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ACRONYMS AND ABBREVIATIONS

AED	Agroecological Division
CEC	Cation exchange capacity
CEP	Community Engagement Programme
CITES	Convention on International Trade in Endangered Species
DBMS	Database Management System
DFID	Department for International Development
DNRD	District Natural Resources Department
DO	Dissolved oxygen
DoE	Division of the Environment
DoM	Department of Meteorology
EC	Electrical conductivity
ECe	Electrical conductivity of the soil extract
EIA	Environmental Impact Assessment
EMES	Environmental Monitoring and Evaluation System
EMP	Environmental Management Plan
ESP	Exchangeable sodium percentage
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
M&E	Monitoring and Evaluation
MOAC	Ministry of Agriculture and Cooperative4s
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
ODA	Overseas Development Administration (now DFID)
RBMSIIP	River Basin Management and Smallholder Irrigation Improvement Project
RBWB	Rufiji Basin Water Board
RBWO	Rufiji Basin Water Office
RLR	Rural Livelihoods Research
RNP	Ruaha National Park
RSC	Residual sodium carbonate
RUBADA	Rufiji Basin Development Authority
SAR	Sodium adsorption ratio
SRMP	Subcatchment Resources Management Programme
SMUWC	Sustainable Management of the Usangu Wetland and its Catchment
TMV	Timu ya Maendelo Vijijini
TDS	Total dissolved solids
UCTS	Usangu Catchment Technical Secretariat

1. RATIONALE

1.1 Need for an EMES

Major development projects and programmes today should include in their preparation not only environmental assessment but also an **Environmental Management Plan (EMP)**. The main components of an EMP include:

- implementation/supervision of any ameliorative (mitigation/compensation/enhancement) measures identified by the environmental assessment;
- environmental management activities required specifically during the construction or establishment stage (here the **Strategy Process** stage – see Section 1.2);
- an **Environmental Monitoring and Evaluation System (EMES)**;
- linked to the EMES, the establishment of environmental standards i.e. threshold values for key environmental parameters (or **indicators**);
- an **Environmental Awareness Programme** to raise the level of environmental consciousness in both the public and government officials.

It is thus apparent that an EMES is a key constituent of environmental management. The need for environmental monitoring in development activities, according to the World Bank (September 1998), is to provide information about the key environmental aspects of the development, particularly its environmental impacts and the effectiveness of mitigation measures. ODA (1996) see the need for an EMES in similar terms.

Environmental monitoring, therefore, is defined here as **the collection of specific information on the characteristics, quantities and functioning of environmental variables over space and time**. The infinite scope of the environment means that the number of variables to be monitored has to be rationalised by the selection of those key environmental issues and their indicators that will optimise the amount and relevance of information in terms of the cost and effort involved in collecting and handling it. **Environmental evaluation** of the monitored data can be defined as **the analysis and interpretation of the monitored information to allocate environmental values to the variables at particular points in time and space and so to determine any significant trends for them.**

Another important role for the EMES is to act as an **early warning system**, identifying as soon as possible any sudden environmental deterioration requiring immediate mitigation.

Both the World Bank (1998) and ODA (1996) also recognised the value of an EMES in the retrospective appraisal of earlier environmental assessment activities, enabling improvements to be identified in the approach to the latter.

1.2 The Usangu EMES and EMP

In the case of the Usangu Catchment, the SMUWC approach to sustainable development planning is rightly to see it as environmental management planning. The ultimate output of the strategic planning

process proposed by SMUWC will be an EMP for the Usangu Catchment. The EMES, therefore, will be the M&E instrument for the overall strategy and management programme agreed by the various stakeholders during the strategic planning period. It will need to focus on the environmental impacts, positive and negative, implicit in the programme and on any specific measures identified to enhance or mitigate them.

A key goal in the SMUWC **Strategy Process** (which equates broadly to the construction/establishment stage of the development cycle) is that the outcome will represent a consensus of stakeholder opinion. It is quite possible, therefore, that the ultimate output, the Environmental Management Plan, could in parts be ecologically unfriendly. The decision could be taken, for instance, to sacrifice the Ihefu and perennial outflow from the Usangu Catchment in order to maximise socio-economic productivity upstream. At this point in time the environmental impacts and any mitigation measures involved in the selected strategy cannot be identified until the strategy and its component management activities have been defined.

However, the development strategy and management programme will take a substantial time beyond the current phase of SMUWC (which ends in March 2001), possibly several years, to be fully agreed and designed. Strategic planning and the design of management options are envisaged as subparallel exercises rather than sequential (as in traditional development planning) and many suggestions for management options have already been identified and discussed by SMUWC. Clearly, the future selection and application of these options will depend on the strategy adopted.

The impact of the exceptionally dry year 2000 has raised fears that the demise of the Ihefu and prolonged cessation of Great Ruaha outflow from Usangu are more imminent than previously thought (see Supporting Report 24). It is possible, therefore, that if the option to maintain the Ihefu and restore perennial outflow is to be retained then some form of **interim action** should be taken during the Strategy Process stage. Should this prove the case, the EMES would have to take account of it and monitor the results.

Preparation of the EMES is complicated by the fact that it is taking place ahead of the EMP and the environmental assessment and mitigation planning for it. For this reason, the aim here is to provide a preliminary design for an **EMES Framework**. Fortunately the Environmental Baseline for the Usangu Catchment is complete and identifies issues currently affected by significant environmental trends there (Sections 2.1 and 2.2 below).

The EMES therefore has initially to be designed to carry out monitoring and evaluation of these and other environmentally important issues throughout the Strategic Process period in order to continuously update baseline conditions. In practice, it is likely that current critical issues and the indicators that characterise them will remain important elements of the EMES whatever strategy and EMP emerge from the Strategy Process. The EMES design should in any case aim to remain flexible and adaptable, assimilating new monitoring needs and discarding old ones as environmental circumstances and priorities change.

Another reason for regarding this initial EMES design as simply a framework is because in the short time available it is not possible to incorporate all the key indicators and their monitoring details, especially as not all technical staff are on-site in SMUWC at the time of initial preparation. There is scope, therefore, to add such indicators and methodology detail for certain issues prior to the Final Report. This is particularly the case with certain human issues. Ultimately, as the Strategy Process is completed, the framework provided here should emerge as a comprehensive and detailed EMES.

1.3 Goals and objectives

The overall goals of the EMES are to afford effective environmental surveillance and to provide reliable information upon which the continuing environmental management of the Usangu Catchment can be updated and refined. Specific objectives of EMES design to be met in achieving these goals include:

- identification and prioritisation of the issues to be monitored;
- identification and prioritisation of the indicators (visible and/or measurable parameters) available for each issue;
- practical design of methods of measuring or estimating values for the selected indicators;
- definition of standards (threshold values) indicating the need for corrective actions;
- establishing means of storing, retrieving, analysing and presenting the monitored data;
- allocation of technical responsibilities for monitoring and evaluation, including the critical activity of field data collection;
- participation of local people, especially at village and district levels, in EMES design and implementation;
- establishment of evaluation and reporting procedures, including "early warning" and retrospective environmental assessment evaluation procedures;
- cost estimation and achieving cost effectiveness;
- sourcing of the necessary financial inputs.

The EMES Framework presented here attempts the tasks implicit in most of these objectives save the last two, although the following section comments briefly on them. Also, the quantification of threshold values for indicators is seen as emerging from the Strategy Process, to establish consensus acceptance and application. The EMES design presentation is largely tabular and the different elements are explained in Section 2 below.

1.4 Cost effectiveness and funding

A fundamental problem with environmental monitoring is its potentially infinite scope: the environment includes all facets of an area and a huge number and range of issues can be identified. The number of possible indicators is much greater still. An EMES has to reduce this profusion to focus on key issues and indicators within a systematic framework that achieves order out of potential chaos, aiming to maximise information relative to cost, time and effort. In developing countries such as Tanzania, where funds, skilled manpower, equipment and logistical support are major constraints, the need for realistic and cost-effective EMES design is even more evident.

Thus, as in identifying and prioritising ameliorative measures, **primary** and **secondary** monitoring activities should be defined. The former are considered essential for meaningful environmental monitoring while the latter are seen as discretionary, providing interesting but not absolutely essential information. Secondary monitoring should only be undertaken where cost is low or where specific funds are available for the purpose. In Usangu it would be possible to include many of the secondary monitoring activities so long as environmental management there continues to receive external financial and technical support, either through SMUWC or some comparable organisation. In the longer term, however, Government will take full responsibility and then the scope of the EMES might have to be reduced.

Another major difficulty with environmental or any other form of monitoring is that it is a long-term exercise. In theory, in fact, it is infinite and continues indefinitely. Sometimes it is convenient to limit it temporally to the "life" of the project or other development activity concerned but even this is arbitrary in that the impacts of a development might go on long after it has ceased e.g. after a mine closes. In the developing world this then begs the question of where do the funds to implement an EMES come from, when money is usually so desperately short? During the development planning the funds are often available to plan and design the EMES as part of an aid package to finance the planning. However, invariably once implementation is reached such funds dry up and certainly no donor wishes to fund a government activity indefinitely. This is precisely the situation with SMUWC, where even the second phase of planning (the Strategy Process) might not continue to receive external funding support.

Clearly no solution to this fundamental problem of long-term financing can be offered here other than to re-emphasise the need for the Usangu EMES to focus primarily on critical monitoring issues. Even in poor countries like Tanzania certain major resource issues are perceived by Government as important enough to attract long-term government financial support for the collection of relevant data e.g. agricultural production, major river discharges, climatic data, population growth, etc. The EMES must aim to take full advantage of any on-going monitoring activities by Government or any one else. More ambitious monitoring programmes can only be implemented if special funding can be sourced, almost certainly externally.

Any Usangu EMP will be meaningless without an Usangu EMES, and vice versa. Thus whatever the funding source for the EMP it must include a cost component for the establishment and operation of the EMES.

1.5 EMP implementation monitoring

It is noted above that ultimate planning will be in the form of an EMP. Thus the EMES might also include M&E of the overall EMP programme itself i.e. "project monitoring", in traditional development planning terminology. This would be in terms of implementation progress for the constituent EMP activities: specific amelioration measures as they are identified, the awareness campaign, establishment of environmental standards/threshold values, any interim measures required during the Strategy Process, and the operation of the EMES itself. It could also include M&E of the EMP economic benefits, if this were required.

