in the Western Wetland, which showed only about 25% (about 160 sq km) to be under water, in a series of discrete tracts. This partly reflected the 30% rainfall deficit in the 1998-99 wet season but seemed too great an impact from rainfall alone, especially as the low rainfall also substantially reduced rice irrigation and associated water use as well. Under original natural conditions it would be expected that the Western Wetland would in a "normal" rainfall/run-off year expand in a single continuous sheet of water over some 600-700 sq km (Figure 2.1).

This widespread flooding would have resulted partly from in situ rainfall but probably more from over-bank flooding from the Great Ruaha and its tributaries when they passed from the Alluvial Fans to the Western Wetland. Unlike the Eastern Wetland, the Western Wetland seems to comprise a series of sub-basins separated by very slightly elevated land or levees along drainage lines. Hence the discrete areas of flooding seen by the 1999 aerial survey. Overbank flooding would have been encouraged by the very narrow flow constriction created at Nyaluhanga, where the River in recent decades is said not to have overflowed its distinctive levee.

In the Interim Environmental Baseline it was suggested that in a more "normal" rainfall season, inundated land might amount to as little as only half the Western Wetland being flooded (300-350 sq km), or even less. Rainfed cultivation by the Sukuma, using their cattle for ploughing the heavy soils, occurs between Ukwaheri and Solulwambo, providing further evidence that the Western Wetland is beginning to dry out. In practice the 2000 wet season was probably the driest on record and virtually the entire Western Wetland remained unflooded, presumably for the first time.

It is apparent, therefore, that at least half the Western Wetland is now infrequently inundated and so no longer meets the strict definition of a wetland. This marked negative trend is evidenced by what looks like accelerating invasion of woody vegetation and by a quite dramatic change in the surface appearance of the soils over substantial areas even during the short life of SMUWC (see Section 3.2.2).

The belief prior to 2000 was that seasonal flooding in the Eastern Wetland would continue to be maintained at the natural level by inflows from the Western Wetland via the Great Ruaha (combined with lesser inflows from the Ndembera/Mwima in the north east). In situ rainfall and, to a presently unknown degree, groundwater must also contribute. It was assumed that "Lower than normal wet season rains and flooding, as in 1998-99, do not reduce its extent". However, the abnormally low wet season rains in 2000 showed that the critical threshold is probably much closer in time than then thought. Only about half the Eastern Wetland was inundated and in the following dry season the "perennial" Ihefu was also reduced in extent by about 50%.

It seems evident that irrigation along the southern margin of the Western Wetland will continue to expand in the immediate future, absorbing more and more of the inflow, especially if as is likely the Kapunga Scheme is handed over to people who will fully utilise it (at present only a tiny fraction of the 3,000 ha is used). Meanwhile in the north east the full development of the Madibira Scheme, if exacerbated by the same mismanagement, could greatly reduce contributions from the Ndembera/Mwima. It is now apparent that a point can be reached at which inflow into the Eastern Wetland from either or both sources could diminish to a level which is inadequate to maintain the Seasonal Wetland. Under these conditions the Eastern Wetland will start to suffer the degradation that may be happening in the Western Wetland.

The Interim Environmental Baseline postulated that this point may be some way off for the Great Ruaha because if the theory presented in Section 3.1.3 is correct, there remain some 150-300 sq km of seasonal flooding to be lost in the Western Wetland before wet season flows to the river are significantly affected. Since the Madibira Scheme outfall is less than 5 km from the Ihefu, changes there could arrive much sooner. The experience of 2000 suggests that already, given the variable climate, the Eastern Wetland recharge and extent are also under imminent threat. The marked negative trend noted in the Interim Environmental Baseline regarding the seasonal wetlands issue is therefore even stronger than previously thought.

3.1.6 Perennial Swamps recharge/extent

The recharge and extent of the main Perennial Swamp, the Ihefu, pose even more complex issues than in the Seasonal Wetlands, even though with the completion of the hydrolically surveys and modelling, understanding of how the Ihefu maintains its extent has improved. Groundwater recharge remains a possibly significant information gap. What seemed to be the case, from satellite imagery dating back to 1984, is that the extent of the Ihefu had changed little in the last 15-20 years, as would be expected if the surrounding Seasonal Wetland had continued to fill up every year (even in the dry 1999). In fact, local hearsay from Baluchis claims that 30 years ago the extent of the Ihefu was less in the north east because in the dry season they could drive in a straight line from Ikoga to Ngiriama, a line which today appears to cross the Ihefu's north eastern extremity.

The most difficult thing to explain about the Ihefu is how dry season flow prior to 1993 continued over the exit while since then it has failed to do so, assuming the Ihefu extent (and therefore its water level) was not significantly different from today. The water level in the central parts of the swamp is currently more than 2.5m above the level of the exit sill when flow over the sill ceases, implying

substantial hydraulic inefficiency over the few kilometres that separate these points. The water level in 1984 must have been at least as high as now for the swamp shape/extent to be so similar.

The explanation, therefore, appears to lie not in the extent or level of the swamp but in its hydraulic efficiency. The changing pattern and nature of the swamp vegetation and topography, within much the same external boundaries, seem to have significantly impeded the flow of water through the swamp to the exit. Thus although the areas of open water appear to have increased substantially the swamp vegetation in other parts of the swamp has become significantly denser, possibly partly due to factors such as decreased hippo activity and siltation reducing water depth so that less of the vegetation is floating. Water can presumably pass much more easily beneath floating vegetation than through a dense and continuous wall of aquatic plants. Possibly the findings of the Environmental Functions work will clarify the situation when it is completed.

In the 1970s it is said by local people that the main route to the exit for swamp waters was along the "north west passage", a channel clearly evident on the satellite imagery. Flow in this channel has been blocked by a solid "bridge" built by the Sukuma to give their cattle access to grasslands south of the Channel. If this is correct a relatively minor programme of dredging and obstacle clearance could quickly facilitate outflow from the central swamp to the exit and greatly increase hydraulic efficiency.

However, acceleration of outflow from the Ihefu would then seem certain to diminish the extent of permanent swamp, amounting in effect to partial drainage. This implies that inflows into the Ihefu must have also diminished over the years, otherwise the extent would have increased rather than remained constant. The very slight decrease of inflow needed to achieve this is easily explained in terms of upstream diversions for dry season irrigation and early wet season preparation and planting of rice.

Prior to the exceptionally poor 2000 wet season, the current situation appeared to be that the Ihefu was remaining stable and in terms of recharge and extent no significant negative trend was occurring. However, it was envisaged that the eventual decreases in wet season inflows from the Western Wetland and the Ndembera/Mwima noted in Section 3.1.5, if they occurred, might create such a trend in the longer-term future. More imminent could be the impact of dry season inflows decreasing further due to increasing dry season diversions causing prolonged drying up at Nyaluhanga. It was assumed that the current dry season inflows from all sources (Great Ruaha, Ndembera/Mwima and groundwater) must be sufficient to balance evaporation from the apparently stable Ihefu surface area. It has to be assumed that the Great Ruaha is the most important of these three sources.

This perception of Ihefu stability has had to be sharply modified in the face of the severe impacts on the Ihefu of the low 2000 wet season rains. The total extent of the Ihefu reduced to only about 40 sq km, half the assumed "permanent" swamp, and it disintegrated into a number of discrete areas. It seems evident that the hydrological balance in the Ihefu is much more delicate than previously thought and the critical threshold values at which destruction of the perennial swamp begins are much closer in time. This has obvious implications for the strategic planning period proposed by SMUWC, during which at least the option of maintaining the Ihefu, and for that matter the Eastern Wetland, must be retained. The "negligible" negative trend in permanent swamp recharge and extent recorded in the Interim Environmental Baseline is revised here to a moderate, possibly even a strong, negative trend in this issue, created by the declining hydraulic efficiency in the Ihefu and the declining flows into it.

There are two other areas where tiny localised permanent swamps occur: around Kapunga Rice Scheme and in the upper catchment of the Ndembera River. Neither are of sufficient extent to create any significant current trends in swamp recharge and extent. Recharge around Kapunga seems likely

to depend on the Rice Scheme itself to some extent, while the 5-6 sq km of permanent swamp within the almost wholly seasonal Ndembera Wetland are fed from the perennial flow of the Ndembera River, which in turn seems to depend in the dry season on a proliferation of perennial springs, especially along the western margin of the steep-sided catchment.

3.1.7 Wetlands water quality

Water quality in the seasonal and permanent wetlands reflects that in the rivers (Section 3.1.3). Water quality analyses in the Ihefu in November 1999 (at what would have been peak concentration) revealed what would be expected to be near-natural levels of salinity and pH, with no evidence of agrochemical or sewage pollution. SMUWC's Environmental Functions Study has still to report and also to then complete a final input that will check these findings further but no negative trends are expected to be revealed.

The possible deterioration in river quality resulting from increasing sewage (Section 3.1.3) is unlikely to persist so far downstream, given the largely unpopulated middle and lower reaches of the Great Ruaha within the Eastern Wetland.

3.1.8 Groundwater levels

The SMUWC groundwater inputs recognised the possibility that accelerated run-off over the Alluvial Fans (Section 3.1.1 above) might be influencing groundwater levels within the Lowlands and also wetland recharge. However, to date very little hard information is available and with no likelihood of any scope for drilling in the remaining months it is unlikely to be obtained under SMUWC. There is much anecdotal evidence of water tables dropping in the Lowlands and Wetlands.

Currently an increasingly large proportion of natural river and stream flow is being diverted into irrigation channels and fields. In these the farmer endeavours to reduce seepage (by puddling etc). Also, to achieve gravity flow, optimum micro-topography and minimum natural infiltration, irrigation fields are located wherever possible on heavy, poorly permeable soils, thus maximising evapotranspiration relative to percolation. Water escaping from the rice areas partly re-enters rivers and streams but also partly ends up in local swamps and wetlands, where again it evapotranspires rather than percolates. Much less flow now uses the lower reaches of river and stream courses over the Alluvial Fans, where in the past the cobbly, gravelly and sandy channel beds would have encouraged substantial percolation to the groundwater. In addition, in the initial stages of the annual inundation of the Western Floodplain the would have been substantial intake of water into the large and often deep cracks in the Vertisol soils, before they sealed up. Some of this is likely to have penetrated to the much more permeable substratum and hence to the groundwater. On this basis, it would be expected that groundwater recharge is decreasing.

Since almost nothing is known on the hydrogeology of the Wetlands, the influence of this on recharge of the Ihefu remains a mystery. Artesian pressure has been noted in some parts of the plains and wetlands, and this might prove to be critical in the recharge of Ihefu.

More detailed investigation of the hydrogeology of the lower Usangu Catchment is urgently required – it could also have practical implications in planning the much-needed provision of healthy domestic water supplies (as achieved by SMUWC at Ukwaheri). With present understanding of the hydrogeology, a weak or even medium negative trend in groundwater recharge might be surmised.

3.1.9 Groundwater quality

Analysis of groundwater quality has been undertaken by SMUWC and data from other relevant studies has been collected. As expected, since it can usually be expected to be better than in streams and wetlands (where Sections 3.1.3 and 3.1.7 show no cause for concern) no significant trend seems apparent.

3.1.10 Drainage

Given the general emphasis on rice irrigation and the need to maintain the Seasonal Wetlands, there is little call for improved drainage in the Usangu Catchment. Natural drainage has been deliberately distorted to implement the rice cultivation. Wetland flooding seems to be diminishing as a result. Drainage thus appears to be an insignificant issue. The "red routes" suggested for conveyance of dry season flows through the main irrigation areas (Supporting Volume 7) could be construed as a form of drainage, but are seen here as maintaining river discharge rather than as a drainage mechanism.

3.1.11 Flooding

As noted, wetland flooding seems likely to have decreased, at least in the Western Wetland where flooding might be regarded as a positive (ecological and livestock reasons) as much as a negative (access, damage and disease reasons) impact. Localised flooding on the lower fans around rice cultivation probably occurs sporadically and on a small scale. No significant trend on flooding as such is discernable, although of course reduced wetland inundation is a major concern (Section 3.1.5).

3.2 Land

Six potential environmental issues have been considered as possibly arising from current trends affecting land resources:

- soil erosion
- soil physical degradation
- soil fertility
- soil salinity and alkalinity
- land availability
- land capability

More detailed discussion and data presentation relating to many of the issues covered here are to be found in Supporting Volume 1.

3.2.1 Soil erosion

In the Uplands natural soil erosion must always have been significant, especially on the very steep slopes of the various escarpments but also on the different plateau levels which over much of their extents are deeply dissected. Clearance of natural vegetation for cultivation in the basaltic Medium Plateau AED in the south west of the project area seems to have caused surprisingly little soil erosion,

even on very steep slopes. This must be mainly because of the erosion-resistant basalt soils but also because in places farmers have adopted soil conservation techniques, encouraged by the HIMA Project.

The much greater extent of cleared Medium Plateau in the east of the Usangu Catchment, and the adjacent extensive Low Plateau, have mainly granitic geology and much more vulnerable soils. In places gully and sheet erosion seem to have been accelerated by human activities (cultivation, grazing, wood-cutting, road construction, etc). However, the limited degree of serious erosion is again somewhat surprising in this very large area. Maize cultivation, with its lengthy cropping seasons, must provide reasonable protection for the land. Where land is abandoned it seems also that regeneration of grass cover and then Miombo bushland is rapid, maintaining this protection.

Much the same thing occurs widely on the cleared and semi-cleared parts of the Alluvial Fans, especially in the Southern Fans AED. The Sand Hills AED has more permeable soils which increases resistance to erosion, while the IFn are typically on near-level topography which is levelled further and bunded into rice fields when cultivated. Occasionally erosion is associated with the IFn where rice water has suddenly been released, causing gullying.

There are increasing soil erosion problems in the Southern Fans AED where cultivation and grazing can be intensive; as noted in Section 3.2.3, a form of shifting cultivation often occurs, accelerating vegetation clearance. Gully erosion is particularly noticeable along access tracks, footpaths and cattle trails. Often, all of these are combined into a multi-purpose and intensively used track where soils are extremely compacted and become totally impermeable. Here the heavy wet season rains initiate erosion and rutting eventually develops into gullying. Erosion is most marked on the middle and upper slopes of the fans, where relative elevation and gradients are greatest.

The distinctive lower reaches of the Northern Fans AED are already intensively grazed by the Sukuma, who have established hamlets and camps there. In the dry season the hardpan soils typical of the AED, occupying the open tracts of land between the clumps of *Acacia kirkii* scrub, become bare and have coarse sandy material thinly scattered over the surface. Much local opinion felt that this represented widespread sheet erosion caused by over grazing, but the luxuriant regrowth of grass each wet season belies this idea, as recently confirmed by the SMUWC Range Ecology Specialist.