2. APPROACH

2.1 Environmental baseline

The design of the EMES Framework is greatly facilitated by the comprehensive environmental baseline preparation already carried out by SMUWC as the first and fundamental step in the Strategy Process. The Final Report includes both the Baseline 2001 document (Annex 1 to the Main Report) and the formal Environmental Baseline (Supporting Report 24), backed by a wealth of detailed baseline data presented in the other numerous and wide-ranging Supporting Reports. Current environmental status and trends thus established allow the identification of key environmental issues in the Usangu Catchment, as well as providing benchmark information and data for the monitoring process.

2.2 Environmental resources and issues

The SMUWC Environmental Baseline (Supporting Report 24) defines environmental resources and issues under the three basic headings: physical, biological, and human. The importance of including human issues is stressed: without it monitoring would be ecological rather than environmental. Under each of these three headings major resource groupings have been identified (Table 2.1). The Environmental Baseline then identifies those specific issues for which current environmental trends, positive or negative, might be regarded as significant. Issues with pronounced trends are often but not always considered critical from a monitoring viewpoint because the environmental importance of an issue is one of the elements in evaluating the trend (or impact in an environmental assessment).

However, it is possible that resource issues for which current trends are not significant might also be considered of special importance for monitoring e.g. climate is an essential element of any EMES, even if it is not changing or being impacted significantly. Conversely some of the most marked current changes or threats affect issues of minor importance, as in the case of small mammals and invertebrates in the Ihefu. Numbers and diversity are too low to give these issues sufficient importance to justify what would be expensive monitoring, despite the impending threat to them of the Ihefu drying out.

Figure 2.1, summarising the Usangu EMES Framework, indicates those environmental issues that have been selected here for monitoring, ranking them as primary or secondary issues in this respect. Selection is based on the discussion in the Baseline 2001 and Environmental Baseline documents. Prioritisation takes into account their environmental importance relative to the practicality and cost of monitoring them. With time, it can be expected that issues will vary in relative importance, with primary issues becoming secondary and vice versa. River water quality at present seems to be a minor concern. However, should contrary evidence emerge, say a marked increase in the sale of agrochemicals in Usangu, then it would be upgraded to primary status to identify the expected impact of this change.

Of the 69 issues identified in the Environmental Baseline report 44 are included in the EMES, 34 of them as primary issues and 10 as secondary. Physical issues comprise 13 of this total (9 primary, 4 secondary); biological issues comprise 8 (7 primary, 1 secondary); the remaining 23 are social issues (18 primary, 5 secondary). These figures underline the importance of socio-environmental issues in the Usangu Catchment.

2.3 Environmental indicators

Environmental issues are defined here as **convenient groupings of environmental parameters in which change indicates environmental improvement or deterioration**. This helps to rationalise the infinite number of environmental parameters and criteria that exist, providing a systematic and manageable framework. Many environmental parameters of a particular issue are visible from field or other visual observations (aerial photos, satellite imagery, topo-maps) and/or measurable either from these observations or from data collected specifically about them. Such parameters are termed **environmental indicators** because they can be used to indicate and quantify environmental change. Some indicators, especially those relating to human issues, might initially be expressed in qualitative terms, although questionnaires can be specially devised to transform these into quantitative data.

Again, many indicators can exist for a single issue. River water quality for instance can be evaluated by salinity (measured by the criteria of electrical conductivity, or total dissolved solids, or a particular ion such as chlorine); alkalinity (measured by such criteria as pH, or sodium adsorption ratio, or residual carbonate); and dissolved oxygen. In addition to these relatively easily monitored criteria, some of which can be measured in the field (Section 2.5), there is a wide range of other more esoteric water quality criteria which in total and sometimes individually involve expensive collection and laboratory techniques. Thus indicators also are ranked as primary (1) or secondary (2), in an attempt to increase the cost-effectiveness of the EMES. Secondary indicators require much less intensive monitoring than primary indicators; usually all that is needed is a sufficient check that no significant change is occurring. Some indicators can be used for more than one issue: river flows, for example, are an indicator for both river discharge and catchment run-off.

Indicators identified for each EMES issue are presented in the design for each issue, as presented in Sections 3-5. Certain of these indicators were originally identified by local people taking part in training courses organised by SMUWC, a process that will be encouraged during EMES detailed design and future operation. In addition, reference has been made to Tanzania's nation-wide list of poverty and welfare indicators, in respect of social indicators. Finally, the experience of the various CEP activities has been valuable in leading to grass-roots identification of issues and indicators in the villages and hamlets, again especially in the human issue context.

Many of the indicators have emerged from the work carried out during the current phase of SMUWC, during which intensive field studies have been possible because of the substantial funding provided by DFID. For long-term monitoring some indicators have had to be simplified and broadened in scope to make them practicable. A good example of this simplification is found in the reduction of land cover/use units to a minimum, compared to their detailed classification and mapping during SMUWC. This latter level of detail is not feasible for the EMES, even every 2-3 years. Indicators for issues are often also issues in their own right, as issues are frequently interrelated and interact with each other.

The main confusion with environmental indicators is between what might be termed **direct** and **indirect** indicators. Thus for deforestation (in the Usangu EMES broadly defined as changes in the extent and condition of dense forest, woodland and bushland) a direct indicator would be the actual measured change in the extent of densely treed land within a particular area, quantifying the change in total and in spatial distribution terms also. Indirect indicators are usually much more numerous and wide-ranging than direct indicators. In the case of deforestation in Usangu they might include charcoal production nearby or within the treed areas or piles of timber or gully erosion or increased flooding downslope and so on. The problem with indirect indicators is that they are not always easy to relate to particular areas: timber by the main highway could have come from several different parts

of Usangu and even from outside it. In addition indirect indicators are often even more difficult to relate causally. Soil erosion may be occurring but how much of it has been induced by man and how much is natural? How much of the induced erosion is due specifically to deforestation and how can the changes in deforestation be quantified from the changes in (induced) soil erosion? The same questions arise for downslope flooding. It may be useful to monitor soil erosion as an issue in itself and quantify it as such, but this will not help quantify, spatially distribute or even necessarily demonstrate increased deforestation.

Many indirect indicators represent subjective judgements, often highly influenced by preconception, prejudice and oversimplification. They are often difficult to quantify and so are expensive to monitor in quantifiable terms. They are at best symptoms of the changes in environmental issues, rather than a direct representation of them. Evaluation of indirect indicators is much more difficult and unreliable because they are often not easily quantified or directly related to the issue in question. The Usangu EMES therefore avoids indirect indicators so far as possible because often they are cost ineffective in terms of information versus cost/effort. However, they can be useful as evidence where subjective assessments have to be made, as say in forest condition in a particular area or for a wide range of less tangible social issues such as social conflict or attitudes, where social survey questionnaires might include indirect indicators. In general, therefore, the Usangu EMES attempts to rely mainly on indicators that directly reflect changes in issues and are quantifiable.

In Sections 3-5 the monitoring design for each indicator for each issue is described by the following:

- general location of monitoring, often in terms of AEDs (more precise location of monitoring sites is usually a specialist function to be completed later);
- method of data collection (again, more detailed design of these broad methods will be completed by the relevant specialists later);
- schedule of data collection (daily, monthly, seasonally (i.e. twice yearly, in the wet and dry season), annually, two-yearly, etc), accompanied by the timeframes for data evaluation;
- institutional responsibility for data collection.

2.4 Definition of environmental standards

An **environmental standard** is defined here as **an environmental threshold value that establishes maximum and/or minimum limits for the criteria by which indicators are measured**. The establishment of agreed environmental standards and their application are major problems in environmental management throughout the world. These problems are especially difficult in the often very extensive and remote rural environments of developing countries, where uniformity of standards may not be easy to achieve and where the resources available for enforcement are limited. Tanzania provides a good example of such a situation, with as yet no consistent definition of environmental standards at national, regional or local levels.

For the Usangu EMP, therefore, it will prove necessary for the technical management body to coordinate closely with local institutions and people within the Strategy Process in establishing acceptable threshold values for the EMES indicators, identifying those points at which corrective action becomes necessary. Successful application of environmental standards in Usangu will depend very much on the success of the Strategy Process in creating the socio-political will at both Village and District levels to implement effective environmental management. The EMP's Environmental Awareness Programme will also be focused on achieving this, and especially on invoking a level of public support and involvement in the EMP that will greatly facilitate the application of environmental standards.

Again, it is evident that environmental standards where possible should be set in accordance with prevailing socio-economic conditions in Usangu, so that they are practical, fair, consistent and commensurate with local living standards. Emulation of stricter standards set in the developed world will often prove impracticable. In addition, the application of environmental standards has to be cost-effective, ideally paying for itself by firm adoption of the *polluter-pays* principle.

2.5 Monitoring tools

The various monitoring tools recommended for the different methodologies in Sections 3-5 include the following.

Environmental baseline. As noted in Section 2.1, the detailed information and evaluation relating to current environmental trends presented in the Baseline 2001, the Environmental Baseline and many of the other Supporting Reports provides the benchmark for the EMES. It is again stressed that environmental evaluation of monitored data should be against the projected trend for an issue, rather than for the single point in time represented by year 2001.

Spatial framework. Many issues occur only in particular parts of the Usangu Catchment, even though their causes and/or impacts might also occur elsewhere. Hydrological changes in the Ihefu can only be measured there, although the primary causes are upstream and critical impacts also occur downstream outside the Catchment. The Environmental Baseline (Supporting Report 24) presents a spatial framework comprising Agroecological Divisions (AEDs), derived directly from the geomorphic divisions in Baseline 2001 – see Table 2.2 and Figure 2.2. This facilitates the geographical design of the EMES and the spatial evaluation of the monitoring data collected, notably by simplifying locational references.

Satellite data and imagery. This is one of the most useful tools for the EMES because today it is relatively inexpensive and easy to acquire. In addition, SMUWC has created considerable familiarity and skills with respect to the handling of satellite data through its well-established GIS component. Several Tanzanian members of the SMUWC Team have improved their skills in interpreting and using satellite imagery. The data/imagery provides an accurate base for the mapping of spatial variations and is of course integral to the GIS (see below). At the same time it is an invaluable tool for the interpretation of such changes, especially those that occur on a macro-scale such as in land cover/use. Interpretation still generally has to be manual but if sound enough correlations can be established between data registration and interpretation units, computerised interpretation becomes possible, although usually units differentiated in this way are very coarse.