Soil erosion is not widely seen in the Wetlands, where gradients are near-level and the dominant Black Mbuga soils are resistant to long-term compaction because of their vertisol characteristics. However, concern has already been expressed regarding possible degradation of these soils in the Western Wetland. At least two substantial areas of gullying occur in the Black Mbuga, south of Ukwaheri, in an extensive area where annual flooding seems to have ceased. Here the soils appear to be changing their surface characteristics from Black to Grey Mbuga (Section 3.2.2), a trend that would increase run-off and gullying. The reduced seasonal flooding noted in Section 3.1.5 is a trend likely to continue, threatening continuing and probably accelerating soil degradation and erosion there.

Superimposed on all these erosion trends in different parts of the Usangu Catchment is the now imminent danger of very rapid erosion acceleration in all vulnerable areas. This results from the recent establishment of the Usangu Game Reserve, occupying virtually all of the Eastern Wetland, where huge numbers of cattle graze during the dry season (see Sections 4.1.3, 4.4.1 and 5.4.3).

These livestock can either go elsewhere within the Usangu Catchment or leave the Catchment altogether. The former move will impose immense grazing pressures on the Western Wetland and the Alluvial Fans in particular, but also on the Low and Middle Plateaus in the east (where there is no

tsetse fly to repel cattle). Major pressure is likely on the Western Wetland, which offers comparable grazing but which seems likely already to be under pressure because of reduced seasonal flooding. Even the relatively undisturbed miombo in the Northern Hills AED outside the Game Reserve could come under threat because the Sukuma are skilled in clearing woodland to get rid of tsetse fly. Out-migration of the livestock to other grazing areas in Tanzania, mostly already under pressure, will simply increase the threat of soil erosion and other associated problems off-site.

Overall, increasing induced soil erosion seems to be a medium negative trend that is about to become a strong negative trend as cattle are moved out of the Game Reserve.

3.2.2 Soil physical degradation

Much the same discussion applies here as for soil erosion (Section 3.2.1). Clearance of vegetation and unimproved cultivation lead inevitably to soil degradation on the largely poorly structured granitic soils of the upper Usangu Catchment and Alluvial Fans. Destruction of soil structure reduces infiltration, permeability and moisture holding capacity, while making the root zone more difficult to penetrate. Topsoil deterioration encourages accelerated run-off and hence soil erosion. The well-structured and resilient basalt soils in the south west will resist such trends for much longer.

Intensive rice cultivation in the IFn AED sets out to degrade the soil by puddling and prolonged wetting. In the NFn, as noted in Section 3.2.1, there are distinctive hardpan soils, where compaction has been blamed on overgrazing. This seems unlikely to be the explanation as the soils appear to be naturally formed. Closer examination of these soils might prove interesting and useful.

The distinctive vertisol physical characteristics of the Black Mbuga soil in the Wetlands will persist only so long as they are seasonally wetted. However, flooding in the Western Wetland seems to be rapidly reducing in extent. The impact of the 2000 exceptionally poor wet season meant that the Western Wetland was not flooded at all and even the Eastern Wetland received only partial inundation. It is to be expected that those areas in either Wetland that are no longer regularly flooded will be likely to suffer soil degradation because the resilience of the Black Mbuga soils will decline. In this scenario cattle will be a catalyst in the degradation, as they will remove much or all of the reduced grass cover that will result and also impact soils that can no longer recover. However, cattle will not be the initial cause: rice irrigation seems inevitably to be the originator of any such trend. Removal of cattle from the new Game Reserve will greatly exacerbate the problem by increasing pressure on the currently more vulnerable Western Wetland.

Field observations in mid-November 2000 revealed a surprising and dramatic change in the extensive Black Mbuga south west of Ukwaheri. Only a year previously a field traverse across this area encountered a typical if weakly developed Black Mbuga soil, with moderately developed cracking, evidence of self-mulching and a characteristic black colour. In November 2000 the field party was initially confused by the much greyer colours of the surface and by the virtual absence of cracking and self-mulching. This was a very much more rapid transformation of soil type than had been expected, when a barely perceptible change over several decades had been envisaged. It seems probable that, apart from in the exceptionally wet *El Nino* year of 1997-98, this area now rarely receives inundation.

A vicious circle ensues as seasonal wetting diminishes: the soil cracks and mulches less and so absorbs less *in situ* rainfall and any flooding that does occur, so that less grass grows and the annual re-supply of organic matter diminishes. The vertisol characteristics thus weaken further and the deterioration in wetting the following year increases, apart from any reduction in flood waters due to

increasing rice diversions upstream. If extremely heavy rain occurs, as in 1997-98, surface run-off becomes much greater as the vertisol characteristics weaken. This will accelerate the gullying already occurring in the area in question and similar events are likely in other parts of degraded Black Mbuga.

Overall, there now has to be recognised a strong rather than medium negative trend in soil degradation in the Catchment. In the Uplands and on the Alluvial Fans this might be countered by improved farm management. However, it is difficult to see how the Black Mbuga soils can be saved, especially in the Western Wetland, given the entrenched and still expanding rice cultivation upstream. Again, this trend will deteriorate further in the near future as cattle are moved out of the Game Reserve and/or the unexpectedly early limitation of flooding in the Eastern Wetland persists.

Vertisols are one of the world's most important and extensive soil types, often of great importance to local rural economies and development planning. In many parts of the world drainage and other forms of development threaten such soils. The probably unavoidable deterioration of the Usangu Western Wetlands offers an excellent opportunity for valuable, practical research into the processes, changes and time framework involved. Unfortunately it is likely to be over a considerable time period (i.e. possibly decades) but the findings would have important applications worldwide.

3.2.3 Soil fertility

There are three main areas of concern regarding soil fertility in the Usangu Catchment.

First, there is the observed deterioration in the fertile Black Mbuga soils of the Western Wetland, now that SMUWC's postulations about greatly reduced flooding have proved correct, accompanied now by real fears that the Eastern Wetland also is under immediate threat. As noted in Section 3.1.5, this would mean poorer grass cover much more prone to overgrazing, so that organic contents would diminish over time and quite rapidly. Intake of soluble nutrients via the large crack patterns during the onset of seasonal flooding would disappear where such flooding ceased. The drier, more compacted soils following the failure to flood would hamper nutrient intake and grass seeding. The Black Mbuga soils will only maintain their fertility so long as they continue to be seasonally flooded (and currently they also benefit from huge amounts of livestock manure returning the grassland nutrients to the soil). As noted in Section 3.2.2 these impacts seem to be occurring much more rapidly than previously anticipated, with extensive areas of Black Mbuga in the Western Wetland already taking on the appearance of the much less fertile Grey Mbuga.

Rainfed cultivation in parts of the Alluvial Fans is quite intensive, usually using little or no fertiliser to sustain the natural low fertility of the soils. Soil exhaustion is rapid, often resulting in a form of shifting cultivation whereby the farmer cuts down more woodland and bush while leaving the previous area to recover.

Third, the substantial areas of intensive rice irrigation must reduce in fertility if fertilisers are not used. Again, these are mostly not naturally rich soils and the persistent flooding associated with paddy cultivation must result in prolonged if slow leaching, even if offset by puddling. It is not surprising, therefore, that rice yields on the Kapunga Scheme have declined rapidly during a mere eight years of existence.

The most naturally fertile soils in the Catchment are those derived from the Rungwe Volcanics rocks, found in the south west corner of the Catchment on the Alluvial Fans and inner Medium Plateau. Mahongole, one of the seven SMUWC CEP villages, has such soils. The rich, chocolate-brown soils of Mahongole (crumbly because like the Black Mbuga they are self-mulching but to a much finer

tilth) contrast sharply with the pale grey-brown and coarsely or massively structured soils of Mabadaga. Natural soil fertility on these basaltic soils will persist much longer than elsewhere in the SFn and IFn AEDs, although eventually mismanagement could also start to degrade them. It is noticeable that the basaltic soils also encourage a much higher proportion of brick houses at Mahongole (and on the Medium Plateau), as they are clearly more suitable for this purpose.

Declining soil fertility in the Catchment, like soil degradation, needs to be addressed where feasible by improved farm management. However, this is not an option on the extensive Black Mbuga soils where fertility is now under threat from lack of seasonal inundation. The removal of cattle from the Game Reserve has now also been clearly signalled by Government and this will increase pressure substantially on all other grazing lands in the Catchment, so that the decrease in soil fertility will accelerate further. Overall, in the light of findings and developments during 2000, the previously-envisaged medium negative trend in soil fertility seems more accurately assessed as a strong trend.

3.2.4 Soil salinity and alkalinity

This issue is mentioned in various documents relating to Usangu and it is included here simply to clarify that salinisation and sodicity are highly unlikely ever to be problems in the Catchment. Even in the Lowlands and Wetlands, rainfall is too high and intensive and flooding too widespread for salts, especially the very soluble sodium, to accumulate. In addition, the main areas of any salt concentration by evaporation are the Seasonal Wetlands, where the mostly Black Mbuga soils have initial huge intakes of water at the start of each wet season through their deeply and widely cracked surfaces, effectively leaching any soluble salts. The substantial river flows across and out of the lower catchment during the wet season also provide efficient removal of the very small amounts of soluble salts entering it from the upper catchment.

3.2.5 Land availability

There is a positive trend in land availability, albeit as a result of ecologically negative activities such as forest and woodland clearance. Large extents of land have thus become available for more intensive human use, notably on the Alluvial Fans (especially in the SFn, IFn and SHs AEDs) and in much of the extensive MPl and LPl occupying the eastern third of the Usangu Catchment (figure 2.1). Soil erosion counters the trend in small areas.

3.2.6 Land utility

Similarly, the rapid spread of irrigation in recent decades, and especially since the mid-1980s, has considerably raised land utility, especially in the IFn AED and the irrigated parts of Grey Mbuga AEDs within the Seasonal Wetlands. Often irrigation attracts other improved inputs to raise land capability, such as mechanisation, better seed, fertilisers, etc. In Usangu, however, this has not happened outside the State operations and even there such initiatives have rapidly declined.

A more recent increase in land utility can be observed on the higher parts of the Western Wetland where a number of quite extensive tracts of rainfed cultivation in the Black Mbuga between Ukwaheri and Solulwambo have appeared. Nowhere else in Usangu are the Black Mbuga cultivated, except perhaps on the lowest parts of the Madibira Rice Scheme, where macinery is available. In the Western Wetland it is Sukuma cultivation; only they have the animals to enable the very heavy

Vertisol soils to be ploughed. This represents a decline in the Western Wetland grasslands (Section 4.1.3) but the drier soil conditions increase its utility, given that cultivation should yield higher returns per unit area than pastoralism.

Against the overall positive trend, there are the declining trends in soil erosion, physical degradation and fertility noted in Sections 3.2.1-3.2.3, reducing it to a medium positive trend.

3.3 Atmosphere

Four potential environmental issues have been considered as possibly arising from current trends affecting the atmosphere (or air):

- dust
- odour
- air pollution
- noise

3.3.1 Dust

A slight negative trend results from the steady increase in land cleared of its natural vegetation, especially where the land surface is then disturbed for uses such as cultivation, construction, etc, notably on the Alluvial Fans in the south and in settled parts of the Low and Medium Plateaus where such activities are concentrated.

The Western Wetland may also be suffering if seasonal inundation is decreasing as feared. On the Black Mbuga grass cover will be poorer and less extensive, and soil resilience will be diminishing, while the Grey Mbuga would be prone to rapid topsoil degradation following vegetation clearance. In both AEDs land will be drier for longer periods of time.

However, it is likely that in the dry season dust has always occurred to some extent. In addition, large parts of the Uplands are not significantly affected by vegetation clearance. These factors plus the wet conditions that persist for a substantial part of the year help keep dust increase to a weak trend.

3.3.2 Odour

In very localised areas the increase in population and human activities, especially on the Alluvial Fans and settled parts of the Low and Medium Plateaus, is likely to be causing an increase in unpleasant odours but this is clearly not on sufficient scale to be significant.

3.3.3 Air pollution

Excluding dust, discussed in Section 3.3.1, the same comments apply to air pollution as to odour.

3.3.4 Noise

Similarly, increasing noise pollution undoubtedly occurs in a few highly localised places around often expanding human settlements but again not on a scale or to a degree that is significant in the Catchment as a whole.

3.4 Climate

Three potential environmental issues have been considered as possibly arising from current trends affecting climate:

- microclimate change
- regional climate change
- global climate change

More detailed discussion and data presentation relating to many of the issues covered here are to be found in Supporting Volume 4.

3.4.1 Microclimate change

Changes in temperature, moisture content and evapotranspiration around the perennial swamplands might be expected if these are significantly decreasing or increasing in extent. This happened in the exceptionall dry year 2000, when the Ihefu disintegrated into several discrete tracts of much reduced total extent. Much more widespread is the substantial variation in microclimate in the seasonal wetlands where extensive areas that used to be regularly inundated in the wet season now remain permanently dry or flood only rarely. The wet season microclimate in the Western Wetland must be significantly different over large areas.

Another impact, outside the wetlands, might be vegetation clearance on parts of the Alluvial Fans, notably in the SFn, IFn and SFn AEDs. Decreased shade will raise temperatures while thinning of the tree canopy will increase the amount of rain reaching the ground surface; the different vegetation will result in changes in evapotranspiration.

Overall, it is now probably necessary to recognise a weak but significant deterioration in microclimate, especially in the Western Wetland.

3.4.2 Regional climate change

It seems unlikely that the changes in the Usangu Catchment in recent years have been sufficient to significantly influence regional climate. A theory has been postulated in various publications and formal discussions about the Catchment that trees attract rainfall and so their removal has decreased the regional rainfall. No data have been produced to substantiate this idea, which apparently is even taught in local schools. In fact rainfall data indicate that although rainfall is less it is not decreasing in statistical terms. Many local people insist that rainfall is decreasing.

3.4.3 Global climate change

Methane gas contributes to global warming. It is released from livestock and from rice cultivation, both of which have increased substantially by local standards in recent decades; the latter, at least,

promises to continue increasing. On a global scale, however, this very weak negative trend in some parts of the Usangu Catchment is unlikely to be significant.

4. BIOLOGICAL ENVIRONMENTAL RESOURCES BASELINE

4.1 Biodiversity

It is convenient to consider three forms of biodiversity:

- genetic biodiversity - variability among and within species;
- species biodiversity - number of species (including number of endemic species i.e. found only in a particular habitat or at a particular site;
- ecosystems biodiversity – variability of habitats.