Annual acquisition of satellite data/imagery covering at least the Lowlands should be affordable, and certainly data/imagery every two years for the whole Catchment would be very good value and would be adequate to capture broad regional changes in land use/cover. Ideally data/imagery should be acquired well into the wet season to catch the maximum extents of rice and seasonal wetland flooding. On this basis April might be the best month for acquisition; it would also leave several months for interpretation and reporting (see Section 2.9). Twice-yearly data and imagery would be very useful, with dry season (September-October) imagery to show the perennial swamp and dry season cultivation extents, but this might prove too expensive. The scale of the imagery should be 1:100,000, to give the best balance of cover, definition and cost.

Aerial photography/survey. These are tools that have been used very effectively by SMUWC in compiling the baseline. However, they are very expensive, especially the formal acquisition of

comprehensive aerial photography with three-dimensional overlap. The latter is unlikely to be affordable unless special funds are provided for the EMES. It is of course a powerful monitoring tool, especially for detailed measurement of small-scale surface changes, say in annual rice extent, that may be difficult to estimate accurately from satellite imagery, where definition is coarser.

Aerial transects and other forms of aerial survey, including handheld camera and usually oblique aerial photography at special sites, are less expensive but still costly and again probably only justifiable if special funding is available. This tool could probably not normally be justified on a regular (say, annual) basis but might become necessary for any catastrophic or other sudden major change (such as the Ihefu drying out in a particularly dry or low river flow year). On the other hand it might prove a viable alternative to annual acquisition of satellite data/imagery if the latter were only to be used for very site-specific exercises, such as estimation of Ihefu extent.

Laboratory services. The EMES will need the support of a technically reliable, geographically convenient and (relatively) inexpensive laboratory. One solution would be to incorporate an environmental laboratory within the technical body coordinating the EMES (Section 2.7) but again this is likely to prove too expensive and difficult to maintain in the longer term. Thus a suitable laboratory has to be identified: at present SMUWC relies on the Ministry of Water laboratory in Mbeya, as most current analyses relate to water. Specialist laboratory analyses will need specialist (and therefore almost certainly expensive) laboratories, probably in Dar Es Salaam or even overseas, and so should be avoided if at all possible.

As a general principle, the EMES should rely on laboratory analysis only where field measurement is not possible or where it needs supporting data to check its reliability. Then analyses should focus on indicators that are relatively easy to perform in bulk and at relatively low cost. Even so, certain important environmental indicators might have to depend on expensive, specialist analysis.

Field monitoring equipment. A fundamental tool for the EMES is GPS (Global Positioning System) equipment. Like satellite imagery this satellite-dependent tool is no longer expensive and greatly reduces the effort involved in monitoring site location and incorporation in a GIS.

In addition there are many instruments available for field measurement of the more basic physical indicators, such as salinity, pH, and DO (dissolved oxygen). These should be used as widely as possible to minimise costly laboratory analysis.

Avoidance of using field equipment on grounds of cost and maintenance is false economy because alternative manual or laboratory methods are almost always far more expensive, especially over the long period of time involved.

Field traverses. Field observations are an obvious source of monitoring data. However, they require some degree of structuring if they are to be of value in identifying changes and trends. In particular they need to be consistent in terms of time and space i.e. they need to be made at the same place and at broadly the same times each year. The most convenient way of doing this is usually by establishing field traverses that have a fixed and easily identifiable location and visiting these at the required time interval (monthly, quarterly, seasonally, annually, etc). The main role of field traverses is likely to be in providing controlled ground-truthing for land cover/use change. Set at regular intervals such traverses can provide statistically acceptable estimates of unit distribution, but incorporating them with satellite imagery interpretation is likely to be more precise and provides an overall mapped picture.

Airboat. The SMUWC airboat will presumably remain in Usangu, so that no further capital cost arises. An exceptionally skilled Tanzanian driver for the boat has been trained by SMUWC and should be retained. The value of the airboat for river, perennial and seasonal swamp investigations has proved inestimable and its continued use is strongly recommended if the Strategy Process aims to retain the Ihefu and restore perennial flow in the Great Ruaha River. In these circumstances it would fully justify its operation and maintenance costs, as there is no other effective way of moving about in the Ihefu. Even the fishermen were finding that canoe mobility was becoming increasingly difficult, before they were evicted.

Geographical information system (GIS) and database management system. See Section 2.7 below.

Social surveys. Monitoring of human and especially social issues is probably the most difficult element of an EMES. This is because the information acquired is often subjective, providing qualitative rather than quantitative data. Social surveys are a means of structuring the acquisition of social data, usually by means of a carefully-prepared questionnnaire that targets the often numerous important indicators relating to key social and other human issues. They are also one way of maximising grass-roots participation in the EMES: while focusing on social indicators the questionnaires can be designed to include queries that might evoke enlightening answers in relation to non-social issues.

A problem with social surveys, however, is that in an area as large and diverse as the Usangu Catchment they could be expensive as they will require considerable skill, time and effort. One approach would be to enlist a major social institution, such as a university or other academic body to provide the expertise to prepare, carry out and analyse periodic social survey in Usangu. Such a body is almost certainly to be found only in Dar Es Salaam and is even more certainly going to be expensive, not only because of fees but because of the considerable logistical costs involved. Another disadvantage might be that high levels of academic skills are less important than awareness and understanding of local social issues in Usangu.

Ideally therefore it is perhaps preferable on both cost-effectiveness and output value to undertake social survey through the Usangu Catchment technical team, which must include a social component, acting in concert with local government through the CEP activities and organisations established under SMUWC. This approach would maximise local know-how and minimise cost. The level of relevant skills, however, might in the early years be dependent on external funding and the availability of SMUWC or some comparable organisation. In the longer-term the government staff involved would be expected to acquire the training and the experience to enable them to carry on without external support. This same long-term approach applies not only to social survey but also to implementation of the EMP as a whole.

It is believed that social surveys would not be necessary every year, as social changes generally occur slowly, but probably every two years would be cost effective. Timing would need to be during the last three months of the monitoring year (i.e. April-June) to ensure findings were as up-to-date as possible and adequate access was possible in the Lowlands, if work began in the Uplands.

The social survey would target representative villages in each of the main AEDs defined in the spatial framework where permanent settlement occurs. An initial broad survey of the 150 or so villages in the Usangu Catchment is planned before the completion of current SMUWC activities and this will provide the basis for the selection of the EMES social survey villages. The survey will in total be carried out in between 30 and 50 villages, depending on likely cost relative to data utility. Possibly

selection should avoid the seven SMUWC CEP villages because they will have already had relatively intensive involvement with SMUWC.

Within each selected representative village the social survey questionnaire is probably best responded to by a **focus group**, whose members represent the main elements of village society (from the perspective of environmental management). As such they are likely to also represent environmental **impact groups**: large farmers, small farmers, irrigators, landless, pastoralists, women, the aged, merchants/shop keepers, artisans or agro-industrial workers, etc. For many indicators formal focus group discussions will provide useful background and interpretation of the data collected.

Stakeholder reviews. For certain issues, notably in relation to institutional indicators, it will be useful to hold stakeholder reviews in which a structured analysis of the views of the various Usangu Catchment stakeholders is carried out. Such reviews might take the form a special meeting or special session at routine stakeholders' meetings. Probably, however, they are best conducted using a questionnaire circulated to the stakeholder groups, as this would be less time-consuming and less costly. They would be organised by the technical team.

Official data/statistics. For many indicators, especially relating to human issues, a prime source of data will be the routine and other official statistics/information produced by relevant government institutions. Such data will be collected by the Usangu Catchment technical team from the relevant institution and then evaluated by them.

2.6 Monitoring schedules

Different indicators will require different time intervals for monitoring: river flows and rainfall need daily measurement, while land cover/use change might need recording only once every several years, unless change is known to be rapid in a particular area. The different time intervals are indicated, where known, in Sections 3-5.

A basic scheduling problem for environmental monitoring is whether to adopt an annual timeframe based on the calendar year or on more technically relevant seasonal dates. The calendar year in Usangu ends in the middle of the wet season, making it complicated to apply to monitoring and evaluation of data. In Usangu an EMES annual timeframe starting on 1st July would be much more convenient, this date coming as it does in the middle of the dry season and when the least extent of rainfed or irrigated crops are on the ground. Data analysis and presentation would be considerably simplified and annual reporting of the EMES would then be greatly facilitated. Final design of the EMES should consider the adoption of this seasonal timeframe (see Section 2.9).

2.7 Data handling – the role of GIS

A major asset for the EMES is the existence of the SMUWC **GIS (geographical information system)**. In addition to its spatial functions the GIS incorporates a comprehensive database management system (DBMS). This will have a fundamental role to play in the accumulation, storage, manipulation, analysis and presentation of both statistical and spatially-related environmental data. Consequently it is essential that the GIS remains an integral unit based within the body that has overall technical responsibility for the EMES. Output from the GIS will be particularly valuable for this body in the preparation of annual or other EMES reports and in providing effective presentation of data in various visual forms.

2.8 Monitoring and evaluation responsibilities

2.8.1 Overall EMES responsibility

The EMES should concentrate monitoring and evaluation activities, and especially field data collection, in as few organisations as possible. This is not easy because of the wide range of issues involved. Field data collection is usually the most difficult, expensive and time-consuming aspect of an EMES, with transport availability often the key problem. Thus if one field team can measure several different and even unrelated indicators during each field foray considerable efficiency can be gained. This can be added to if a range of different indicators can be measured at the same site. Clearly the team measuring river flows or groundwater levels could easily also sample water for quality monitoring and probably do so often at the same site. On the other hand this team is unlikely to have the skills needed for social surveys, for which another team is likely to be needed. However, it should be possible to limit the number of EMES field teams, perhaps to three - one for each of the basic physical, biological and human issue groups.

Data evaluation should be undertaken primarily by the technical body to be established by the Strategy Process. For convenience here, this body has been entitled the **Usangu Catchment Technical Secretariat (UCTS)**. Reference to specialised technical expertise outside this body should be made only as really necessary, especially where such expertise is located outside the Catchment. In particular, therefore, the GIS should remain with the UCTS, located in the same offices. Section 2.6 has stressed the vital role of the GIS in the EMES.

The overall coordination and responsibility for the EMES should rest with the UCTS, as well as responsibility for certain additional or specialised data collection. At present the UCTS role is undertaken by the SMUWC team, which has also developed the GIS in its offices. Without SMUWC it seems highly unlikely that environmental management for the Usangu Catchment has any immediate future, in which case the EMES concept becomes irrelevant. Thus future phases of SMUWC or some equivalent have to be assumed, first to facilitate the Strategy Process and then to help initially implement the EMP that emerges from it. During both these periods the EMES should be operational, continuing to update knowledge and understanding of environmental trends in Usangu. The UCTS, be it SMUWC or some other organisation, is expected to act as a technical (or environmental) secretariat to the Usangu Steering Committee. It should also include government staff. Over time SMUWC will aim to be replaced by these fully-trained government staff who would then continue to carry out the vital technical coordination and technical supervision roles.

2.8.2 Other EMES participants

The refinement of institutional responsibilities in EMES will be a key activity of the Strategy Process. At present, therefore, it is difficult to comment further on the overall institutional responsibility for the EMES. However, the EMES would need to involve a number of other organisations in order to function effectively in terms of both cost and technical accomplishment. These other participants would also increase the acceptability of EMES findings to the wide range of Usangu stakeholders, some of whom might be called upon to act in response to the EMES findings. Where possible, suggestions are made in Sections 3-5 regarding institutional responsibilities for the monitoring of each indicator.

Figure 2.3 presents a preliminary framework identifying the key participant organisations and institutions. This will be updated during the Strategy Process.

Villages. The participation of villagers and village institutions is seen as a vital component of EMES operation. Specific monitoring measurements, especially those required daily or frequently, will rely on local people to provide their services and perform consistently and reliably (rain gauges, river flows, etc). Many of the human issues and their social indicators can only be effectively monitored at village level, be it by periodic social surveys or from the on-going activities of the various village-level social components of SMUWC (CEP, SRMP, RLR, etc).

Districts. Government organisations at the District level are already involved in various monitoring activities (collection of health, agricultural and demographic statistics, for instance) and so form key components of the EMES, which will need to rely on this data for many indicators. District staff have already become closely involved with SMUWC in the environmental management of Usangu, especially from Mbarali District (where most of the Usangu Lowlands are located). SMUWC has strengthened these links through training programmes for District staff and close interaction with the Districts wherever possible. The Districts, like the Villages, are seen as key players in the Strategy Process and as noted in Section 2.3 both have already contributed to the identification of the EMES indicators used in Sections 3-5. A problem with District data is that administrative boundaries rarely conform to the more natural boundaries of the AEDs comprising the environmental spatial framework (Section 2.5).

Wards. As subdivisions of the Districts the Wards can sometimes be more useful data sources because of the greater geographical precision they provide. In addition, the much smaller Ward unit is often wholly within a particular natural unit so that Ward data is easier to apply to the AEDs.

Regions. Regional government institutions have a similar role, notably with respect to the hydrological monitoring already carried out by the Ministry of Water's regional offices. It is anticipated, for instance, that the Rufiji Basin Water Office (RBWO) will play a prominent part in environmental management of the Usangu Catchment, given the overall importance of water resources there.

Other projects. Two projects are of special relevance to the Usangu EMES: HIMA, collecting considerable field data in the Usangu Uplands, and RBMSIIP covering the entire Rufiji Basin, where it contributes substantially to the upkeep of hydrological monitoring stations. Both projects seem likely to end within the next two years or so. However, new projects in and around Usangu are always possible and might contribute similarly. RUBADA has been active in the Usangu Catchment in the past but now seems to have ceased operations there.

Other organisations. There are a number of other bodies that might contribute to the EMES, although not necessarily on a regular basis. In particular, all the bodies shown in Figure 2.3 under this heading might provide specialist skills to assist in the evaluation of monitoring data from time to time. The Ruaha National Park is likely to be involved regularly because it can supply climatic and river flow data, as well as assessments of the impacts of flow cessation on fauna and flora in the Park, a current major off-site impact of environmental trends in Usangu. The Ruaha Game Reserve could be expected to include the monitoring of the return of wildlife to the Eastern Wetland and Ihefu as part of its operations, providing important data for the EMES.

In the discussion of social surveys in Section 2.5 the possibility of involving academic institutions in the EMES was reviewed, with the conclusion that cost would probably be too great an obstacle. The

same consideration is likely to preclude the involvement of NGOs, which also often impose substantial charges for their services.

2.9 Evaluation and reporting procedures

Evaluation of the monitoring data and presentation of data analyses and findings should be on a periodic basis. Most usually and conveniently, this periodic presentation takes the form of an annual report. Section 2.6 recommends that the EMES annual timeframe should start on 1st July rather than on a calendar basis on 1st January. Allowing, say, three months for finalisation of data analysis (which could be expected to continue throughout the period) and report compilation, the annual report would be submitted on 30th September. Short monthly progress reports should also be issued, but with the emphasis on brevity. Another form of output which is useful when monitoring construction projects is the environmental memo or note, which can be used in urgent circumstances as an "early warning" device on matters such as safety. However, it is unlikely that circumstances in Usangu would ever change sufficiently quickly to justify any output more frequent than the monthly progress report, which if necessary could include any "early warning" notes.

Review of the EMES Annual Report by the Usangu Steering Committee and other stakeholders should aim to reach consensus on any mitigatory measures identified as necessary by the EMES. In the short-term (i.e. during the Strategy Process) such mitigatory measures could be defined as interim actions. In the longer term, once the EMP is established, such measures would be integrated into the EMP and their implementation monitored during subsequent monitoring periods.

A final output of the EMES will be the opportunity to evaluate previous environmental assessments. Thus in the shorter term of the Strategy Process the results emerging from the EMES could confirm or otherwise the current environmental trends identified in the Environmental Baseline. In the longer term, following the design of the EMP, the EMES findings could be used to evaluate the environmental assessment of the EMP that will presumably be included in it.

Figure 2.4 illustrates, on an annual basis, how the EMES might operate. Monitoring would be based on the collection of data for primary indicators relating to primary issues and the output analysed against the benchmark of SMUWC's 2001 baseline trends, for presentation in the Annual Report along with any mitigatory measures recommended as necessary. Action would then result from reviews by stakeholders of the EMES Report. The Report would also include monitoring of the overall EMP design/implementation, allowing this also to be reviewed and action taken as agreed. Meantime, at any stage of the monitoring year, "early warning" action could be alerted as necessary, through the EMES monthly progress reports.

3. PHYSICAL ENVIRONMENTAL MONITORING

Key:
Indicators: 1 = primary; 2 = secondary
Location: For key to Agroecological Division abbreviations see Table 2.2; for their location see Figure 2.2
Methodology: For key to abbreviations see List of Abbreviations
Schedule: Mn = monitoring schedule; Ev = evaluation schedule
A = annual; S = seasonal (twice yearly, in wet and dry seasons);
M = monthly; D = daily; 2,3,4 etc = number of years
Responsibility: For organisation acronyms see List of Abbreviations

3.1 Water Issues

Issue: Catchment run-off (primary)

In the Lowlands evapotranspiration exceeds rainfall. Run-off therefore derives primarily from the Uplands, where it concentrates in a relatively small number of rivers. On reaching the Lowlands much of it is diverted and disseminated by people for irrigation and domestic water supply.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Total river flow	Existing gauging stations nearest the head of the Alluvial Fans on all perennial and major seasonal rivers.	River gauge discharge reading.	D	A	MOW/UCTS
1. Seasonal river flow		River gauge discharge reading.	D	S/M	MOW/UCTS
1. River flow intensity (max/min)		River gauge discharge reading.	D	D	MOW/UCTS

Issue: River discharges (primary)

River flows are the key factor in the sustainability of the Ihefu and Seasonal Wetlands and in the incidence of perennial outflow from Usangu, as well as in supplying irrigation and domestic water needs.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Total river flow	Existing gauging stations throughout Usangu Catchment on all perennial and major seasonal rivers at selected critical points.	River gauge discharge reading.	D	A	MoW/UCTS
1. Seasonal river flow		River gauge discharge reading.	D	S/M	MoW/UCTS
1. River flow intensity (max/min)		River gauge discharge reading.	D	D	MoW/UCTS

Issue: River water quality (secondary)

The Baseline reveals no problems with river water quality, so only minimal monitoring is required to check that no significant changes occur. More sophisticated monitoring is not required unless significant change occurs in these basic parameters.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
2. Salinity	Gauging stations throughout Usangu Catchment on all perennial and major seasonal rivers at selected critical points.	Field measurement of electrical conductivity using a conductivity-pH meter.	S	S	MoW/UCTS
2. Alkalinity		Field measurement of pH using a conductivity-pH meter.	S	S	MoW/UCTS
2. Chemical pollution		Field sampling and laboratory measurement of NO3.	S	S	MoW/UCTS; MoW laboratory
2. Sewage		Field sampling and laboratory measurement of coeliform content.	S	S	MoW/UCTS; MoW laboratory
2. Nutrient status		Field measurement of DO using a DO meter.	S	S	MoW/UCTS

Issue: Siltation (primary)

It is possible that river silt loads are increasing and accelerating the infilling of the Ihefu and changes in its vegetation. Even if stable, siltation must influence the capacity and life expectancy of the Ihefu, so that quantitative data on it is needed.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. River silt load	Gauging stations throughout Usangu Catchment on all perennial and major seasonal rivers at selected critical points.	a. Sampling and measurement of silt percentage per unit of river water.	M	M/S/A	MoW/UCTS; MoW laboratory
1. Level of Ihefu bed	Specially selected, levelled and permanently marked sites within the Ihefu (such as the two open-water gauge sites).	a. Measurement of water depth against levelled-in stake gauges.	A	A	UCTS

Issue: Seasonal wetlands recharge/extent (primary)

Major changes are occurring in the Seasonal Wetlands, especially in the Western Wetland. Diminishing recharge is causing a rapid reduction in extent that needs to be accurately quantified. Groundwater contributions to recharge are at present an unknown quantity but are probably much less than to the Ihefu.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Extent of wet season inundation	Western Wetland; Eastern Wetland	a. Estimation by interpretation of satellite data/imagery. b. Field ground-truthing /annual updating (field traverses). c. Aerial check during wet season wildlife aerial surveys.	A A 3	A A 3	UCTS/?? UCTS/?? UCTS/??
1. Catchment run-off	(see above)	(see above)	(see above)		(see above)
1. Use of water for irrigation	Subcatchments/irrigation systems. Social survey villages.	a. Water User Association diversion data; field observations. b. Social survey questionnaires: village diversions estimates.	A 2	A 2	WUAs/UCTS UCTS (CEP)
1. Great Ruaha River discharge	Nyaluhanga gauge. N'giriama gauge.	a. River gauge discharge reading. b. River gauge discharge reading.	D D	M/S/A M/S/A	UCTS/MoW UCTS/MoW
1. Ndembera River discharge	Madibira gauge.	a. River gauge discharge reading.	D	M/S/A	UCTS/MoW
2. Groundwater recharge	?	?	?		?