In the Usangu Catchment little information exists on genetic biodiversity and the main focus here is on species biodiversity (i.e. fauna and flora communities) and ecosystems biodiversity (i.e. habitats occupied by these commmunities).

4.2 Vegetation (Flora)

SMUWC Vegetation Surveys have studied the Usangu vegetation in some depth, especially in the Lowlands and Wetlands. In addition ground observations have been made throughout the project area by the SMUWC Team as a whole. Potential environmental issues have been considered as possibly arising from current trends affecting four main vegetation types:

- forests/woodlands extent/integrity
- savannahs extent/integrity
- grasslands extent/integrity
- swamp vegetation extent/integrity

More detailed discussion and data presentation relating to many of the issues covered here are to be found in Supporting Report 1 and, for aquatic vegetation, Supporting Report 14.

4.2.1 Forests/woodlands extent/integrity

As discussed in Section 3.1.1, large areas within the Uplands have been cleared of natural vegetation, most of which was forests and woodlands. Many areas remaining uncleared have been degraded by selective logging or localised cutting for charcoal. Uncontrolled burning has been cited as another cause of declining extent and integrity but burning always occurred under natural conditions and the often typical miombo woodland (*Brachystegia sp, Julbernadia sp*, *Pterocarpus angolensis* etc) is known to be a fire dis-climax McClanahan and Young (1996). Only the inaccessible Northern Hills AED is largely free from forest and woodland depletion.

All the Alluvial Fan AEDs have suffered considerable depletion of the typical *Acacia/Commiphora/Terminalia* woodland. The IFn AED has lost practically all its woodland, while cultivation, grazing and cutting for charcoal, fuelwood and livestock *bomas* in the Southern Fans and Sand Hills have greatly reduced woodland cover there. One particular species, locally termed "mpangala" (*Dichrostachys cinerea*), is used by fishermen for in situ smoking of the catfish caught in

the Ihefu and lower Great Ruaha (Section 5.4.4). However, this is a rapidly growing and very successful invasive species on the fans and the amounts used for smoking seem unlikely to outpace regeneration. Several hundred canoes were counted in the Wetlands, mostly in and around the Ihefu. These are made from hollowing out large trees such as *Pterocarpus angolensis* (a bloodwood), *Afzelia quanzensis* (pod mahogany) and *Faidherbia albida* (apple ring acacia). The total annual tree requirement for canoes is thought to be negligible, although the relatively small size of many canoes might suggest that such trees are becoming more difficult to find.

Against this general depletion at least the initiation of invasive tree growth in the Western Wetland due to the reduced seasonal flooding thought to be resulting from the wet season irrigation diversions. This will eventually create savannah woodland (see Section 4.1.2) and even true woodland. Both already occur naturally in the Seasonal Wetlands, especially along drainage lines and the mini-levees that line them in places. They are dominated by often mature *Acacia seyal*, with *A. tortilis* and sometimes *A. kirkii* also present. Such areas are of course not strictly *mbuga* because this term relates to seasonally flooded open grassland but are included here because of scale.

The trend towards tree and bush invasion of the Western Wetland was unfortunately greatly and mistakenly exaggerated by Charnley (1994), causing the pastoralists to be blamed for the implicit deterioration of the Wetland. As noted, in the Western Wetland invasion is in its earliest stages, reflecting primarily the influence of irrigation diversions rather than grazing. No such trend is evident in the Eastern Wetland, where seasonal flooding continues to cover the Black Mbuga and the land remains essentially tree-less except on very narrow levees along old drainage lines in the north west.

It does appear that tree regeneration is occurring much more widely on the lower slopes of the Southern Fans AED, encouraged by current restrictions on burning in areas cleared many years ago. This may be another source of the exaggeration in wetland tree invasion in Charnley (1994), since she also greatly exaggerates the extent of the true Seasonal Wetlands by including extensive fan areas.

Overall, a medium negative trend in the extent and integrity of forest and woodland is identified. This is a trend that needs to be carefully monitored, both for conservation purposes and in order to chart any regeneration.

4.2.2 Savannah bushlands extent/integrity

On the Northern Fans the *Acacia kirkii* savannah bushland is also used to fence *bomas* and provide fuelwood but the mainly Sukuma pastoralist population density is very small, so the impact is limited. On the other hand, as noted in Section 4.2.1, savannah bushland seems to be starting to develop on the higher and drier parts of the Western Wetland in both Grey and Black Mbuga AEDs. Other bushland, with *Acacia kirkii* usually the dominant species, is already widespread on the lower slopes of the Southern Fans AED. Overall, therefore, savannah bushland seems to be increasing steadily, especially as the Black Mbuga ceases to flood, creating a medium positive trend overall for Savannah bushland. This is of course at the expense of grasslands (Section 4.2.3).

4.2.3 Grasslands extent/integrity

Grasslands in the Usangu Catchment equate largely with the Black and Grey Mbuga AEDs of the Seasonal Wetlands, with the former much more extensive. In addition, two major tracts of Grey

Mbuga are now occupied by large rice schemes, at Kapunga in the west and Madibira in the east. The open grasslands are dominated by *Echinochloa sp*, rhizomatous grasses which are difficult to destroy by surface actions. The condition of the range in both Seasonal Wetlands is considered fair by the SMUWC Range Ecologist. Certainly, compared to the many spectacular examples of overgrazing to be seen in southern and eastern Africa, the grassland appears in reasonable, if not good, condition. However, discussion in Sections 3.1.5, 4.1.1 and 4.1.2 reveal that current trends appear to differ between the Western and Eastern Wetlands, primarily in terms of their timeframe.

In "normal" rainfall years the latter still continue to be wholly flooded each wet season and the resulting grass cover seemed as luxuriant as ever during a visit in January 2000. Upto this point in time its extent also seems unchanged, except where rice irrigation is expanding at Madibira. Despite the large numbers of cattle that congregate on the grassland in the dry season, the SMUWC Range Ecologist found no major concerns with the grassland and soil conditions in the Eastern Basin, although some scattered seasonally overgrazed areas must occur. Such areas disappear the following wet season when the resilience of the Black Mbuga reasserts itself and the whole area becomes thickly grassed. Thus no significant trend seemed to exist in the grasslands of the eastern Seasonal Wetland. However, Section 3.1.5 postulates that conditions currently seeming to affect the Western Wetland grasslands could arrive in the Eastern Wetland if inflows from the Great Ruaha and Ndembera/Mwima are even further disrupted by increasing irrigation diversions. The exceptionally low wet season of 2000 and the failure of half the Eastern Wetland to flood have indicated that the initiation of significant grassland deterioration in the Eastern Wetland is perhaps much more imminent than previously envisaged.

The grasslands of the Western Wetlands already seem to be under serious threat, illustrated this year by the failure of any significant inundation to occur there. Continued reduction in the incidence and extent of seasonal flooding and associated changes in soil conditions will result in declining grassland quality and integrity, the latter already evident in the initiation of tree invasion noted above. It seems very likely that confusion has arisen in local opinion because only the closer and more accessible Western Wetland is observed, and degradation there noted. It may be that this degradation is then inferred to occur also in the Eastern Wetland, which until now has not been the case.

More substantial evidence of the loss of grassland in the higher parts of the Western Wetland (again generally associated with old drainage lines) can be observed in a number of extensive tracts of rainfed cultivation in the Black Mbuga between Ukwaheri and Solulwambo. This ironically enough is Sukuma cultivation; only they have the animals to enable the very heavy Vertisol soils to be ploughed.

Grassland currently occupies the outer parts of the Medium Plateau north of Matamba, between the Chimala River headwaters and the Chimala Scarp. Here it correlates closely with a change in geology from the favourable basalt around Matamba to the acid granitic rocks so widespread in Usangu. It is difficult to ascertain whether this grassland was ever forest that has been cleared or whether it is natural. The near-total absence of trees suggests the latter. Natural dissection and erosion in such vulnerable soils are to be expected. However, the area is presumably grazed and induced erosion is also to be expected. The relatively limited degree of accelerated erosion is surprising: possibly herds are small because of the commitment to intensive cultivation found on the adjacent basalt soils.

In other more extensive granitic Medium Plateau areas in the eastern Uplands tracts of grassland occur both in seasonally flooded valley bottoms (notably in the mis-named Ndembera "swamp") and on the broad, gently convex crests of the hills. The latter are reached after ascending valley and hill sides through Miombo bushland and/or woodland. Popular belief has it that these crests were once forested but it is difficult to envisage by whom, when and how such extensive deforestation would

have been accomplished. Population density is probably the highest it has ever been and yet still remains very sparse. It seems at least as likely that the crest grasslands represent a fire disclimax from a time when fires were fewer and fiercer, preventing forest growth. The influx of people, with crops and animals to protect, may have reduced the impact of fires, even if increasing their incidence. Now there does appear in places to be regeneration of the typical high-altitude Miombo bush dominated by *Uapaca*.

Irrespective of this situation, overall it seems likely that a strong, negative trend is discernible in grassland extent and integrity because of the current threat to the Western Wetland and the possibly imminent spread of the problem to the east. SMUWC needs to concentrate grassland field analysis in the Western Wetland to ascertain what degree of degradation is occurring. The establishment of the new Game Reserve adds to the immediate threat because a high proportion of the excluded cattle are likely to gather on the now highly vulnerable Western Wetland grassland.

4.2.4 Swamp vegetation extent/integrity

The extent of the Perennial Swamp AED (the Ihefu) is thought to have been largely unchanged in recent times (Section 3.1.6). Consequently the total extent of its vegetation will not have changed. However, it seems likely that changes in the type of vegetation within the Ihefu have occurred. Anecdotal evidence from fishermen and locals suggests that the areas of dense grasses (dominated by the aggressive *Echinochloa scabra*), *Vossia* and wild rice (*Oryza longistaminata*) are increasing, while open water areas mostly covered by water lilies (*Nymphea sp*) and associated vegetation are decreasing. Satellite imagery over the past 15 years seems to support this, a logical trend if the Ihefu is getting infilled with silt and thus shallower, as Section 3.1.4 suggests. However, confusion is caused by the 1977 topo-map. This defines only about 1.5 sq km of open water and if the air photo-interpretation on which this is based is accurate there was then a rapid increase to 1984, when satellite imagery suggests 15-20 sq km, decreasing again to the 10 sq km interpreted from the 1998 imagery.

Previous descriptions of Ihefu vegetation have spoken of dominantly “floating” grass vegetation, even though the grass species concerned are rooted species. The implication seemed to be that the dense layer of grass vegetation floated on the surface, even when attached by long stems to roots in the ground. Today it is evident that not only is the grass vegetation extremely dense but that in most places it maintains this density underwater also, creating a significant barrier down to the bed of the swamp. A further possible problem is the presence of water cabbage (*Pistia stratioles*), a fast-colonising species which has caused widespread blockage of waterways in Africa. Overall, swamp vegetation would appear to exhibit at least a medium negative trend.

Two other types of permanent swamp occur in Usangu, both of too limited extent to influence the overall trend noted above.

Ndembera “Swamp” occurs at a higher elevation but was said to be of almost comparable size to the Ihefu and with much better preserved biodiversity. As noted in Section 2.4, SMUWC field observations demonstrated that this was very misleading: a total of only some 5-6 sq km permanent swamp occurs in a series of scattered locations. Vegetation diversity, however, did appear greater, possibly because of the altitude (about 1,800m): major swamp species such as bulrush and papyrus occurred in patches, especially in narrow riverine mini-swamps along the Ndembera River, while there was one Ihefu-like area of permanent very shallow open water within (floating?) grasses or reeds. This occurs immediately below a large village with associated cultivated land, and was seen to be fished by wading (not being large enough for canoes).

The vast majority of the Ndembera Wetland AED is seasonal, forming extensive grasslands in the bottoms of the steep-sided valleys. It is in large stretches flanked by roads, villages and associated cultivation (usually irrigation from springs). The small permanent swamp tracts do not seem to have reduced into extent and if anything have expanded slightly due to the common practice of constructing dykes across the near-level valley floors, presumably to hold back seasonal floods and to provide cross-valley access in the wet season.

The other type comprises a series of similarly very small permanent swamps in the Western Wetland, east of the Kapunga Rice Scheme, mostly comprising the Ifushiro Swamp. Prior to the Scheme being established, there was a more extensive swamp here and it is claimed that the Chimala River used to empty into a permanent swamp north west of the Scheme (which has in effect obliterated the River). Little is currently known about the Kapunga swamps, except they are tiny and might be sustained only by overspill from the Scheme.

Within the Northern Fans, the Lyanami Swamp appears to be a seasonal swamp although little is currently known about it.

4.3 Animal Life (Fauna)

Large mammals were studied by aerial counting and ground observations. Fish biodiversity was examined broadly within the Fisheries Study. The remaining fauna groups were studied during the Biodiversity ground surveys, focused on the Eastern Wetlands, including the Ihefu, and adjacent parts of the Southern Fans AED. Thus at present most SMUWC biodiversity information relates only to the Eastern Wetlands and the immediately adjacent parts of Alluvial Fans. Given the importance now assumed by the potential degradation of the Western Wetlands, there is a call for more biodiversity inputs there.

Potential environmental issues have been considered as possibly arising from current trends in seven main fauna groups:

- large mammal communities/habitats
- small mammal communities/habitats
- amphibian communities/habitats
- reptile communities/habitats
- invertebrates communities/habitats
- fish communities/habitats
- bird communities/habitats

More detailed discussion and data presentation relating to many of the issues covered here are to be found in Supporting Volumes 3 and 8.

4.3.1 Large mammal communities/habitats

Large mammals are rare outside the Northern Hills AED and numbers are limited even there they are not common. Sporadic sightings have been made by the SMUWC Team during fieldwork, again primarily in the north west of the project area. Over the very long term (100-150 years) this represents a major change from the teeming herds of zebra, wildebeest, elephants, rhinoceros, giraffe, impala, topi, hartebeeste, warthog, ostrich etc said to have occupied the grasslands and woodlands

around the perennial swamps in the 19th century. A number of large mammals, such as elephant, rhinoceros and wildebeeste, have long disappeared, although elephant are thriving to excess in the adjacent Ruaha National Park. Only a handful of hippopotami seem to survive in the Ihefu, where only six individuals were counted in the aerial survey.

So far as is known no species of large mammal is endemic to Usangu, although an isolated sub-species of topi has been described (the so-called Usangu Topi (*Damaliscus korrigum eurus*). None of the species now remaining have specific conservation concerns. Many of the species that have virtually disappeared from Usangu are of course thriving in the adjacent Ruaha National Park.