Issue: Perennial swamps recharge/extent (primary)

Major changes are also occurring in the Ihefu more rapidly than had been thought. Diminishing recharge threatens to cause a reduction in extent; both need to be accurately quantified. Groundwater contributions to recharge are at present an unknown quantity.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Extent of Ihefu	Ihefu Swamp.	a. Estimation of extent by interpretation of dry season satellite data/imagery. b. Field ground-truthing/annual updating of estimates (dry season field traverses using airboat). c. Topographic field survey (using established SMUWC benchmarks). d. Aerial checks during wildlife aerial surveys.	A A 3 3	A A 3 3	UCTS/?? UCTS/?? UCTS UCTS/??
1. Great Ruaha River discharge	Nyaluhanga gauge. N'giriama gauge.	a. River gauge discharge reading. b. River gauge discharge reading.	D D	M/S/A M/S/A	UCTS/MoW UCTS/MoW
1. Ndembera River discharge	Madibira gauge.	a. River gauge discharge reading.	D	M/S/A	UCTS/MoW
1. Groundwater recharge	?	?	?		?

Issue: Wetlands water quality (secondary)

The Baseline reveals no problems with Ihefu water quality, so only minimal monitoring is required to check that no significant changes occur. More sophisticated monitoring is not required unless significant change occurs in these basic parameters.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
2. Salinity	Specially selected and permanently marked sites within the Ihefu (such as the two open-water gauge sites and the gauge at the outflow point at N'giriama).	Field measurement of electrical conductivity using a conductivity-pH meter.	S	S	MoW/UCTS
2. Alkalinity		Field measurement of pH using a conductivity-pH meter.	S	S	MoW/UCTS
2. Chemical pollution		Field sampling and laboratory measurement of NO3	S	S	MoW/UCTS; MoW laboratory
2. Sewage		Field sampling and laboratory measurement of coeliform content	S	S	MoW/UCTS; MoW laboratory
2. Nutrient status		Field measurement of DO using a DO meter.	S	S	MoW/UCTS

Issue: Groundwater levels (primary)

The SMUWC ToR allowed the role of groundwater in the Usangu Catchment hydrology to be covered only superficially. It remains a pssibly significant gap in the hydrology model. RBMSIIP continues to propose the drilling of exploratory wells at a handful of carefully selected sites but this has still to happen. Groundwater could prove a primary issue in wetland recharge and provision of domestic or even irrigation water supplies.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Depth to groundwater	Selected existing wells, especially in Lowlands/Wetlands; proposed new wells.	a. Measurement of depth to watertable.	M	M/S	UCTS/RBMSIIP
1. Groundwater levels	Selected existing wells, especially in Lowlands/Wetlands; proposed new wells.	a. Levelling-in of the selected wells to the mean sea level (MSL) datum. b. Calculation of level above MSL from watertable depth measurement.	Initial		UCTS/RBMSIIP
1. Artesian pressure	As identified.	a. Investigation and explanation of any occurrences of significant artesian pressure	As required		UCTS/RBMSIIP

Issue: Groundwater quality (secondary)

The Baseline reveals no problems with groundwater quality, so only mimimal monitoring is required to check that no significant changes occur. More sophisticated monitoring is not required unless significant change occurs in these basic parameters.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
2. Salinity	Gauging stations throughout Usangu Catchment on all perennial and major seasonal rivers at selected critical points.	Field measurement of electrical conductivity using a conductivity-pH meter.	S	S	MoW/UCTS
2. Alkalinity		Field measurement of pH using a conductivity-pH meter.	S	S	MoW/UCTS
2. Chemical pollution		Field sampling and laboratory measurement of NO3	S	S	MoW/UCTS; MoW laboratory
2. Sewage		Field sampling and laboratory measurement of coeliform content	S	S	MoW/UCTS; MoW laboratory
2. Nutrient status		Field measurement of DO using a DO meter.	S	S	MoW/UCTS

3.2 Land Issues

Issue: Soil erosion (primary)

Induced soil erosion in Usangu is often difficult to distinguish from natural erosion, which in the Uplands must always have occurred on the steep slopes. However, a negative trend is identified now in some AEDs, with the increased pressure from vegetation clearance, cultivation and grazing, notably on the Alluvial Fans. It is, however, a difficult issue to monitor because of measurement problems, especially for sheet erosion by water or wind. For this reason only gully erosion is included here.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Gully erosion	Usangu Catchment: sites as identified.	a. Identification of selected representative gullied sites for different AEDs.	Initial		UCTS
		b. Definition of benchmark extent/depth by permanent markers, photographs, etc.	Initial		UCTS
		c. Ground measurement of gully expansion, deepening, etc.	A	A	UCTS
		d. For larger sites: mapping & estimation of increased extent by interpretation of satellite imagery.	A	A	UCTS
		e. Aerial photography at time of wildlife aerial surveys.	3	3	UCTS/??

Issue: Soil degradation (primary)

The same difficulties as for soil erosion. Many of Usangu's soils are naturally degraded because they occupy very old land surfaces and often are easily degradable. Main concern focuses on the extensive Black Mbuga soils, especially in the Western Wetland, which seem to be rapidly losing their distinctive vertisol characteristics as seasonal flooding continues to diminish. Degradation is likely to be accelerated there and on the Alluvial Fans because of increased grazing intensity resulting from displacement of livestock from the new Game Reserve. Large areas of land excellent for grazing and suitable for cultivation are likely to deteriorate.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Loss of vertisol characteristics (Change from Black to Grey Mbuga)	Seasonal Wetlands Black Mbuga.	a. Late dry season fixed field traverses with stops at fixed intervals to estimate soil characteristics: colour, cracking, mulching, compaction, etc.	A	A	UCTS
		b. Identification of selected representative degraded sites.	A	A	UCTS
		c. Collection and lab analysis of surface soil samples: organic matter, Ca, Mg, ECe, pH.	A	A	UCTS/??
		d. Grassland condition (see Section 4.1).			
2. Excessive leaching	Irrigated Fans and Sand Hills AEDs.	a. Identification/marking of selected representative degraded sites.	A	A	UCTS
		b. Collection and lab analysis of surface soil samples: organic matter, Ca, Mg, ECe, pH, clay content.	A	A	UCTS/??
2. Excessive compaction	Northern & Southern Fans AEDs.	a. Identification/marking of selected representative degraded sites.	A	A	UCTS
		b. Estimation of compaction: simple penetration test with instrument/water; sampling/analysis for lab measurement of bulk density.	A	A	UCTS UCTS/??

Issue: Soil fertility (secondary)

Soil degradation and changes in soil fertility will be closely linked, with the main concerns again with the Black Mbuga and the more intensively cultivated Alluvial Fan soils. Very little fertiliser is currently used and natural replenishment of nutrients is unlikely to keep up with crop extractions, although ploughing in of stubble helps. Grazing of stubble/stover can supply natural nutrients most efficiently as animal dung but this is often avoided. This could become a primary issue quite quickly if present trends persist. It would be useful to compare the resilience of basaltic soils in both Uplands and Lowlands by including them.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn Ev	Monitoring Responsibility
2. Organic matter content	Seasonal Wetlands Black and Grey Mbuga; Irrigated Fans and Sand Hills AEDs; Medium Plateau basalt and non-basalt soils; Low Plateau granitic soils.	a. Identification/marking of selected representative degraded sites. b. Collection and lab analysis of surface soil samples: organic matter.	Initial 2 2	UCTS UCTS/??
2. Nutrient content: N, P, K	Seasonal Wetlands Black and Grey Mbuga; Irrigated Fans and Sand Hills AEDs; Medium Plateau basalt and non-basalt soils; Low Plateau granitic soils.	a. Identification/marking of selected representative degraded sites. b. Collection and lab analysis of surface soil samples: N, P, K.	Initial 2 2	UCTS UCTS/??
2. Cation exchange capacity (CEC)	Seasonal Wetlands Black and Grey Mbuga; Irrigated Fans and Sand Hills AEDs; Medium Plateau basalt and non-basalt soils; Low Plateau granitic soils.	a. Identification/marking of selected representative degraded sites. b. Collection and lab analysis of surface soil samples: CEC.	Initial 2 2	UCTS UCTS/??
2. Soil reaction	Seasonal Wetlands Black and Grey Mbuga; Irrigated Fans and Sand Hills AEDs; Medium Plateau basalt and non-basalt soils; Low Plateau granitic soils.	a. Identification/marking of selected representative degraded sites. b. Collection and lab analysis of surface soil samples: pH +/- CaCO3.	Initial 2 2	UCTS UCTS/??

3.3 Climate Issues

Issue: Regional climate change (primary)

There is a widespread local belief in Usangu that rainfall is decreasing: rainfall data suggests this might be so but not sufficiently to be statistically significant. In any case climatic data is important for many other issues and is already widely monitored by Government.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn Ev	Monitoring Responsibility
1. Rainfall	Usangu Catchment: government, SMUWC and other climate stations.	a. Collection & analysis of rainfall data from climate stations.	D A/S/M/D	UCTS/MoW,/DoM/RNP/HIMA/
1. Temperature	Usangu Catchment: government, SMUWC and other climate stations.	a. Collection & analysis of temperature data from climate stations.	D A/S/M/D	UCTS/MoW,/DoM/RNP/HIMA/
1. Wind	Usangu Catchment: government, SMUWC and other climate stations.	a. Collection & analysis of wind data from climate stations.	D A/S/M/D	UCTS/MoW,/DoM/RNP/HIMA/
1. Relative humidity	Usangu Catchment: government, SMUWC and other climate stations.	a. Collection & analysis of relative humidity data from climate stations.	D A/S/M/D	UCTS/MoW,/DoM/RNP/HIMA/
1. Radiation	Usangu Catchment: government, SMUWC and other major climate stations.	a. Collection & analysis of radiation data from major climate stations.	D A/S/M/D	UCTS/MoW,/DoM/RNP/HIMA/
1. Evaporation (open-water)	Usangu Catchment: government, SMUWC and other major climate stations.	a. Collection & analysis of evaporation data from major climate stations.	D A/S/M/D	UCTS/MoW,/DoM/RNP/HIMA/
1. Evapo-transpiration	Usangu Catchment: government, SMUWC and other climate stations.	a. Collection/calculation & analysis of evapotranspiration data from climate stations.	D A/S/M/D	UCTS/MoW,/DoM/RNP/HIMA/