Despite the radical long-term change in the environmental status of large mammals, their numbers and diversity within any meaningful current timeframe (the last two or three decades) seem likely to have remained much the same. The one species which has survived from earlier times but is now probably about to disappear from the Ihefu is the hippopotamus (which may be part of the explanation for the expansion of vegetation). This, plus legalised hunting and especially poaching may be creating a weak negative trend, given the very small numbers that occur. The greater imminence of the threat to the Ihefu's future implicit in its shrinkage in 2000 adds to this trend.

Until recently the key area for large mammals was mostly within the Usangu Game Control Area, which offered relatively little protection. This (including the Ihefu) has now been replaced by the new Game Reserve which in theory will offer much more protection. The current weak negative trend might then be perceived as strongly positive. However, without the Ihefu and Greater Ruaha to provide drinking water the expansion of game eastwards onto the Mbuga will not take place, particularly as the quality of the Mbuga grazing will also diminish without seasonal flooding. The current situation whereby game are found largely in the dense and largely undisturbed Miombo woodlands to the west, where many minor streams are perennial, would persist.

4.3.2 Small mammals communities/habitats

Species diversity of small mammals proved to be low, with no Tanzanian endemics and no species of conservation concern. Most were trapped in the woodlands on the margins of the Ikoga Fan where it adjoins the Black Mbuga AED of the Eastern Wetlands. The SMUWC Biodiversity Surveys emphasised the importance of this habitat to a wide range of fauna, including small mammals. Should the Eastern Wetland cease to flood completely, as it did in 2000, then this habitat will decline rapidly. A very weak negative trend might be recognised but in view of the limited numbers and diversity this is unlikely to be significant.

4.3.3 Amphibian communities/habitats

Relatively few species were found in the permanent waters and floating vegetation of the Ihefu. However, at the start of the rains in December 1999, huge numbers of frogs and toads emerged from aestivation on the eastern Seasonal Wetland, especially towards its interface with the dry woodlands of the Southern Fans AED (Ikoga Fan, in this instance). The Ikoga Fan is much less affected by cutting and cultivation than Alluvial Fans further west.

The number and range of species was normal for such a habitat and are widely occurring in eastern and southern Africa. No endemic species were noted, except possibly a Sand Frog (*Tomopterna sp*) that may be endemic to the Ruaha ecosystem as a whole, including Usangu. Two other interesting

species were: a Pygmy Toad (*Bufo sp*) which was not immediately identifiable to species); a Shovel-nosed Frog (*Hemisus sp*) which previously may have been found only in dry areas of Tanzania.

None of the species seen is regarded as threatened or is on any CITES index. No legless or other amphibians were observed.

As noted in Sections 3.1 and 3.2, major physical changes took place in the Eastern Wetlands in year 2000, when only half the area was inundated. The ecologically critical interface with the Southern Fans AED adjacent to the south east therefore failed to occur. The possibility that this situation will occur with increasing frequency from now on suggests a weak but significant negative trend relating to amphibian communities and habitats. Another possible future threat might be excessive exploitation of the surrounding Alluvial Fans, especially near the current wetland margin.

4.3.4 Reptile communities/habitats

The limited survey programme encountered few reptile species and little species diversity. Terrapins (*Pelusios sp*) were found in the Ihefu, where the aerial survey also counted three crocodiles. The latter seem to be approaching extinction within the Ihefu but numbers are likely to have been low for a long time.

Few reptiles were found on the open dried grassland of the seasonal Eastern Wetland. Most species were observed in the woodland margins at the foot of the Ikoga Fan, around the survey camp. Again, these species are widely found in eastern and southern Africa and none were endemic of or special interest. Most were lizards, geckos, skinks etc although snakes are certain to occur and larger Monitor Lizards have been seen previously.

Despite the startling changes during 2000 in what had previously been presumed a fairly stable environment, reptile numbers and diversity seem to have declined a long time ago to a level at which significant negative impacts are unlikely. The very low and largely seasonal human population of fishermen and pastoralists is diminishing further with the Game Reserve establishment proceeding. These may have killed snakes but probably not in numbers that matter. One possible negative trend is that there has been a recent acceleration in the decline of crocodile in the Ihefu due to fishermen killing them for safety (there is no evidence of any live animal or crocodile skin trading); however, it is more likely that crocodile numbers depleted below the critical survival point a long time ago. Overall an insignificant trend is assumed.

4.3.5 Invertebrates communities/habitats

To date the SMUWC biodiversity investigations have not included invertebrates, so little is known about their status in the Project Area, and especially in and around the Ihefu. Dragonflies and butterflies have been seen in large numbers but not studied. Common cattle flies are certainly present in vast and very uncomfortable numbers in the Eastern Wetland, especially when it is dry. Invertebrates are an important source of food for the amphibians, as well as some birds. It is anticipated that SMUWC's Environmental Functions Study will include information on invertebrates when it is completed. At present, no significant trends are assumed.

4.3.6 Fish communities/habitats

Section 5.4.4 shows that the fish catch in the Ihefu, its surrounding seasonal wetlands and upstream in the lower reaches of the Great Ruaha River consists almost entirely (99% estimated) of catfish (*Clarias gariepinus*, locally "kambale"). Only a tiny number of other, much smaller fish (barbids and cyprinodonts) have been observed and/or reported by fishermen. Although no specifically ecological study of fish has been undertaken, it appears unlikely that significant additional species or communities occur. Again, SMUWC's imminent Environmental Functions Study should help confirm this assumption. The low fish species-diversity reflects the stressful environmental conditions in the Ihefu and surrounding seasonal wetlands, to which the catfish have adapted extremely successfully.

Tilapia (*Oreochromis* sp) is likely to occur in the middle reaches of the Great Ruaha and its perennial tributaries where they cross the Alluvial Fans and Western Wetlands. It is certainly caught in the upper reaches of the Nbembera River (where catfish are still the main catch, from the tiny tracts of permanent swamp).

No endemic fish species seem to occur, nor any species of conservation concern. It is possible that the arrival on the Seasonal Wetlands of much larger numbers of cattle in the 1970s significantly increased the fertility of the grasslands for young catfish by providing a great increase in cattle dung. Even though catfish are not ecologically exciting they occur in huge numbers as a very successfully adapted species. The eviction of the fishermen from the Ihefu (as part of the Game Reserve) has largely destroyed the small fishing industry there, so no significant impacts from fishing are possible. After the events of 2000 the possible future threat to the fish population posed by the possible drying-up of the Eastern Wetland and Ihefu appears much nearer reality. In view of this a negative trend has to be identified, the low ecological importance and near-total dominance of the catfish limiting it to weak.

4.3.7 Bird communities/habitats

It has been seen that the environmental status of the fauna groups reviewed above reveals nothing special in the way of diversity or endemism. Birds, and especially wetland birds, are different in terms of their numbers and diversity. The Ihefu and its surrounding Seasonal Wetland form a highly successful habitat for wetland birds, but other parts of Usangu also provide intensively-used temporary habitats during the uneasy period from November to January between the dry season and the main rains. One such area is the anthropic habitat created by the flooded rice fields: large numbers of some 30-40 species of wetland bird were observed there in mid-January 2000. Another is the Northern Fans AED, where early rains create shallow pools of water on the hardpan soils and a first flush of luxuriant grass around them: several hundred water birds were observed here during January 1999, including numerous Crowned Cranes (said to be rare in Usangu).

The most spectacular sight, however, are the thousands of wetland birds concentrated on and around the Ihefu during the dry season, when no other wetland of any size is available. Even though no endemic species appear to occur in Usangu, the sheer numbers of birds and species in and around the Ihefu illustrate its fundamental importance as a wetland. In addition, it does support certain species becoming rare in Tanzania or otherwise of special interest. These include the Wattled Crane (*Bugeranus carunculatus*), Crowned Crane (*Balearica regulorem*), the White-throated Swallow (reported only three times in Tanzania, two of which were in the Ihefu), and the Yellow-crowned Bishop (*Euplectes afer* – a scarce weaver bird species). All of these have been observed by SMUWC.

Denham's Bustard (*Neotis denhami*), a decreasing species in East Africa) has been reported from other sources to occur in Usangu.

Certain species found in Usangu are important because of their conservation status. "Near-threatened" species include the Pallid Harrier (*Circus macrouros*), Black-winged Pratincole (*Glareola nordmanni*), Great Snipe (*Gallinago media*), and Basra Weed Warbler (*Acrocephalus griseldis*). Species defined as "vulnerable" include the Wattled Crane and the Lesser Kestrel (*Falco naumanni*). Usangu is also the only location in Tanzania where the four species of Coucal (Black, Senegal, White-browed, Coppery-tailed) are found together.

Despite the greatly increased human interventions in Usangu during recent decades, it is difficult to see how the wetland bird communities have suffered significantly because they persist in such vast numbers and diversity. At least 300 species have been sighted in a very short period of time by a German team (Max Planck Institute for Behavioural Physiology, pers. Comm., January 2000) which is currently studying the Black Coucal at Kapunga - there are only about 250 bird species in the whole of Europe! In fact, the obvious value of the rice paddy habitat to the wetland birds suggests that they represent a positive trend with respect to their habitats and hence their communities (although some of the rice areas, notably Kapunga, was previously under permanent swamp, an even better avian habitat).

Against this certain species may have suffered or even disappeared because of human activities, although there is no evidence that this has happened. Such activities include:

- intensive cattle grazing causing trampling of nests and young around the margins of the Ihefu;
- birds caught in fishing nets or by hooks and lines, or taken for food by the fishermen (although the latter already have abundant food available from their fish);
- birds shot by hunters and local people for recreation;
- birds shot or trapped to protect crops.

The wetland birds are especially important because their habitats are relatively few and localised in Tanzania and elsewhere in Africa, compared to the vast areas available to dryland birds. In addition, many of the wetland birds are migratory. Usangu seems to be on an established and important flyway for birds migrating between southern Africa and the Palaearctic in northern Europe. Considerable effort and expense in Europe are being directed to protect and sustain these birds, making it important that they do not then suffer unduly in Africa. Other species are IntraAfrican migrants. Tanzania's recent signing up to the Ramsar Convention means that Ramsar sites have to be selected and established in the country: the Ihefu ought to be considered as such to ensure no future decline occurs.

The imminent threat to the Ihefu and the Seasonal Wetlands implicit in the events of 2000 changes the whole discussion of the Interim Environmental Baseline in respect of wetland birds. The Wetlands, and especially the Ihefu, provide by far their most important habitats in Usangu and if these are under serious and possibly imminent threat a negative trend has now been established. Given the numbers and diversity of wetland bird life in Usangu, this is further assessed as a medium negative trend at this early stage.

Outside the wetlands, the widespread destruction or degradation of habitats on the Alluvial Fans and in the Uplands will have had some negative effect on dryland bird species, although huge relatively undisturbed areas of such habitats remain.

4.4 Protected Areas

Strictly speaking, protected areas are a human rather than biological resource but they are included here because of their importance to biotic resources in and adjacent to the Usangu Catchment. Potential environmental issues have been considered as possibly arising from current trends affecting two protected areas:

- Usangu Game Reserve
- Ruaha National Park

More detailed discussion and data presentation relating to the issues covered here are to be found in Supporting Volume 1.

4.4.1 Usangu Game Reserve

The Usangu Game Reserve was established during 1998-99. It occupies almost the whole of the the Eastern Wetland and all of the Ihefu within it, as well as extensive miombo areas in the Northern Hills AED to the west. The latest conservation policy at national level recognises the need for a new category of protected area, a **Wildlife Management Area**, where community-based conservation will be practised and multiple use to include controlled grazing, fishing, etc will be accepted. Even within the current status of Game Reserve such multiple uses are possible under ministerial decree.

However, the present sentiment expressed at District Government level is that all cattle must leave the Usangu Game Reserve, all fishing must cease, and any villages must be abandoned. Thus most of the fishermen have during 2000 been evicted from the Ihefu and their huts and work places burned. Similar eviction of pastoralists has been initiated, with some burning of bomas. Even so, numerous cattle remained within the Game Reserve boundaries during the 2000 dry season. It is said that the necessary compensation to those affected is being paid. It is difficult to see how the Game Reserve will ever generate revenues comparable to those from pastoralism; livestock is currently the source of over half Mbarali District's taxation income.

As noted in Section 3.2, much larger areas and many more people than currently found in the Eastern Wetland are likely to suffer following the establishment of the Game Reserve. The livestock will have to go somewhere else, either within Usangu Catchment and/or outside it to other Tanzanian grazing areas. It is highly unlikely any of these areas thus affected will be anything like so suitable for livestock, especially as the Western Wetland grasslands rapidly decline (Section 4.2.3). The Eastern Wetland is currently otherwise unused (and, apart from wildlife, largely unusable in the local context). On a much smaller scale, a highly successful local fishing enterprise has been destroyed. Neither grazing nor fishing can be shown to have been adversely affecting the Ihefu or the Eastern Seasonal Wetland to any unmanageable extent.

What the Game Reserve does offer is a valuable administrative framework within which a more flexible approach might be considered and achieved. From the point of view of the Game Reserve itself and its potential impact on biotic resources, of course, a medium positive trend has been established with the setting-up formalities completed. How successful grazing, fishing and settlement controls will be still remains to be seen – in November 1999 a recently deserted Sukuma village just within the Reserve was observed being re-occupied by Sukuma, who were busy re-thatching hut roofs. However, the events of the 2000 dry season suggest that Government is determined to fully implement Game Reserve regulations.

Despite the many negative human, biological and physical impacts that will result from the Game Reserve, its proceeding implementation clearly represents at least a moderately positive trend from its own perspective.

4.4.2 Ruaha National Park

The Ruaha National Park has to date been the main off-site sufferer from the decreased dry season flows in the Great Ruaha. Pre-1993 even the very low dry season flow served to maintain sizeable communities of hippopotami and crocodiles in the Park. This has become increasingly difficult as the river has dried up for longer and longer periods where it serves as the eastern boundary of the Park. Many of the animals, terrestrial and aquatic alike, are subject to increasing stress, morbidity and death. In addition, the scenic attraction of a running river, however, small the flow, outweigh those of a dried river bed. Even more of a problem is that this drying-up drives the terrestrial wildlife further and further away from the river (and the tourist camps) to find water further to the west in the hills, so that viewing them becomes more difficult for the tourists. The Park is clearly suffering a serious negative impact on both its tourism role and on its biotic resources as a result of the hydrological changes in the Great Ruaha River.