4. BIOLOGICAL ENVIRONMENTAL MONITORING

Key:
Indicators: 1 = primary; 2 = secondary
Location: For key to Agroecological Division abbreviations see Table 2.2; for their location see Figure 2.2
Methodology: For key to abbreviations see List of Abbreviations
Schedule: Mn = monitoring schedule; Ev = evaluation schedule
A = annual; S = seasonal (twice yearly, in wet and dry seasons);
M = monthly; D = daily; 2,3,4 etc = number of years
Responsibility: For organisation acronyms see List of Abbreviations

4.1 Vegetation (Flora) Issues

Issue: Forests/woodlands/bushlands extent/integrity (primary)
This issue can be summarised as **deforestation** i.e. the change in densely treed areas in the Catchment. It is important because of the potential implications for a range of other issues, notably catchment run-off, river discharges, erosion, flooding, etc. The issue could be monitored in more detail by differentiating the component types of treed area but this could become expensive and time-consuming.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Extent of forest, woodland, bushland	Forest/woodland/bushland areas throughout Usangu Catchment, especially in the Uplands and Alluvial Fans AEDs.	a. Estimation for each AED by interpretation of satellite data/imagery. b. Field ground-truthing/annual updating of estimate (field traverses).	2 A	2 A	UCTS/DFDs/HIMA? UCTS/DFDs
1. Forest, woodland, bushland condition		a. Identification/estimation of possible degraded areas on imagery. b. Field evaluation of selected areas: tree stumps; charcoal, firewood, timber production; clearance for cultivation/grazing, soil degradation/erosion.	2 A	2 A	UCTS/DFDs/HIMA? UCTS/DFDs

Issue: Savannah bushlands extent/integrity (primary)

In both Uplands and Lowlands of Usangu invasion of grasslands to form new or expand existing savannah bushlands seems to be occurring. This has important and often conflicting socio-economic implications (e.g. decreasing grassland suitability for grazing but increasing local energy sources).

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Lowlands savannah bushland extent (including Wetlands)	Savannah bushland areas in Usangu Lowlands, especially in the Seasonal Wetlands & Alluvial Fans AEDs.	a. Estimation per AED by interpretation of satellite data/imagery. b. Field ground-truthing /annual updating of estimate (field traverses).	2 A	2 A	UCTS/DFDs? UCTS/DFDs
1. Lowlands savannah bushland condition (including Wetlands)		a. Identification/estimation of possible expansion/contraction areas from imagery and field observation. b. Field traverse evaluation of selected areas: species/communities, density of scrub & tree invasion/retreat.	2 A	2 A	UCTS/DFDs UCTS/DFDs
1. Uplands savannah bushland extent	Savannah bushland areas in Usangu Uplands AEDs.	d. Estimation per AED by interpretation of satellite data/imagery. e. Field ground-truthing /annual updating (field traverses).	2 A	2 A	UCTS/DFDs/HIMA? UCTS/DFDs
1. Uplands savannah bushland condition		a. Identification/estimation of possible expansion/contraction areas from imagery and field observation. b. Field traverse evaluation of selected areas: species/communities, density of scrub & tree invasion.	2 A	2 A	UCTS/DFDs/HIMA? UCTS/DFDs

Grasslands extent/integrity (primary)

The Baseline identifies a strong negative current trend for Usangu grasslands, especially the extensive Seasonal Wetland grasslands that represent such a valuable resource. These are now under severe and immediate threat, especially in the Western Wetland, due to increasing diversion of run-off for irrigation.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Lowlands grasslands extent (including Wetlands)	Grassland areas in Usangu Lowlands, especially in the Seasonal Wetlands & Alluvial Fans AEDs.	a. Estimation per AED by interpretation of satellite data/imagery. b. Field ground-truthing /annual updating of estimate (field traverses).	2 S	2 S	UCTS/MOAC/DFDs?? UCTS/ MOAC/DFDs??
1. Lowlands grasslands condition (including Wetlands)		a. Identification/estimation of possible degraded areas from imagery and field observation. b. Field traverse evaluation of selected areas: type, cover, duration, palatability of grasses, scrub & tree invasion, soil degradation/erosion.	2 S	2 S	UCTS/MOAC/DFDs?? UCTS/ MOAC/DFDs??
1. Uplands grasslands extent	Grassland areas in Usangu Uplands AEDs.	a. Estimation per AED by interpretation of satellite data/imagery. b. Field ground-truthing /annual updating (field traverses).	2 S	2 S	UCTS/MOAC/DFDs/HIMA?? UCTS/ MOAC/DFDs/HIMA??
1. Uplands grasslands condition		a. Identification/estimation of possible degraded areas from imagery and field observation. b. Field traverse evaluation of selected areas: type, cover, duration, palatability of grasses, scrub & tree invasion, soil degradation/erosion.	2 S	2 S	UCTS/MOAC/DFDs?? UCTS/ MOAC/DFDs??

Issue: Swamp vegetation extent/integrity (primary)

The Baseline identifies a significant negative current trend for the main Usangu perennial wetland, the Ihefu. As the main habitat of special ecological interest remaining in Usangu, the Ihefu and its vegetation appear to represent a primary ecological issue. This vegetation is also important because of its impact on the hydraulic efficiency of the Ihefu, which it is postulated by SMUWC has greatly reduced in recent decades. The occasional patches of perennial swamp vegetation found elsewhere in Usangu (Ndembera, Kapunga) are too small to warrant monitoring.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Extent of different types of swamp vegetation in Ihefu	Ihefu Swamp.	c. Estimation of species/community extents by interpretation of dry season satellite data/imagery.	A	A	UCTS/??
		d. Field ground-truthing/annual updating of estimates (dry season field traverses using airboat) and identification of key species/communities.	A	A	UCTS/??
1. Condition of different types of swamp vegetation in Ihefu	Ihefu Swamp.	a. Dry season field traverses to evaluate vegetation condition: density, nature (floating etc), degrading, thriving, evidence of hippo activity, etc.	A	A	UCTS/??
1. Proportion of dense to open water vegetation in Ihefu	Ihefu Swamp.	a. Calculation from above data.	A	A	UCTS/??

4.2 Animal Life (Fauna) Issues

Issue: Wildlife communities/habitats (secondary)

Wildlife communities are virtually absent from large parts of Usangu, especially the more developed south and east. Even in the undeveloped northern miombo numbers are low, while in the Seasonal Wetlands very few sightings have been made in recent years. Aquatic species in the Ihefu are mostly reduced to a handful of crocodile and hippo. Wildlife is therefore a secondary issue at this stage. Should the new Usangu Game Reserve be successful in attracting game back, this could of course change.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
2. Numbers of large terrestrial mammals: giraffe, impala, hartebeeste, ostrich, zebra, reedbuck, warthog, sable, elephant, topi (especially the so-called *Usangu topi*), etc	Lowlands, Wetlands & northern Uplands AEDs.	a. Aerial statistical survey to estimate numbers of each species.	3	3	UCTS/??
		b. Collection/analysis of Game Park data on species variety and numbers.	A	A	UCTS/Usangu Game Park
		c. Casual field observations during field traverses for other purposes.	A	A	UCTS
2. Numbers of crocodile, hippopotamus	Ihefu Swamp.	a. Aerial statistical survey to estimate numbers of each.	3	3	UCTS/??
		b. Collection/analysis of Game Park data for each.	A	A	UCTS/Usangu Game Park
		c. Casual field observations during field traverses for other purposes.	A	A	UCTS

Issue: Bird communities/habitats (primary)

By far the most important fauna issue in Usangu is that of birdlife, and especially wetland birds. Centred on the Ihefu but with a number of other important habitats (including the anthropic habitat created by paddy rice), there is a huge and diverse bird population comprising both native and migrant species. Usangu could be an ecologically important stopping place on the East African migratory routes. This is consequently a primary issue, especially given the impending threat to both the perennial and some seasonal wetland bird habitats. Non-wetland bird communities are of less interest in Usangu.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Migratory wetland species: numbers & diversity	Ihefu/Eastern Wetland. Irrigated Fans. Northern Fans. Western Wetland.	For all monitoring locations: a. Structured ornithological survey to identify and count key species. b. Casual field observations during field traverses for other purposes. c. Game Park data collection/analysis.	 A A A	 2 A A	 UCTS/?? UCTS/Game Reserve staff Usangu Game Park/UCTS
1. Resident wetland species: numbers & diversity	Ihefu/Eastern Wetland. Irrigated Fans. Northern Fans. Western Wetland.	For all monitoring locations: a. Structured ornithological survey to identify and count key species. b. Casual field observations during field traverses for other purposes. c. Game Park data collection/analysis.	 2 A A	 2 A A	 UCTS/?? UCTS/Game Reserve staff Usangu Game Park/UCTS
2. Other migratory species: numbers & diversity	Lowlands Region. Uplands Region.	In both Geomorphic Regions: a. Casual field observations during field traverses for other purposes.	 A	 A	 UCTS/Game Reserve staff
2. Other resident species: numbers & diversity	Lowlands Region. Uplands Region.	In both Geomorphic Regions: a. Casual field observations during field traverses for other purposes.	 A	 A	 UCTS/Game Reserve staff

4.3 Protected Areas Issues

Issue: Usangu Game Reserve (primary)

Events in 2000 indicate that Government is intent on firmly establishing the new Game Reserve. This is a primary issue because of the major negative impacts this will have on pastoralism, fisheries (already destroyed), and those other grazing areas both in and outside Usangu to which the displaced pastoralists and their large herds will have to move. Against these negative impacts will have to be measured any positive aspects of the Game Park, notably in terms of increased game in the Eastern Wetland and Ihefu.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Numbers of large terrestrial mammals: giraffe, impala, duiker, hartebeeste, eland, ostrich, zebra, reedbuck, kudu, warthog, sable, elephant, dikdik, topi (especially the so-called *Usangu topi*), etc	Eastern Wetland AED. Northern Hills AED (within the Reserve)	In both AEDs: a. Game surveys to identify and enumerate species; evaluate seasonal game movements. b. Aerial statistical survey to estimate numbers of each species. c. Casual field observations by Game Reserve staff.	 S 2 D	 S 2 M/S	 Game Reserve UCTS/?? Game Reserve
1. Numbers of crocodile, hippopotamus	Ihefu.	a. Game surveys to identify and enumerate both species. b. Aerial statistical survey to estimate numbers of each species. c. Casual field observations by Game Reserve staff.	S 2 D	S 2 M/S	Game Reserve UCTS/?? Game Reserve
1. Migratory wetland species: numbers & diversity	Ihefu/Eastern Wetland.	a. Structured ornithological survey to identify and count key species. b. Casual field observations by Game Reserve staff.	2 D	2 M/S	UCTS/?? Game Reserve
1. Resident wetland species: numbers & diversity	Ihefu/Eastern Wetland.	a. Structured ornithological survey to identify and count key species. b. Casual field observations by Game Reserve staff.	2 D	2 M/S	UCTS/?? Game Reserve
1. Numbers of visitors	Game Reserve: Ihefu, Eastern Wetland & Northern Hills (part) AEDs.	a. Income data for entrance, residence, catering, etc.	D	M/S	Game Reserve
1. Income from visitors	Game Reserve: Ihefu, Eastern Wetland & Northern Hills (part) AEDs.	a. Income data for entrance, residence, catering, etc.	D	M/S	Game Reserve
1. Income from hunting licences	Game Reserve: Ihefu, Eastern Wetland & Northern Hills (part) AEDs.	a. Income data for hunting licences.	D	M/S	Game Reserve