Should the Usangu Game Reserve be successfully established and the Ihefu continue to survive, further problems could be created for the National Park. The numbers of wildlife already leaving the main tourist area on the Park could accelerate, as animals discover the safety and ample perennial water supply in the Game Reserve, which is a very considerable distance away.

5. HUMAN ENVIRONMENTAL RESOURCES BASELINE

Note: Certain of the issues in Chapter 5 have not been considered in any depth by SMUWC and so little data are to hand regarding them. They are included here for completeness. The trends identified, therefore, are often based on more casual observation and anecdotal evidence and are consequently broader and less substantiated than in Chapters 3 and 4. Most issues can be assessed in terms of four main impact groups: dry (i.e. rainfed cultivation) farmers; irrigation farmers; pastoralists; women. In practice of course these groups may overlap, with farmers belonging to two or more of them.

5.1 Social

Nine potential socio-environmental issues have been considered as possibly arising from current trends affecting the different human impact groups:

- human carrying capacity
- population
- demographic structure
- land tenure/security
- social equity
- social cohesion/conflicts
- social attitudes
- gender and age issues
- health and safety

More detailed discussion and data presentation relating to some of the issues covered here are to be found in Supporting Volume 9.

5.1.1 Human carrying capacity

Clearly the rapid expansion of irrigation development in Usangu in recent decades has greatly increased the human carrying capacity of the area. To a much lesser extent, the clearing of woodland and scrub on the Alluvial Fans has added to this strong positive trend. To date, there is little evidence that human carrying capacity has been significantly reduced by human interventions or natural changes. The now apparent deterioration in the Western Wetlands implies a decrease in livestock carrying capacity which in turn leads to reduced human capacity. It is unlikely that the embryonic cultivation in the Western Wetland could reach significant proportions, given the low rainfall, deteriorating soils and lack of inundation. The establishment of the Game Reserve in the Eastern Wetland and Ihefu also reduces human carrying capacity there. However, the density and numbers of people involved in pastoralism and fishing are very much less than for irrigated or even rainfed agriculture.

5.1.2 Population

Clearly the rapid expansion of agricultural development in Usangu in recent decades (especially irrigated rice but also including dry season irrigation, rainfed cultivation and pastoralism) and

associated agro-industrial activities and service industries has led to a considerable population growth. There has inevitably been some out-migration of younger people but on nothing like the scale experienced in less-developed rural areas in Tanzania and much of Africa. In any case, this has been more than balanced by the successive waves of in-migrants from many other parts of Tanzania, most noticeably the Maasai in the 1950s and the Sukuma in the 1970s. Although the last population census was in 1988 the current growth rate is thought to be around 3.0% per year. This is a high rate for a rural area but not perhaps as high as the known scale of in-migration and the rapid expansion of irrigation might have been expected to create.

Population growth is particularly centred in the Alluvial Fans of the south and on the Low and Medium Plateaus in the east, especially along the Iringa-Mbeya highway. However, in the under-developed north and west of Usangu, population growth has been much less. The main stimulus has been the arrival of the Sukuma, who have established numerous small hamlets in the Northern Fans AED and even in parts of the Seasonal Wetlands. But despite the large numbers of cattle, the herds support relatively small numbers of people. Any mainly Sangu villages in the north and west are more likely to have seen migration of their younger males to the larger villages and towns further south, where employment opportunities created by the greater development are more available.

There are two other imponderables which might be reducing population. The first is if the Sukuma are leaving Usangu in significant numbers, spurred by the efficient taxation of their herds and by the exclusion from their main dry season grazing area now gazetted as a Game Reserve. The second is the impact of the AIDS epidemic felt throughout much of Africa. Reliable data for either of these is lacking but they may explain why population growth is not even greater, given the intensive development and near-continuous in-migration in recent decades.

Another limit might be the exhaustion of natural resources, especially in relation to continued rice expansion. However, suitable land in the shape of Lower Alluvial Fan slopes, Grey Mbuga and now even rapidly degrading Black Mbuga seems in plentiful supply. The natural limit, when it is reached, will be water. However, at present only very small proportions of the Mbarali and Kapunga rice schemes are being utilised and attempts are being made to increase the cropped area through smallholder and other non-government development. At the third large scheme, Madibira, only half is being utilised, even though it is now a smallholder enterprise. Thus several thousand hectares of rice are currently available using existing land and water resources, if the right management initiatives can be attained. More efficient management of water resources,as illustrated by SMUWC, would release additional water resources, some of which would be available for expanded cultivation even if much is reserved to preserve the Ihefu and Great Ruaha flow out of Usangu. A judgement by stakeholders that these last aims are of relatively lesser importance would allow further rice and dry season crop expansion. Alternatively a market limit to cultivation might be reached but this seems unlikely for national or export markets, to which Usangu has very good communications and access.

At present, as a result of the variable distribution of settlement and possible adverse factors noted above, the current trend in population growth is estimated as medium rather than strong positive.

5.1.3 Demographic structure

Many undeveloped areas exhibit a typical redistribution of a “normal” demographic structure because the young and middle-aged males in particular have to migrate out to other areas to find work and income. Thus the demographic structure thins in the middle, leaving it top-heavy in terms of the proportion of old people and with an unwieldy wide base representing children. This means that there are too few able-bodied males to undertake heavy duties in the village, putting an extra burden on the

already overworked females. Also, the absent males might decide never to return or at least to spend most of their earnings in their new localities. As noted, this weak demographic structure might be the case in the north and west of Usangu, although to a large extent it will have been countered, statistically at least, by the Sukuma in-migration there.

In the developed south and east of Usangu it is unlikely that this negative trend has occurred and that demographic structure remains reasonably stable. The substantial development there may even cause a positive demographic trend if workers are attracted in from north west Usangu or elsewhere. Overall, the various trends probably balance out to give no significant net trend. It is possible, of course, that AIDS has had a significant impact, of which SMUWC is currently unaware.

5.1.4 Land tenure/security

In theory all land in Tanzania belongs to the Government and is allocated to farmers and others by the Village Council, whose actions have to be approved by the Village Assembly (theoretically comprising all adults in the village). This system appears to work remarkably successfully, leading to few problems of cultivated land subsequently being taken away from farmers against their will. In addition, in practice it appears that these land rights can be bought and sold at a village level, as happens mainly with irrigated land.

It is not clear what happens with irrigated land: does a farmer with 5 ha of rainfed land retain all of it if irrigation water suddenly becomes available, given that returns per unit of land would increase dramatically?

Women have in theory benefitted from the recent Land Act which gives them similar land tenure rights to men. However, this is unlikely to have been implemented on any significant scale at this early stage.

Grazing land rights are much weaker than for cultivated land. When new agricultural lands are needed for an expanding population, the easiest and most obvious source lies in the village's grazing lands. Since the farmer wanting land is usually a Sangu or other type of cultivator settled permanently in the village and the grazing rights have often been bestowed on Sukuma or other pastoralists, this practice is a common source of conflict.

Thus cultivated land tenure is basically secure but grazing land tenure is not. As population has grown and the intensity of both cultivation and grazing has increased, the struggle to obtain and hold land has become more difficult and complicated, especially with the factors of increasing irrigated area and increasing grazing. Overall it would seem that a medium negative trend in land security has been created.

5.1.5 Social equity

Unless special measures are taken, it is usual in the developing world for rural development in general and irrigation in particular to exacerbate social inequity. This is because those higher up the socio-economic scale are usually in a position (both geographically and socio-politically) and have the experience to take greater advantage of socio-economic improvements. The land at the head of an irrigation system always seems to belong to the rich and the often-deprived lower end to the poorer farmers.

In Usangu similarly increased social inequity is related primarily to access to irrigation water and so is concentrated in the Irrigated Fans AED. The differentiation in equity here often results more from geographical position than from pre-existing social status, although the two are sometimes interlinked. Differences occur not only between individual farmers but also between hamets and even villages (e.g. Madabaga and Kimani) that share the same irrigation supply system.

One major example of inequality is created by the Madibira Rice Scheme. This was supposed to have been set up to encourage smallholder rice. Unfortunately, by failing to establish any sort of credit system and setting very high initial investment levels, only the relatively wealthy can afford to participate in the Scheme. As a result less than half the 3,000 ha have been taken up and land ownership within the Scheme is said to be concentrated in a few families using multiple relatives to gain allocations. It remains to be seen who will be allocated land within the currently almost defunct Kapunga Rice Scheme.

Another source of inequity is the greater status given to cultivated land relative to grazing land (Section 5.1.4). Thus cultivators seem often to receive preferential treatment by village and local government, especially regarding land allocation and tenure. This is a disparity that has strengthened with the arrival of the Sukuma pastoralists, partly in response to their aggressive and insular grazing activities, which have often enabled the pastoralists to counter any inequity.

Social inequity is certainly less marked in Usangu than in more feudal or tribal rural societies elsewhere in Africa and the developing world. This perhaps may be because so many smallholders have been able to participate in the irrigation development - in this respect the locations of the large State enterprises on the lower Alluvial Fans and beyond may have helped. In addition, the land allocation system via the Village Council must have helped fairer land distribution for irrigation, if not for grazing. Overall a medium rather than strong negative current trend in social equity might be recognised.

SMUWC's various social initiatives in coordination with the Districts and selected villages and subcatchments (the CEP, with its TMV, SRMP, RLR) are designed to combat social inequity but will need considerable time to achieve major results.

5.1.6 Social cohesion/conflicts

For several decades now there seems to have been an acceleration in the breakdown of social cohesion and increase in social conflicts caused by the clash between cultivators (especially the Sangu) and the pastoralists (especially the Sukuma). The high-handed attitudes of the Sukuma regarding their rights to graze result in endless clashes with farmers whose fields are trampled or crops destroyed by rampaging herds of livestock.

Section 5.1.4 highlights a fundamental source of the conflict, in the weak hold over grazing land rights compared to generally secure cultivated land rights. This constant dispute over land has now culminated at District level in the recent establishment of the Usangu Game Reserve on the main dry season grazing lands, with the possibility of dire environmental consequences (see Section 3.2.

Social conflict is a vital and complex issue in Usangu. Whereas most of the in-migrants have eventually been accommodated and assimilated, even the Maasai, the Sukuma remain largely a people apart from the mainstream farming culture. A strong negative trend is apparent and needs urgent attention. In many ways the Sukuma are a substantial economic benefit to Usangu, paying

considerable livestock taxation while utilising a major resource (the Seasonal Wetlands) which is unlikely to provide significant economic benefits in any other way.

Again, SMUWC's various social initiatives in coordination with the Districts and selected villages and subcatchments (CEP, TMV, SRMP, RLR) are designed to help resolve social conflict but will need considerable time to achieve major results.

5.1.7 Social attitudes

Ironically, Government's policies of decentralisation and privatisation have still to take successful root in rural communities such as those in Usangu. This is because they have been accompanied by the disappearance or decline of many government support services, such as the now non-existent veterinary service. Another factor is the widespread disillusionment among villagers with the effectiveness and trustworthiness of government or public authority in any form.

Against this the greatly improved health, education and transport communications in much of Usangu presumably meets the wishes and earns the plaudits of the local people. Even so, the basic distrust of government is a major obstacle to the community participation believed neceswsary for sustainable development. Overall, there seems to be a medium negative trend.

SMUWC's various social initiatives in coordination with the Districts and selected villages and subcatchments (CEP, TMV, SRMP, RLR) aim specifically at participation by all stakeholders, including the local people, in major strategy decisions. Such processes should help counter negative attitudes towards Government.

5.1.8 Gender and age issues

Women have traditionally suffered inequality in African society. In Tanzania attempts are being made to redress this situation. The new Village Land Act gives women the right to "own" land in the same way as men (i.e. to be allocated land by the Village Council). In addition, 25% of the Village and District Councils must now be women. In these very early days, implementation is not always satisfactory but the vital first legal steps have been taken.

Another advantage in Usangu for women, at least in the south and east, is that out-migration by their men has become much less than in most rural areas of Tanzania (Section 5.1.3), which reduces the heavy burden on women to some extent. In the irrigated areas water supply is often via the irrigation channels, a much denser network than natural channels, so that one of the most arduous female tasks, water carrying, is lessened. Piped or well water supplies are said to reach 60% of the people in Usangu, much more than a few decades ago, and again reducing water-carrying demands on women. The accelerated development has led to improvements in education, with women receiving education much more than previously. Health treatment has expanded and improved, with probably greater benefits to women than men because of childbirth-related problems, although women are being slow to take advantage of the services regarding the latter. Women still carry a disproportionate share of the workload, especially in the less-developed north and west, where water and health facilities remain very limited.

The aged have probably benefitted significantly in recent decades from benefits such as better food and nutritional supplies, better health facilities, etc, while children would also benefit from these and from increased and improved educational opportunities, albeit now at a cost that will limit the benefits for many families.

Overall, it would seem likely that there is a medium positive trend in gender and age issues in Usangu.

5.1.9 Health and safety

There are no major safety issues in Usangu. However, wherever water resource development occurs, there will the threat of major health hazards from increased water-related diseases, such as malaria and, in Africa, bilharzia. Bilharzia is said to be a major problem in Usangu but is not mentioned in the long lists of problems prepared by the CEP villages, which are very representative.

The extent of standing water in the wet season has actually greatly reduced, as Section 3.1.5 implies: 40,000 ha of wet rice fields appear to have replaced some 300,000-350,000 flooded area in the Western Wetland. This reduces the net extent of breeding waters for mosquitoes and other disease carriers, but not the snails that host bilharzia as they would not occur in seasonal wetland that is dry for several months of the year (although localised patches of longer-term wetland occur in drainage lines and depressions.

Although covering a much smaller extent than the seasonal wetland, the rice is much nearer to the main population areas in the south (creating a rare comparative advantage for the under-developed north and west). Human activities in the paddy fields and channels are also much more intensive than in the wetlands. A further intensive human use is the fisheries in and around the Ihefu, where bilharzia is likely to be rife. Thus irrigators and farmers are particular impact groups for bilharzia and malaria. Malaria is reported by the CEP villages and is considered generally to be a problem, although this must partly reflect the much denser population. Water-borne disease data would be of value in managing water resource development in Usangu.

The numbers of fishermen were already tiny in relation to the population of Usangu prior to their eviction from the Game Reserve. Herders for the livestock in the surrounding Eastern Wetland, would seem likely also to be prone to water-borne health threats, as well as to diseases induced by the vast fly population that appears there at certain times of the year. Like the fishermen they will escape these health hazards by eviction.

The 40% of the project area in the large and often highly populated Low and Medium Plateau units in the east should be relatively free of water-related diseases because there are no major wetlands or rivers except for the Ndembera seasonal wetlands and tiny perennial swamp patches.