Issue: Ruaha National Park (primary)

The most important off-site impact area affected by the Usangu Catchment is the Ruaha National Park, the eastern boundary of which is formed by the Great Ruaha river after it leaves the Usangu Catchment at N'giriama. The annual cessation of outflow at N'giriama during the last decade creates major problems for the Park, especially with respect to crocodile and hippo but also in changing the seasonal distribution of terrestrial wildlife.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Great Ruaha River flow	Great Ruaha River: N'giriama, Hauptmann's Bridge, Msembe.	a. River gauge measurements.	D	M/S	MoW/UCTS
1. Movement of wildlife	RNP: away from Great Ruaha Usangu Game Reserve	a. Wildlife movement monitoring: species, numbers, direction. b. Wildlife increase monitoring: species, numbers, source.	S S	S S	RNP RNP

5. HUMAN ENVIRONMENTAL RESOURCES BASELINE

Key:
Indicators: 1 = primary; 2 = secondary
Location: For key to Agroecological Division abbreviations see Table 2.2; for their location see Figure 2.2
Methodology: For key to abbreviations see List of Abbreviations
Schedule: Mn = monitoring schedule; Ev = evaluation schedule
A = annual; S = seasonal (twice yearly, in wet and dry seasons);
M = monthly; D = daily
Responsibility: For organisation acronyms see List of Abbreviations

5.1 Demographic Issues

Issue: Population Growth (primary)
The ecological and social pressures building in the Usangu Catchment result ultimately from the rapid growth of population there, making this a primary issue.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Total number of people	Whole of Usangu.	a. Periodic national census. b. Extrapolation of population growth projections.	10 A	10 A	National census ?/UCTS UCTS (CEP)
1. Number of people per administrative unit	Whole of Usangu, broken down by Region, District, Ward, Village.	a. Periodic national census. b. Extrapolation of population growth projections.	10 A	10 A	National census?UCTS UCTS (CEP)
1. Annual growth rate	Whole of Usangu, broken down by Region, District, Ward, Village.	b. Periodic national census. b. Extrapolation of population growth projections.	10 A	10 A	National census?UCTS UCTS (CEP)
1. Number of people per village	Social survey villages.	a. Social survey questionnaire: population estimate.	2	2	UCTS (CEP)
2. Population density	District/Ward. AEDs.	a. Calculation of population density from population and area data. b. Estimation of population density by adjustment of ward data.	5 5	5 5	UCTS UCTS

Issue: Demographic structure (secondary)

The Baseline postulates no significant distortion of the natural demographic structure due to in- and out-migration. It would be informative to quantify and check this assumption

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
2. Sex structure: male/female ratio per age group	Whole of Usangu, broken down by Region, District, Ward, Village. Social survey villages.	a. Periodic national census. b. Extrapolation of population growth projections. c. Social survey questionnaire: male/female count.	10 A 2	10 A 2	National census??/UCTS UCTS (CEP) UCTS (CEP
2. Age structure: distribution per age group	Whole of Usangu, broken down by Region, District, Ward, Village. Social survey villages.	a. Periodic national census. b. Extrapolation of population growth projections. c. Social survey questionnaire: age group count.	10 A 2	10 A 2	National census??/UCTS UCTS (CEP) UCTS (CEP
2. Natural birth rate	Districts, Wards. Social survey villages.	a. Collection of routine data at the different administrative unit levels. b. Social survey questionnaire: birth rate calculation.	A 2	A 2	District Health Authorities??UCTS UCTS (CEP
2. In-migrants and out-migrants	Whole of Usangu, broken down by Region, District, Ward, Village. Social survey villages.	a. Periodic national census. b. Social survey questionnaire: migration estimates.	10 2	10 2	National census??/UCTS UCTS (CEP)
2. Ethnic diversity	Whole of Usangu, broken down by Region, District, Ward, Village. Social survey villages.	a. Periodic national census. b. Social survey questionnaire: birth rate calculation.	10 2	10 2	National census??/UCTS UCTS (CEP

5.2 Socio-economic Issues

Issue: Incomes (primary)

For the individual income is perhaps the most obvious indicator of quality of life. Collectively the levels of income in a developing country are a prime indicator of socio-economic change. The assumed current positive trend could decline as the pastoralists come under and cause increasing pressure. A strong contrast can be expected between the less developed north and west of Usangu and the more developed south and east, a dichotomy that could continue to increase.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Levels of personal income	Whole of Usangu, broken down by Region, District, Ward, Village. Social survey villages.	a. Periodic national census? (If incomes included). b. Collection/analysis of routine income data (if any). c. Social survey questionnaire: income estimates per impact group.	10 A 2	10 A 2	National census??/UCTS Tax & other financial authorities/UCTS UCTS (CEP)
1. Levels of government income	Whole of Usangu, broken down by Region, District, Ward, Village.	a. Periodic national census? (If incomes included). b. Routine income data (if any).	10 A	10 A	National census??/UCTS Tax & other financial authorities/UCTS

Issue: Employment (primary)

For the individual employment is also often a prime indicator of well-being. Collectively it is also a sound indicator of socio-economic activity and stability in an area. Again, the positive trend assumed in the Baseline could decline slightly as pastoralism declines, but relatively few people are employed in pastoralism. Employment is difficult to quantify in Usangu because many people are involved in several different forms of employment and employment data is poor. A strong contrast can again be expected between the less developed north and west of Usangu and the more developed south and east, a dichotomy that could continue to increase.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Level of employment	Whole of Usangu, broken down by Region, District, Ward, Village. Social survey villages.	a. Periodic national census? (If employment included). b. Collection/analysis of routine employment data (if any). c. Social survey questionnaire: total employment estimates.	10 A 2	10 A 2	National census??/UCTS Tax/employment authorities/UCTS UCTS (CEP)
1. Forms of employment: rainfed agriculture, irrigated agriculture, livestock, agro-industry, service industries, marketing, government, etc	Whole of Usangu, broken down by Region, District, Ward, Village. Social survey villages.	a. Periodic national census? (If type of employment included). b. Collection/analysis of routine employment data (if any). c. Social survey questionnaire: total employment estimates.	10 A 2	10 A 2	National census??/UCTS Tax/employment authorities/UCTS UCTS (CEP)
1. Employment distribution per gender	Whole of Usangu, broken down by Region, District, Ward, Village. Social survey villages.	a. Periodic national census? (If employment included). b. Collection/analysis of routine employment data (if any). c. Social survey questionnaire: total employment estimates.	10 A 2	10 A 2	National census??/UCTS Tax/employment authorities/UCTS UCTS (CEP)
1. Employment distribution per age group	Whole of Usangu, broken down by Region, District, Ward, Village. Social survey villages.	a. Periodic national census? (If employment included). b. Collection/analysis of routine employment data (if any). c. Social survey questionnaire: total employment estimates per impact group (including age and gender groups).	10 A 2	10 A 2	National census??/UCTS Tax/employment authorities/UCTS UCTS (CEP)

Issue: Land values (secondary)

Land value is a difficult concept in Tanzania, where in theory Government owns all the land. Even so, land rights appear to be bought and sold and so have a commercial value that the Baseline assumes must have risen in recent decades. It remains, however, a less satisfactory measure of socio-economic status in Usangu and is here regarded as a secondary issue, especially as data is likely to be very difficult to obtain. A strong contrast can again be expected between the less developed north and west of Usangu and the more developed south and east, a dichotomy that could continue to increase.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
2. Cost of land rights for different types of land: irrigation, rainfed cultivation, grazing, construction, etc	Whole of Usangu, broken down by Region, District, Ward, Village. Social survey villages. AEDs.	a. Collection/analysis of routine land rights allocation data (if any). b. Social survey questionnaire: land rights costs estimates. c. Adjustment of available data for each AED.	A 2 A	A 2 A	Land registers, Village Councils/UCTS UCTS (CEP) UCTS

Issue: Credit availability (secondary)

Credit availability is an important factor in development and is often limiting for rural development. The Baseline assumes some slight improvement due to increased prosperity over recent decades but the situation remains far from satisfactory in Usangu. Future trends could be important, although as in recent decades sufficient credit seems to have been found, presumably primarily from traditional sources, for rapid development, so that credit is perhaps only a secondary issue.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
2. Number of formal credit institutions: credit banks etc	Whole of Usangu, broken down by Region, District, Ward, Village. Social survey villages.	a. Collection/analysis of routine credit data. b. Social survey questionnaire, focus groups: access to credit banks etc.	A 2	A 2	Banks & other financial institutions/ UCTS UCTS (CEP)
2. Number of NGOs providing credit	Whole of Usangu, broken down by Region, District, Ward, Village. Social survey villages.	a. Collection/analysis of credit data. b. Social survey questionnaire, focus groups: access to credit.	A 2	A 2	NGOs/ UCTS UCTS (CEP)
2. Form and number of traditional credit sources: money-lenders, merchants, large land-owners, etc	Whole of Usangu. Social survey villages.	a. Collection/analysis of informal credit data (if any). b. Social survey questionnaire, focus groups: access to and form of informal credit sources.	A 2	A 2	??? UCTS (CEP)
2. Standard of service from the different sources of credit	Social survey villages.	a. Social survey questionnaire, focus groups: perceived standards of service received from different credit sources.	2	2	UCTS (CEP)
2. Importance of credit to people	Social survey villages.	a. Social survey questionnaire, focus groups: perceived importance of credit availability for village development/individual prosperity.	2	2	UCTS (CEP)