Apart from water-related diseases, and especially bilharzia, the overall health of the community should be improving (if AIDS, about which SMUWC has no information, is discounted). Obvious reasons for this include the now more numerous hospitals and village dispensaries (although many villages still lack a clinic or the staff to operate it, again especially in the north and west). The higher levels of income from the development lead to higher nutritional levels, directly impinging on health. Better education (Section 5.1.8) should also be leading to better health. A medium positive trend might reasonably be assumed overall regarding health throughout the Usangu Catchment, any strong trend being tempered by the assumed increase in water-related diseases in the Irrigated and Southern Fans AEDs.

5.2 Socio-economic

Four potential socio-economic issues have been considered as possibly influenced by current environmental trends:

- incomes
- employment
- land values
- credit availability

More detailed discussion and data presentation relating to many of the issues covered here are to be found in Supporting Volume 9.

5.2.1 Incomes

The major expansion of agricultural development in Usangu in recent decades (especially irrigated rice but also including dry season irrigation, rainfed cultivation and pastoralism) and associated agro-industrial activities and service industries must inevitably to have led to a considerable improvement in incomes at most socio-economic levels of the population. There is a possibility that natural resource and/or market limitations might soon reduce the strong positive trend of recent decades but as discussed in Section 5.1.2 this might be some way off.

Again this has to be qualified sub-regionally because this strong positive trend in the south and east of Usangu is unlikely to have been repeated in the Sangu villages of the north and west. However, there may have been a significant rise in incomes even in the north and west because of the influx of the Sukuma pastoralists, with their valuable herds, although much of their nominal wealth remains in terms of livestock owned rather than annual income. This latter trend will now be threatened and possibly reversed by the establishment of the Game Reserve. For the fishermen the positive trend has been catastrophically reversed during 2000, with their eviction from the Ihefu.

5.2.2 Employment

Much the same comments apply to employment, with opportunities flourishing in the south and east relative to the north and west, with the Sukuma again providing their own employment as pastoralists. Overall, there is likely to be a strong positive trend.

5.2.3 Land values

In theory all land in Tanzania belongs to the Government but in practice land rights can be bought and sold at a village level on a “freehold” basis. Agricultural development, and especially the establishment of irrigation, must have substantially raised the price of lands in such transactions, another strong positive trend from the “owner’s” viewpoint.

5.2.4 Credit availability

Credit availability has probably improved in the main development areas in the south and east, but less so in the under-developed north and west. However, credit funds from formal banking sources seem limited and much of the local credit is probably informal. Rates may be high but possibly less than previously, since as the developed areas have thrived, the chances of default are likely to have decreased.

Madibira Rice Scheme is again a special case. Here it was apparently intended to set up a credit system as part of the development. In practice it has not happened and, as noted in Section 5.1.5, it has proved difficult for smallholders to find the money, collateral and confidence to participate, given the very high capital investment demanded.

The best that is likely regarding credit availability is a weak positive trend, which contrasts with the currently strongly positive trends in the other socio-economic indicators.

5.3 Institutional

Three potential environmental institutional issues have been considered as possibly arising from current trends:

- institutional activity
- institutional effectiveness
- community participation

More detailed discussion and data presentation relating to many of the issues covered here are to be found in Supporting Volume 10.

5.3.1 Institutional activity

In recent decades there has been a strong upsurge in institutional activity in the project area and at national level in areas that relate to environmental resource management. First, above all, has been Government's decentralisation policy, greatly increasing the roles and powers of District Governments. In addition, there has been the privatisation policy, removing the huge but impotent state monopolies in so many areas. Then, in the Usangu Catchment, there has been the establishment of a new District, Mbarali (centred on Rujewa) correlating broadly with the main Lowland and Wetland parts of the project area..

These major changes have been backed up by some key government initiatives, legislation and projects:

- National Environmental Management Council (NEMC);
- National Environmental Action Plan (NEAP), 1994;
- National Environmental Policy (NEP), 1997;
- Division of Environment (DoE), 1990 - now within the Vice President's Office;
- Local Government Reform Programme (LRGP);
- Institutional and Legal Framework for Environmental Management (ILFEMP), 1998 - leading to National Environmental Management Programme (NEMP);
- River Basin Management and Smallholder Irrigation Improvement Project (RBMSIIP);
- Rufiji Basin Water Board (RBWB), 1993/4;

- Rufiji River Basin Authority (RUBADA) and its Community-based Watershed Management Programme for the Usangu Plains and Catchment;
- National Land Use Planning Commission (NLUPC) - within the Vice President's Office;
- National Land Policy (NLP);
- Land Act and Village Land Act, 1999;
- National Water Resources Management Policy (under preparation).

Just recently the Vice President's Office issued directives that each District should establish a separate Environmental Committee, rather than it coming under the Economic and Environment Committee as at present.

5.3.2 Institutional effectiveness

The above appears to create a formidable institutional, legal and planning framework for environment resource management, providing the institutional apparatus for sound strategic planning of resource management in the Usangu Catchment (and other parts of Tanzania). Unfortunately implementation is not as easy as establishing policies and agencies. Legislation has been slow but the basic difficulty is that at District level there is dearth of experience, equipment and funds available for implementation of these excellent ideas. Thus institutional capacity and effectiveness with regard to resource management show no significant positive trend and need urgently to be addressed - precisely the aim of the SMUWC Project in the Usangu Catchment. The positive trend here is at best only weak.

5.3.3 Community participation

Again, the above institutional agencies and activities provide a reasonable framework for community participation in resource planning and implementation. The LRGP and Village Land Act invest villages with their own land planning and management responsibilities and the right to pass their own bye-laws in this respect. However, the capacity of village institutions to administer and manage their own communities' land, natural resources and funds is generally very weak. Many factors contribute to this:

- shortage of people at village level with competence and experience in planning, managing and implementing programmes in the public domain;
- widespread disillusionment among villagers in the effectiveness and trustworthiness of government or public authority in any form;
- a weakening of traditional forms of authority without replacement by effective modern forms;
- large size of village areas and distances between hamlets;
- differences in ethnic origins, languages and livelihoods between the inhabitants of hamlets within the same village;
- high proportion of newcomers;
- the Sukuma, with their set ways and large disruptive herds;
- poor intercommunication between hamlets and people within the same village;
- untrained and uninformed village officers;
- rapid turnover of village officers;
- village revenue goes almost wholly to pay village officer allowances;
- lack of accounting understanding , leading to fund losses and mistrust;

- focus on tax-collecting and simple actions, avoiding the more complex but often more important or urgent tasks;
- resource assessment, land use planning and environmental management have previously always been regarded at village level as responsibilities of District and higher levels of government.

Against this long list of problems certain aspects of local level cooperation and organisation reveal the potential that is there to be tapped for community participation. The development of smallholder irrigation in Usangu, for instance, has been a cooperative effort involving many people and activities, as well as a degree of trust. Similarly, the DANIDA-funded piped water supply to certain villages demanded that local people learned to maintain and organise the systems, with a degree of success. Thus there is some justification for recognising at least a weak positive trend in community participation.

SMUWC has already begun to tackle the problems of community participation through its Community Engagement Programme (CEP) and other socio-institutional activities and is optimistic. However, it is extremely unlikely that the early impetus created to date could be maintained in the now-probable absence of a SMUWC.

5.4 Human Use

Potential environmental issues have been considered as possibly arising from current trends affecting 12 main areas of human use activities:

- rainfed cultivation
- irrigation
- livestock/pastoralism
- fisheries
- forestry
- agro-industrial activities
- transport communications
- domestic water supplies
- recreation
- tourism
- energy supply
- energy utilisation

More detailed discussion and data presentation relating to many of the issues covered here are to be found in Supporting Volumes 1-5.

5.4.1 Rainfed cultivation

As noted in Sections 3.1 and 3.2, extensive areas have been cleared and devoted to rainfed (i.e. wet season) cultivation, mostly growing mainly maize plus crops such as sorghum, millets, beans and other vegetables. Fruit trees, especially mango, have been established in and around many hamlets. Rainfed cropping occurs in a variety of areas. The two main locations are:

- on the upper slopes of the Southern Fans AED and the often associated Sand Hills AED;

- over other very large tracts of the Medium and Low Plateau AEDs occupying much of the eastern third of the project area.

In addition there are a number of more localised and often specialised rainfed cultivation areas:

- on the margins of the Northern Fans AED in villages such as Upagama and Solulwambo and nearby rare "islands" of lighter soils in the Western Wetland, such as Ukwaheri village hamlets;
- within the small but increasingly frequent cultivated "bomas"scattered further upslope on the Northern Fans AED, providing mainly subsistence maize and millet for the Sukuma living there;
- in the clearings in the miombo created around villages such as Msangaji and Idunda in the Northern Hills AED;
- a quite specialised area of essentially rainfed cultivation (supplementary irrigation can occur but is minimal) of maize and potatoes around Matamba, on the rich basalt soils of the Medium Plateau in the Chimala upper catchment, with potatoes and pyrethrum grown on the margin of the High Plateau above.

Many of these rainfed cultivation areas were initiated a very long time ago, so that the current trend starts from a substantial base. Even so, rainfed areas have increased in extent in recent decades, often markedly so, creating a medium positive trend.

5.4.2 Irrigation

SMUWC has focused closely on the steady expansion of irrigation (see Supporting Volume 5) in the Usangu Catchment during recent decades, currently a very strong trend. Expansion seems likely to persist in the immediate future, although slowing down as water availability and possible market limits approach (Section 5.1.2).

The major irrigated areas are to be found on the lower slopes of the Southern Fans AED and on two main expanses of Grey Mbuga: Kapunga Rice Scheme and associated smallholder development spread from the Kapunga Fan into the Western Wetland margin, while Madibira Rice Scheme impinges on the north eastern extremes of the Eastern Wetland (although most is probably on the lowest part of the Ndembera Fan). At least 40,000 ha of wet season rice are estimated by SMUWC to be cultivated today in a reasonable rainfall year. This may have been higher in the 1998 *El Nino* excessive rainfall year (although some of the crop was washed out). Rice extent is thought to have been halved during 1999's 30% rainfall deficit to the "core areas" totalling about 15,000-20,000 ha. In the much drier 2000 wet season the extent may have been towards the lower end of this core range.

The core area in fact may currently exaggerate the extent of rice cultivated because it seems to include the total areas of the three big schemes. In recent years only an increasingly small proportion of Kapunga has been cropped and less than one third of Mbarali, while Madibira as noted has been expanding only slowly to its current cropped extent of just over half. Thus some 6,000-6,500 ha of the rice core area may not be actually cropped, even though the requisite water is diverted for it.

Rice is defined as a wet season crop but the high prices obtained for early harvested rice in April have pushed paddy preparation and planting earlier and earlier, until now some rice operations start as early as the beginning of October. This activity increasingly overlaps with dry season irrigation of maize, beans and other vegetables (estimated at about 2,500 ha), with severe implications for the very low river discharges in the late dry-early wet season. About 28% of dry season river discharge is

estimated to be used directly by irrigation, while a disproportionate 87% of dry season river flows are diverted to achieve this and provide the small domestic supplies needed.

Minor irrigation occurs sporadically throughout the rest of the project area in the following locations:

- the minimal supplementary irrigation noted in Section 5.4.1 around Matamba on the Medium Plateau AED in the Chimala Catchment;
- tiny strips of vegetables and maize irrigated from perennial springs along the western margins of the Ndembera Wetland;
- very small tracts of rice irrigation by water harvesting at the foot of the Northern Fans AED, as seen at Upagama and Solulwambo, which receive sufficient water only in very wet years;
- very small, scattered and highly localised areas assumed to occur in the Low and Medium Plateau AEDs in the eastern third of the project area, fed by temporary stream flows and springs.

5.4.3 Livestock/pastoralism

The vast seasonal grasslands of the Seasonal Swamps are ideal for pastoralism and in recent decades successive waves of pastoralist in-migrants have taken advantage of this, as did the once more pastoralist Sangu before them. The Maasai, who started to arrive in the 1950s, have now at least in part adopted an essentially sedentary life combining pastoralism and cropping. Even the Sukuma, who now dominate much of the grasslands and its margins (especially to the north west), have also indulged in cultivation, partly to feed themselves by cropping within special bomas but also in places on a much larger scale.

During the wet season the livestock herds follow the retreating waters of the Seasonal Wetlands, congregating in particular in the wetter Eastern Wetland around the Ihefu, so that by the end of the dry season almost the entire Usangu herd is clustered around the permanent Ihefu swamp. SMUWC estimate some 280,000 to 300,000 cattle and about 100,000 of other livestock (goats, sheep, donkeys). This contrasts sharply with unreal estimates of 1.0-2.0 million livestock upto a year or two ago. The last livestock census in the mid-1980s estimated some 400,000-500,000 livestock of which about 75% were cattle.

The very positive trend regarding livestock in Usangu over recent decades seems to have been completely reversed in the last year or so, primarily by the establishment of the Usangu Game Reserve to cover all of the Eastern Wetland (including the vital Ihefu permanent water source). The trend was already slowing and under control by Government through its highly efficient taxation of cattle, which brought in a huge annual revenue (to the new Mbarali District in particular). As yet data are unavailable to identify and quantify the response of the pastoralists, and especially the Sukuma, to this devastating change.

The threats to land, water and vegetation natural resources in Usangu and possibly off-site in other parts of Tanzania have been outlined in Chapters 3 and 4. Clearly the Sukuma have three options regarding where to take their herds within Usangu: the already degrading Western Wetland; upslope onto the Alluvial Fans (the most ecologically vulnerable parts of Usangu); and the less vulnerable Low and Medium Plateau AEDs. These last areas are often fully settled and where they are not occupation would involve large-scale deforestation or bush clearance.

The establishment of the Game Reserve is especially unfortunate because the Black Mbuga of the Eastern Wetland is ideally suited to pastoralism and of little value for anything else, other than

wildlife. However, even with the Game Reserve it is difficult to envisage the return of wildlife on the scale of 100-150 years ago, now that population and development are so much greater and closer. It is possible that some of the anticipated pressure the Game Reserve will put on the rest of Usangu will be averted by mass emigration of the Sukuma and their livestock out of the Catchment to other grazing areas in Tanzania, especially any adjacent or near to Usangu. All of such areas, however, are likely already to be under pressure from livestock and Usangu will have simply exported a problem for others, which ironically within Usangu is not a problem except in perception.

5.4.4 Fisheries

Fishing in Usangu prior to 2000 was dominated by the operations in the Ihefu and immediately upstream in the Great Ruaha River. About 700 tons per year were estimated by SMUWC to be caught and smoked there, varying with rainfall patterns. In effect the entire catch (99%) consisted of catfish, which is so well adapted to the difficult ecological conditions in the Ihefu and its surrounding seasonal wetland. This was a highly adapted and successful local enterprise based on the initiative and hard work (in often dire conditions) of the fishermen.

However, even more than with pastoralism in the Eastern Wetland, the strong positive trend created by this admirable enterprise has been abruptly reversed overnight by the establishment of the Usangu Game Reserve. During 2000 the fishermen were forcibly evicted from the Ihefu area. Serious thought ought still to be given as to how the Game Reserve could accommodate the fishery, as the problems do not appear too great, given the effective adminstrative control mechanisms implicit in the Reserve's legal base.

Elsewhere in Usangu commercial fishing is a negligible activity. A few tilapia and catfish are caught for subsistence consumption in the upper reaches of the Ndemebera and these and other types of fish are caught in the middle reaches of the Great Ruaha and its tributaries where they cross the Alluvial Fans and Western Wetland. With the demise of the Ihefu fishery enterprise, Usangu will become dependent largely on outside fish supplies.

5.4.5 Forestry

The huge forestry development at Sao Hill is just outside the project area, in the Little Ruaha catchment. Within the Usangu Catchment there are no major forestry enterprises. Minor forestry areas have been planted within conservation areas on the extreme south west margin of the Uplands, near Mbeya, and along the divide along the top of the Chunya Escarpment. A certain amount of illegal logging has gone on, with selective cutting of economically valuable species. No significant trend exists.

5.4.6 Agro-industrial activities

There must be at least a medium positive trend in agro-industrial activities resulting from the rapid expansion of cultivation and especially rice irrigation, although many occur off-site in the large towns of Mbeya and Iringa. In addition to the rice mills there are the numerous activities which support agriculture, such as vehicle and tractor repair shops. The main impact is felt along the Iringa-Mbeya highway, where the largest towns (other than Rujewa, the new District Government centre, and the old capital of Utengule) have developed.

5.4.7 Transport communications

These have improved enormously in the south and east of the project in recent decades. This is most evident in the Tazara railway and the parallel Tanzam modern highway which link Usangu with not only the adjacent large towns of Mbeya and Iringa but also with Dar Es Salaam and Zambia. Another modern road links the project area with southern Tanzania from Madambako via Njombe, while a number of good, all-weather secondary roads penetrate the Lowlands to Utengule, Madibira, Kapunga, Rujewa, etc. Less reliable secondary roads ascend the Chimala escarpment and run along the southern watershed from Njombe to Mbeya. There is an airport at Mbeya and a number of remote villages have airstrips. A weak link is the lack of a surfaced road over the very short distance from the highway to Rujewa, given the rapid growth in importance of this centre.

In the north and west, on the other hand, access to the outside world is much more difficult, whilst internal "road" communications break down almost completely in the wet season, when tracks across the mbuga soils become impassable and bridges over the many flowing channels are non-existent.

However, overall and in comparison with a few decades ago, the Usangu Catchment has seen a strong positive trend occurring.

5.4.8 Domestic water supplies

A substantial positive trend might be expected here. Where population is concentrated, in the south and east, there have been two main improvements:

- installation of piped supplies in recent years to many villages;
- improved access to water provided by the greatly expanded irrigation channel network on the southern Alluvial Fans.

However, relative to the increase in settlement and population, domestic water supplies and the associated question of sanitation raise increasingly serious problems even in the most settled areas. In addition, improved water supply and sanitation are often non-existent in the more remote villages of the interior and the north west. Overall, some 40% of the population still lack any improved domestic water supply (i.e. piped or wells) and the proportion lacking improved sewage facilities must be very much greater. The demand for domestic water is only a tiny fraction of the total surface water available, while subsurface water seems adequate for exploitation: natural water supply is not the major problem.

The overall failure of water and sewage facilities to match population growth and expectations adds to health problems in the project area and continues in many parts to impose the heavy burden of water carrying, often over substantial distances, and water-hole maintenance on women. A village well, such as that recently donated by the UK Government to the remote interior village of Ukwaheri, is perhaps the single most valuable asset that development could provide in such places. In this context, the limited hydrogeological input into SMUWC is especially unfortunate. In relation to the growth in population and expectations, the improvements in domestic water supply and sanitation represent only a weak positive trend.

5.4.9 Recreation

No major recreation initiatives seem to have developed in the project area in recent decades, although the improved communications in the south give the people much easier access to the pleasures of the big towns of Mbeya and Iringa. The establishment of the new Usangu Game Reserve may provide better hunting for the few local people likely to take advantage of it (and is more likely to favour local poachers given the relatively easy access from surrounding settled areas). No significant trend is apparent here.

5.4.10 Tourism

The only important initiative related to tourism in the project area is again the new Game Reserve. It is unlikely to develop any significant tourism, even ecotourism or hunting by outsiders and foreigners, in isolation from the adjacent Ruaha National Park. However, there ought to be an opportunity for ecotourism, wildlife tourism and ornithology to be developed as an adjunct to the National Park, which already has the necessary tourism facilities. A day-out from the Park to the Ihefu could be popular with tourists already visiting the Park. On its own, it is difficult to see that the Game Reserve would exert any significant tourism attraction because of its remoteness from any facilities. As yet, clearly, no trend in tourism exists.

Off-site (i.e. outside the SMUWC project area) the negative impact of changes in Great Ruaha hydrology have been noted in Section 4.4.2.

5.4.11 Energy supply

The original call for the SMUWC Project resulted from widespread power cuts in Tanzania resulting from operation failures at the Mtera and Kidatu Reservoirs, where much of Tanzania's electricity supply is generated. At that time the cause was claimed to be inadequate dry season flows in the Great Ruaha River, a main source of water for the reservoirs, when it became known that the River was drying up at the Usangu exit point. This has already been shown to be incorrect, fairly obviously because the dry season flow in the Great Ruaha at the exit, even when intact, was negligible (Section 3.1.2) and could make no significant contribution to the reservoirs. In addition, as noted in Section 3.1.2, the Great Ruaha wet season and annual total flows at the exit show no significant decline.

Events in Usangu, therefore, have had no significant impact on power supplies and no negative trend occurs at present.

5.4.12 Energy utilisation

A medium negative trend in energy utilisation might be ascribed to the project area because the steady growth of population, transport and development must all result in increased energy utilisation. This is an inevitable cost of socio-economic progress. Despite the huge increase in energy utilisation that is occurring, much more of the energy used derives from outside the project area and from less vulnerable and less sensitive sources than the local woodlands and forests. A few decades ago, most energy used in Usangu would have been based on these local sources: charcoal and other fuelwoods would have to be consumed in enormous quantities to meet present day demands. Nevertheless, very large quantities of local wood are still used, as noted in Sections 3.1, 3.2 and 4.1.

5.5 Cultural

Four potential issues have been considered as possibly arising from current environmental trends affecting local culture:

- cultural property
- cultural values
- scenic/landscape values
- lifestyle: quality of life

More detailed discussion and data presentation relating to some of the issues covered here are to be found in Supporting Volume 9.

5.5.1 Cultural property

There is no important cultural property in the Usangu Catchment of which SMUWC is aware. Most buildings, even of a religious nature, are essentially functional in concept and construction and relatively new. One or two old missions, such as Madibira, date back to the 1900s but are not of special cultural note. The only traditional shrine is that of Mama Ngiriama at the Ruaha exit point and this is threatened only by disuse. Therefore no significant trends exist.

5.5.2 Cultural values

The rapid and extensive development in the Usangu Catchment, especially in the south and east, has been accompanied by a comparable increase in population with a broader (i.e. more youthful) demographic structure and including many different groups of in-migrants. Education has become more widely available; media communications such as radio, television and even cinema in the nearby large towns have flourished; and transport communications with the outside world have improved dramatically. All these trends amalgamate into an inevitable decline in cultural (i.e. traditional) values. The trend has been strengthened by:

- a weakening of traditional forms of authority;
- differences in ethnic origins, languages and livelihoods between the inhabitants of hamlets even within the same village;
- high proportions of newcomers in many areas.

Thus it is difficult to believe that Mama Ngiriama and her shrine still have the same importance and application for local people in protecting them when entering the Ihefu.

Two factors moderate the negative trend in traditional values to a medium scale.

- Certain of the in-migrant groups have held stronger cultural values than the Sangu themselves and have clung to these values with greater persistence. The Sukuma, with their set ways, initiation ceremonies, etc are the obvious example.

- Development has been mainly restricted to the south and east of Usangu. Large areas in the west and north are untouched by it. In these areas it is likely that traditional values remain much stronger.

5.5.3 Scenic/landscape values

At present the Usangu Catchment remains a naturally integrated pattern of often impressive landscapes, underlining the need for development there to be sustainable rather than destructive. With all the development, there are few eyesores created.

Sections 3.1, 3.2 and 4.1 have noted a degree of degradation in forests and woodlands, including in parts of the Uplands, while the expansion of urban areas is usually unsightly. The high scenic values of much of the Usangu Catchment derive from the mountainous escarpments and flower-strewn alpine meadows of the High Plateau AED and are not significantly affected by scattered, small areas of such degradation. However, in the Lowlands the vast greenery of the wet season mbuga grasslands and the very distinctive swamp landscape of the Ihefu are now seriously threatened, possibly sufficient to identify a significantly negative trend overall as just beginning.

5.5.4 Lifestyle: quality of life

It seems evident that, despite the many problems still to be overcome in the Usangu Catchment, that the fortunate combination of land and water resources found there has provided the basis for rapid and widespread socio-economic advances in much of the area, especially in the south and east. Undoubtedly this has been to some extent at the expense of traditional ways and attitudes, but overall a strong positive trend in the lifestyles of local people, in their quality of life, seems very evident. SMUWC aims to help the local people and government to ensure that this trend is sustainable.

6. KEY ENVIRONMENTAL ISSUES

6.1 Baseline analysis

Initial screening and scoping, as presented in the SMUWC Inception Report, identified and summarised some 70 potential environmental issues, assessing 24 of them as likely important issues within the context of SMUWC. This has been the starting point for the closer examination here of environmental resources and the current trends affecting them. Evaluation of the scale of current baseline trends differs from the initial assessment of issues in the Inception Report, which was based primarily on the then perceived importance of each issue within the context of SMUWC. Here trends reflect the current strength of the changes that they represent.

Moderate and strong trends, especially if negative, are regarded as representing key environmental issues that must be addressed in the formulation of resource management strategy options. Thus elsewhere in this report (notably in Supporting Volumes 1-5) initial ideas have been formulated for resource management options that would help to counter the adverse environmental trends and encourage any positive ones. These are not therefore discussed further here except to note present actions taken by SMUWC to provide the foundation for option formulation in respect of strategies and management measures.

The analysis presented here differs more than was expected from that in the Interim Environmental Baseline only nine months ago. This is because the exceptionally dry wet season in year 2000 created a number of major surprises.

- The Ihefu halved in size and split into several tracts, when previously it was believed to be broadly stable in size and shape.
- Only about half of the Eastern Wetland was inundated by the seasonal floods.
- The entire Western Wetland remained dry.
- Inspection of an extensive Black Mbuga area south west of Ukwaheri revealed a dramatic degradation in its vertisol characteristics and an almost Grey Mbuga condition and appearance, a change occurring over a period of only 12 months.

In addition it has become apparent during 2000 that Government intends to implement the new Game Reserve forthwith, as seen by the burning of pastoralists' bomas and the eviction of the fishermen from the Ihefu. Previously it had been hoped that a more flexible approach might still be possible.

A point made by the Interim Environmental Baseline was that while SMUWC nominally covers the entire Usangu Catchment, in practice some 40% of the project area in the east was not included in most SMUWC activities. This comprises the very extensive Low and Medium Plateau units occurring east of a NE-SW line from Madibira to the Matamba area. Initially, and understandably, these had in the very limited time available focused on the Lowlands. However, during 2000, in addition to continuing the analysis of the hydrological data collected by Government in this area, SMUWC has completed land cover/land use mapping there and established a seventh CEP village between Madibira and Mafinga. The Upper Ndembera (the Ndembera Seasonal Wetland) had already been closely investigated, demonstrating that no extensive perennial swamp existed there.

6.2 Key physical issues

The environmental baseline analysis reveals that in physical terms the Usangu Catchment is suffering significantly from the impacts of widespread and relatively rapid development, including especially irrigation, rainfed cultivation and in some places livestock, and the considerably increased population pressure these have brought. Of the 23 issues identified (table 6.1), only 2 show positive trends while 12 are negative; 9 show insignificant trends. Of the 14 significant trends, 9 represent key physical issues (2 positive and 7 negative).

Key negative trends in relation to physical issues at present appear to be the following:

- river flows;
- the recharge and hence the extents and condition of the major Seasonal Wetlands;
- perennial swamp (Ihefu) recharge, extent and condition;
- probably a lowering of groundwater levels (about which SMUWC still has inadequate information);
- increasing soil erosion, especially on Alluvial Fans, in certain Uplands areas, and now probably in the Western Wetland;
- increasing soil physical degradation, especially on the Alluvial Fans, in certain of the cleared Upland areas, and in the Western Wetland (with a future threat developing also in the Eastern Wetland);
- decreasing soil fertility, reflecting the two previous trends.

The changes from the Interim Environmental Baseline reflect the surprising discovery during the very dry year 2000 that deterioration of both the seasonal and perennial wetlands seems to be occurring more rapidly than anticipated. This is a critical finding for SMUWC because it suggests that if it is important to retain at least the option to maintain the Ihefu swamp and perennial flow of the Great Ruaha River out of the Usangu Catchment then something fairly immediate has to be done. There is now a real danger that without some sort of interim action plan the Ihefu and the Great Ruaha below Nyaluhanga will cease to function, especially if the current run of poor rains continues. The two obvious constituents of such an interim plan would be to establish the dry season “red routes” through the main irrigated areas (see Supporting Volume 5) and to dredge the requisite release channels within the Ihefu to improve hydraulic efficiency there.

6.3 Key biological issues

SMUWC is continuing to study biological issues, notably through the Environmental Functions Programme focused on the Ihefu and soon to be completed. Most biodiversity and related studies in SMUWC have concentrated on the Ihefu and the adjoining eastern Seasonal Wetlands and surrounding Alluvial Fans or Northern Hills. The findings discussed in Section 3.1.5 indicate that it is in the Western Wetlands and adjoining Alluvial Fans that ecological degradation is the most advanced (key on-site negative trends are most pronounced here). However, the failure of the rains in 2000 and the resulting impacts on the Ihefu and Eastern Wetland suggest that they are not as far behind in terms of degradation threat as previously believed.

The environmental baseline analysis of biological issues therefore requires some revision from that in the Interim Report. It reveals that in biological terms the Usangu Catchment is not in such good condition as then thought. The highly successful development over recent decades, especially of irrigation, is now accelerating its impacts on the lowlands ecology, a trend exacerbated by the

determination to press ahead with the implementation of the Game Reserve. Of the 13 issues identified (table 6.2), 8 show negative trends while only 2 issues show positive trends; 3 have insignificant trends. Of the 10 significant trends, 7 represent key biotic issues (2 positive and 5 negative). More to the point, the 2 positive trends (increasing Savannah Bushland and Game Park establishment) are positive only in terms of their own perspective, having numerous negative implications for other biological as well as physical and human issues.

Key negative trends in relation to biotic issues at present appear to be the following:

- decreasing extent and integrity of forests and woodlands, especially in the Uplands and on Alluvial Fans;
- decreasing extent and integrity of grasslands, especially in the Western Wetland but now also with evidence of an imminent similar threat in the Eastern Wetland;
- the threat to the extent and integrity of the perennial swamp vegetation, now also possibly more imminent than previously thought;
- the threat to wetland bird communities implicit in the possibly more imminent decline in their key habitats in the Ihefu and the surrounding Eastern Wetland;
- the growing threat to Ruaha National Park of accelerated decrease in the already much-reduced flows of the Great Ruaha River out of the Usangu Catchment, with lengthening periods of no-flow occurring.

As with physical issues the increased negative biological trends reflect primarily the threats to the Ihefu, the Greater Ruaha River below Nyaluhanga, and the Eastern Wetland. These threats are now feared to be more imminent, again indicating the need for some sort of early interim action.

6.4 Key human issues

The environmental baseline analysis reveals that in human terms the Usangu Catchment is overall a highly successful development area. Of the 33 issues identified (table 6.3), 17 show positive trends, 9 are negative, and 7 are insignificant. Of the 25 significant trends, 21 represent key human issues (13 positive and 8 negative). Key negative trends in relation to human issues at present appear to be the following:

- land security problems, especially regarding grazing land rights;
- increased social inequity, because the wealthy are better able to take advantage of development;
- social cohesion has diminished and social conflict increased, especially between cultivators and pastoralists but also in disputes over water rights and access;
- the attitudes of the people at grass roots level to the various echelons of government have deteriorated;
- pastoralism is now severely threatened by the establishment of the Game Reserve and the evident decline of the Western Wetland;
- the Ihefu fishery has been destroyed because it is within the new Game Reserve;
- the great increase in development has inevitably increased energy demands in the Catchment;
- cultural values have weakened as more modern influences and attitudes to life have appeared.

Environmental analysis often tends to focus on and emphasise the negative impacts of development. By including human environmental issues, balanced analysis can be achieved. It is important that the positive aspects of development emerge, especially as these are what motivate the people at village

level and dictate the decisions they take or are willing to have taken on their behalf. In the Usangu Catchment such current positive trends include:

- greatly increased human carrying capacity, especially due to irrigation;
- population growth within the capacity of the Catchment to sustain it;
- improvements in some issues affecting women, the aged and children;
- improved health, due to the better facilities and nutrition that usually accompany development;
- substantial increases in incomes, employment and land values;
- creation of a suitable institutional framework, at least down to District level, to guide and support environmental management (although an urgent need remains to implement such management);
- major growth of human use activities such as rainfed cultivation and especially irrigation, and related agro-industrial activities;
- greatly improved transport communications, especially roads and the under-used railway;
- an overall substantial improvement of the quality of life for most people in the Usangu Catchment.

Positive trends largely reflect the success of agriculture in Usangu Catchment and the social and practical benefits that have accompanied it. The most important negative trends relate to social or human use issues, several of them reflecting the central problem of the dichotomy between cultivators and pastoralists (especially the Sukuma).

SMUWC is mounting a series of major social programmes to create a better understanding and greater local involvement and capability with regard to these trends and the formulation of management approaches to counter or enhance them as necessary. These include:

- Community Engagement Programme (CEP) – an extremely important programme to involve and train village communities in natural resources planning and management and in village adminstration. This should help to arrest or reverse the negative trends identified in land tenure/security, social equity, social cohesion and conflict, social attitudes, energy utilisation and possibly cultural values.

- District Village Development Team (TMV) – a team of District staff supported by SMUWC to assist villages in producing Village Development Plans and the institutionalisation of resource management. This should provide the basis to integrate CEP-type activities in village-level development long after SMUWC has disappeared, with the same influence on current human environmental trends as noted for the CEP.

- Rural Livelihoods Research – examining the role of natural resources in household economies, gendered participation, and moral understandings at family level. This could help to counter the negative trends seen in social attitudes and to strengthen the positive trends in gender and age issues and in community participation.

- Environmental Management Training Programme – training District Heads of Departments in environmental planning and management. This should significantly strengthen institutional effectiveness and community participation by enhancing insitutional activity at village level.

- Subcatchment Resources Management Programme (SRMP) – developing a land and water management strategy based on the individual river subcatchments (using the Kimani Subcatchment as a pilot). This could be the key to reversing current negative trends in social equity, social cohesion/conflicts and to improving domestic water supplies and sanititation.

It now seems likely that the end of SMUWC in March 2000 will effectively mark the end of these vital initiatives, as well as killing any hopes of monitoring and so maintaining the very comprehensive environmental baseline for the Usangu Catchment summarised here and ultimately to be prepared by SMUWC as "Baseline 2001". The events of year 2000 have underlined the urgency of the situation if the Ihefu and perennial river flow out of the Catchment are to be maintained. This may or may not be the future consensus of the many stakeholders in Usangu Catchment but at least for the present it is surely essential to retain the option.

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APPENDIX – TABLES AND FIGURES

Table 1.1 Environmental resources framework

Physical Environmental Resources	Biological Environmental Resources	Human Environmental Resources
Water	Flora	Social
Land	Fauna	Socio-economic
Atmosphere	Protected Areas	Institutional
Climate		Human Use
		Cultural

Table 2.1 Agroecological divisions (AEDs)

GEOMORPHIC REGIONS	GEOMORPHIC UNITS	ECOLOGICAL REGIONS	AGROECOLOGICAL DIVISIONS	AED
Uplands	High Plateau Medium Plateau Low Plateau Escarpments Foothills	**Uplands**	High Plateau Medium Plateau Low Plateau Northern Hills Escarpments Foothills	HPl MPl LPl NHi ESc FHi
LOWLANDS	Alluvial Fans Sand Hills	**Alluvial Fans**	Northern Fans Southern Fans Irrigated Fans Sand Hills	NFn SFn IFn SHs
Wetlands	Upland Seasonal Wetland Seasonal Wetlands Perennial Swamp (Ihefu) Fan Swamps	**Upland Wetland** **Seasonal Wetlands (West)** **Seasonal Wetlands (East)** **Perennial Swamps** **Great Ruaha River**	Ndembera Wetland Black Mbuga (West) Grey Mbuga (West) Black Mbuga (East) Grey Mbuga (East) Perennial Swamp (Ihefu) Fan Swamps Great Ruaha River	NDw BMw GMw BMe GMe PSw FSw RRv
Off-site Impact Areas				
Ruaha National Park Mtera/Kidatu Reservoirs Lower Rufiji Basin Other grazing areas in Tanzania				

Table 6.1 Physical environmental trends

Physical Environmental Resources	Physical Environmental Issues	Current Trends
WATER	Catchment run-off	Weak negative
	River discharges	**Strong negative**
	River water quality	Weak negative
	Siltation	Weak negative
	Seasonal Wetlands recharge/extent	**Strong negative**
	Perennial Swamp recharge/extent	**Medium negative**
	Wetlands water quality	Negligible
	Groundwater levels	**Weak/medium negative**
	Groundwater quality	Negligible
	Drainage	Negligible
	Flooding	Negligible
LAND	**Soil erosion**	**Medium/strong negative**
	Soil physical degradation	**Strong negative**
	Soil fertility	**Strong negative**
	Land availability	**Strong positive**
	Land utility	**Medium positive**
ATMOSPHERE	Dust	Weak negative
	Odour	Negligible
	Pollution	Negligible
	Noise	Negligible
CLIMATE	Microclimatic change	Weak negative
	Regional climatic change	Negligible
	Global climatic change	Negligible

Notes: Critical issues/trends **in bold**.

Table 6.2 Biotic environmental issues checklist

Biological Environmental Resources	Biological Environmental Issues	Current Trends
FLORA	Forests/woodlands extent/integrity Savannah bushlands extent/integrity Grasslands extent/integrity Perennial swamps extent/integrity	Medium negative Medium positive Strong negative Medium negative
FAUNA	Large mammal communities/habitats Small mammal communities/habitats Amphibian communities/habitats Reptile communities/habitats Invertebrates communities/habitats Fish communities/habitats Bird communities/habitats	Weak negative Negligible Weak negative Negligible Negligible Weak negative Medium negative
PROTECTED AREAS	Usangu Game Reserve Ruaha National Park	Medium positive Strong negative

Notes: Critical issues/trends **in bold**.

Table 6.3 Human environmental trends

Human Environmental Resources	Human Environmental Issues	Current Trends
SOCIAL	**Human carrying capacity**	**Strong positive**
	Population	**Medium positive**
	Demographic structure	Negligible
	Land tenure/security	**Medium negative**
	Social equity	**Medium negative**
	Social cohesion/conflicts	**Strong negative**
	Social attitudes	**Medium negative**
	Gender and age	**Medium positive**
	Health	**Medium positive**
	Safety	Negligible
SOCIO-ECONOMIC	**Incomes**	**Strong positive**
	Employment	**Strong positive**
	Land values	**Strong positive**
	Credit availability	Weak positive
INSTITUTIONAL	**Institutional activity**	**Strong positive**
	Institutional effectiveness	Weak positive
	Community participation	Weak positive
HUMAN USE	**Rainfed Cultivation**	**Medium positive**
	Irrigation	**Strong positive**
	Livestock/Pastoralism	**Strong negative**
	Fisheries	**Strong negative**
	Forestry	Negligible
	Agro-industrial activities	**Medium positive**
	Transport communications	**Strong positive**
	Domestic water supplies	**Weak positive**
	Recreation	Negligible
	Tourism	Negligible
	Energy supply	Negligible
	Energy utilisation	**Medium negative**
CULTURAL	Cultural property: historic sites etc	Negligible
	Cultural values	**Medium negative**
	Scenic/landscape values	Weak negative
	Lifestyle: quality of life	**Strong positive**

Notes: Critical issues/trends **in bold**.

Figure 1.1 SMUWC Environmental Management Programme

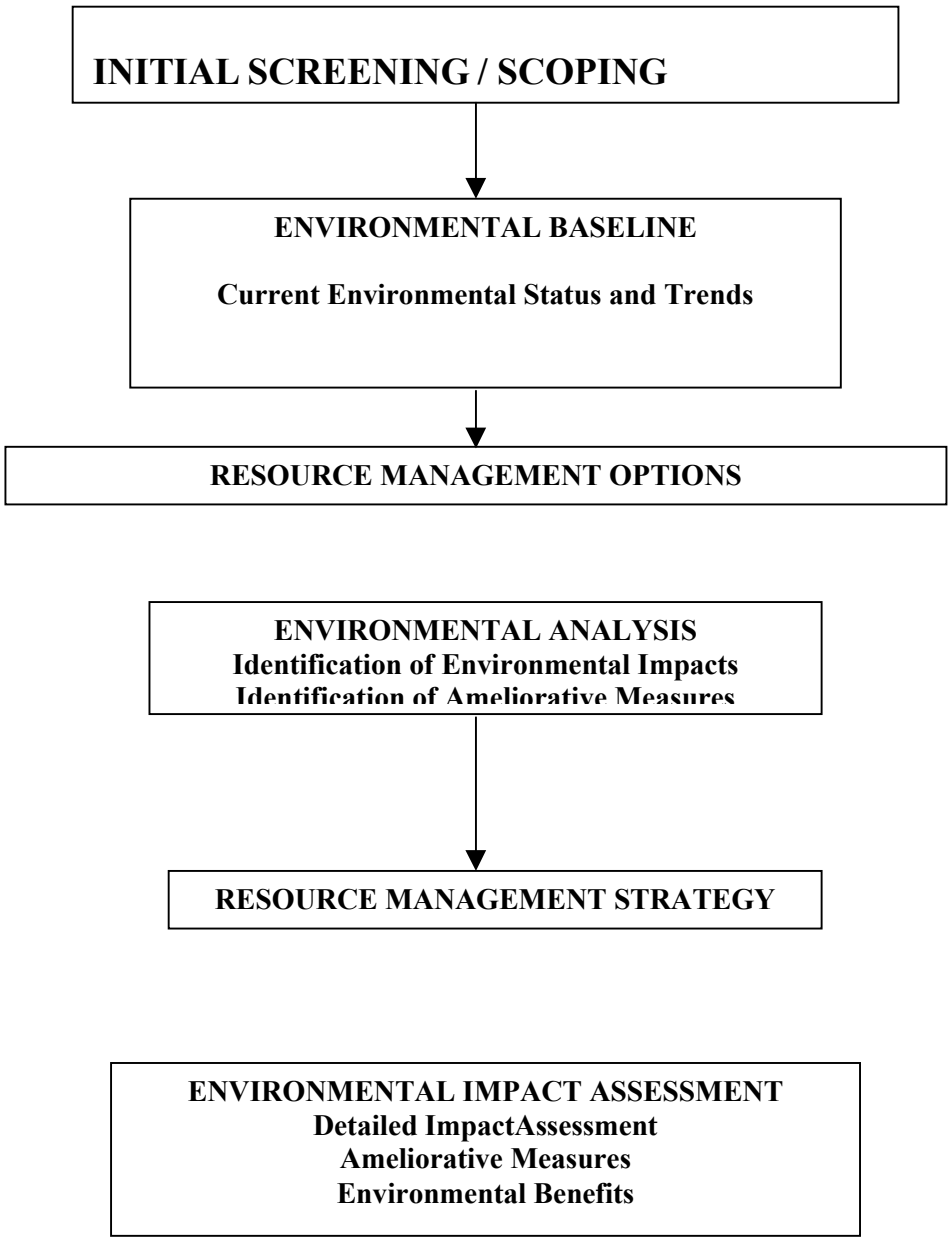

Figure 2.1 Agroecological divisions (AEDs