5.3 Institutional Issues

Issue: Institutional activity (primary)
Decentralisation has increased institutional activity in Usangu. It is important that this trend is maintained and that the participatory Strategy Process helps to do this.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Number of relevant government bodies, staff, responsibilities, programmes	Usangu Catchment. Social survey villages.	a. Identification, meetings, coordination, interaction. b. Social survey questionnaires, focus groups: estimation of local perceptions.	A 2	A 2	UCTS UCTS (CEP)
2. Number of relevant non-government bodies, staff, roles, programmes	Usangu Catchment. Social survey villages.	a. Identification, meetings, coordination, interaction. b. Social survey questionnaires, focus groups: estimation of local perceptions.	A 2	A 2	UCTS UCTS (CEP)
1. Number of active institutions at Village level	Social survey villages.	a. Social survey questionnaires, focus groups: identification of active institutions in village..	2	2	UCTS (CEP)
1. International Aid Donors: numbers, projects, programmes	Usangu Catchment.	a. Identification, meetings, coordination, interaction.	A	A	UCTS

Issue: Institutional effectiveness (primary)
Increased institutional activity ought to mean the increased institutional effectiveness vital for the successful environmental management of the Usangu Catchment.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Achievements of relevant government bodies, staff, responsibilities, programmes	Usangu Catchment. Social survey villages.	a. Stakeholder review of achievements of relevant gov't institutions. b. Social survey questionnaires, focus groups: estimation of local perceptions.	A 2	A 2	UCTS UCTS (CEP)
2. Achievements of relevant non-government bodies, staff, roles, programmes	Usangu Catchment. Social survey villages.	a. Stakeholder review of achievements of relevant NGOs. b. Social survey questionnaires, focus groups: estimation of local perceptions.	A 2	A 2	UCTS UCTS (CEP)
1. Achievements of active institutions at Village level	Social survey villages.	a. Social survey questionnaires, focus groups: estimation of local perceptions.	2	2	UCTS UCTS (CEP)
1. International Aid Donors: Achievements of projects, programmes	Usangu Catchment. Social survey villages.	a. Stakeholder review of achievements of relevant gov't institutions. b. Social survey questionnaires, focus groups: estimation of local perceptions.	A 2	A 2	UCTS UCTS (CEP)

Issue: Community participation (primary)
Decentralisation is leading to more community participation in government and development planning. The Usangu Strategy Process and implementation of the EMP (and within it the EMES) are all seen as strongly participatory activities.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Community involvement with relevant government institutions	Usangu Regions, Districts, Wards Social survey villages.	a. Stakeholder review. b. Social survey questionnaires, focus groups: estimation of local perceptions.	A 2	A 2	UCTS UCTS (CEP)
1. Community involvement with relevant NGOs	Usangu Catchment. Social survey villages.	a. Stakeholder review. b. Social survey questionnaires, focus groups: estimation of local perceptions.	A 2	A 2	UCTS UCTS (CEP)
1. Community involvement at Village level	Social survey villages.	a. Social survey questionnaires, focus groups: estimation of local perceptions.	2	2	UCTS (CEP)
1. International Aid Donors: projects, programmes	Usangu Catchment. Social survey villages.	a. Stakeholder review. a. Social survey questionnaires, focus groups: estimation of local perceptions.	A 2	A 2	UCTS UCTS (CEP)

5.4 Human Use Issues

Issue: Rainfed cultivation (primary)
Rainfed cultivation is extremely difficult to monitor over so large and diverse an area as the Usangu Catchment. However, its importance in sustainable development there means that these difficulties have to be overcome.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Extents of different rainfed crops	Usangu Catchment . Districts. AEDs. Social survey villages.	a. Estimation from District data; satellite imagery interpretation. b. Collection and analysis of routine and other crop data. c. Correlation of data with AEDs. d. Social survey questionnaires: village estimates.	2 A 2 2	2 A 2 2	UCTS MOAC/UCTS UCTS UCTS (CEP)
1. Production of main rainfed crops: maize, beans, bamboo, cassava, groundnuts, potato, sweet potato, sorghum, sunflower,pyrethrum	Usangu Catchment. Districts. AEDs. Social survey villages.	a. Estimation from District data; field observations. b. Collection and analysis of routine and other crop data. c. Correlation of data with AEDs. d. Social survey questionnaires: village yield estimates.	2 A 2 2	2 A 2 2	UCTS MOAC/UCTS UCTS UCTS (CEP)
2. Use of agrochemicals: fertilisers, herbicides, etc	Districts. Social survey villages.	a. Structured collection and analysis of sales data from merchants etc. b. Social survey questionnaires: village estimates.	A 2	A 2	UCTS UCTS (CEP)

Issue: Irrigation (primary)

Irrigation is the major human use issue in Usangu: its rapid development over the past 50 years has influenced many of the physical, biological and human issues included in the EMES. Its future development will continue to do this.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Extent of paddy rice	Usangu Catchment.	a. Estimation from District data; satellite imagery interpretation; field measurements.	A	A	UCTS
	Districts.	b. Collection and analysis of routine crop data.	A	A	MOAC/UCTS
	Social survey villages.	c. Social survey questionnaires: village estimates.	2	2	UCTS (CEP)
	AEDs.	d. Correlation of data with AEDs.	A	A	UCTS
1. Production of paddy rice	Usangu Catchment.	a. Estimation from District data; field measurements/observations.	A	A	UCTS
	Districts.	b. Collection and analysis of routine crop data.	A	A	MOAC/UCTS
	Social survey villages.	c. Social survey questionnaires: village yield estimates.	2	2	UCTS (CEP)
	AEDs.	d. Correlation of data with AEDs.	A	A	UCTS
1. Extents of other irrigated crops	Usangu Catchment .	a. Estimation from District data.	A	A	UCTS
	Districts.	b. Collection and analysis of routine crop data.	A	A	MOAC/UCTS
	Social survey villages.	c. Social survey questionnaires: village estimates.	2	2	UCTS (CEP)
	AEDs.	d. Correlation of data with AEDs.	A	A	UCTS
1. Production of other irrigated crops: maize, tomatoes, vegetables	Usangu Catchment.	a. Estimation from District data.	A	A	UCTS
	Districts.	b. Collection and analysis of routine crop data.	A	A	MOAC/UCTS
	Social survey villages.	c. Social survey questionnaires: village yield estimates.	2	2	UCTS (CEP)
	AEDs.	d. Correlation of data with AEDs.	A	A	UCTS
1. Use of water for irrigation	Subcatchments/irrigation systems.	a. Water User Association diversion data; field observations.	A	A	WUAs/UCTS
	Social survey villages.	b. Social survey questionnaires: village diversions estimates.	2	2	UCTS (CEP)
2. Use of agrochemicals: fertilisers, herbicides, etc	Districts.	a. Structured collection and analysis of sales data from merchants etc.	2	2	UCTS
	Social survey villages.	b. Social survey questionnaires: village estimates.	2	2	

Issue: Livestock/pastoralism (primary)

Over the last 50 years there has been in-migration of a series of pastoralist peoples, culminating in the major arrival of the Sukuma in the 1970s. All save the latter have been largely assimilated into the population. The Sukuma, with their huge herds and independent attitudes, have created antipathy. However, they have largely focused on the previously major but little-used resource of the seasonal grasslands to create a thriving pastoralism sector. This is now facing disaster through the establishment of the Game Reserve, imposing massive grazing pressure elsewhere in the Catchment and also off-site in other parts of Tanzania.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Numbers of cattle	Districts, Wards. Social survey villages. Lowland AEDs.	a. Ward survey based on tax assessment. b. Social survey questionnaires: village estimates. c. Aerial statistical survey: wet & dry season.	1 2 3	1 2 3	MOAC?/UCTS UCTS (CEP) UCTS
1. Numbers of small livestock: sheep, goats, donkeys	Districts, Wards. Social survey villages.	a. Ward survey based on tax assessment. b. Social survey questionnaires: village estimates. c. Aerial statistical survey: wet & dry season.	A 2 3	A 2 3	MOAC?/UCTS UCTS (CEP) UCTS
2. Numbers of other (non-pastoral) livestock: poultry, pigs, etc	Districts, Wards. Social survey villages.	a. Ward survey based on tax assessment. b. Social survey questionnaires: village estimates.	A 2	A 2	MOAC?/UCTS UCTS (CEP)
1. Livestock production: meat, milk, butter, cheese, eggs, wool, hides, skins	Districts, Wards. Social survey villages.	a. Collection/analysis of routine data, if any. b. Social survey questionnaires: village estimates.	A 2	A 2	MOAC?/UCTS UCTS (CEP)
1. Local tax income from livestock	Districts, Wards.	Collection and analysis of data on tax income from livestock.	A	A	MOAC?/UCTS

Issue: Agro-industrial activities (secondary)

The growth of mainly agro-industrial activity and associated services activities has reflected the rapid expansion of development and communications in Usangu, especially in the south and east along the Tanzam highway. It is considered an issue of secondary importance at present.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
2. Numbers of factories, workshops, etc	Usangu Catchment. District. Village.	a. Routine statistics. b. Field observations. c. Social survey questionnaire: village estimates.	2 A 2	2 A 2	???Regional/District Offices/UCTS UCTS UCTS (CEP)
2. Number of banks, eating places, etc	Usangu Catchment . District. Village.	d. Routine statistics. e. Field observations. f. Social survey questionnaire: village estimates.	2 A 2	2 A 2	???Regional/District Offices/UCTS UCTS UCTS (CEP)

Issue: Transport communications (secondary)

Transport communications have improved dramatically in much of Usangu during recent decades, so this is only a secondary issue. However, large parts – particularly in the north and west - remain difficult of access by public or private transport, especially in the wet season.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
2. Primary roads: total length and condition	Usangu Catchment . District. Village.	a. Routine statistics. b. Field observations. c. Social survey questionnaire: village estimates.	2 A 2	2 A 2	MoT???Regional/District Offices/UCTS UCTS UCTS (CEP)
2. Secondary roads: total length and condition	Usangu Catchment. District. Village.	a. Routine statistics. b. Field observations. c. Social survey questionnaire: village estimates.	2 A 2	2 A 2	MoT???Regional/District Offices/UCTS UCTS UCTS (CEP)
2. Bus services: frequency & standard	Usangu Catchment. District. Village.	a. Routine statistics. b. Field observations. c. Social survey questionnaire: village estimates.	2 A 2	2 A 2	MoT???Regional/District Offices/UCTS UCTS UCTS (CEP)
2. Railways: total length and condition	Usangu Catchment . District. Village.	a. Routine statistics. b. Field observations. c. Social survey questionnaire: village estimates.	2 A 2	2 A 2	MoT???Regional/District Offices/UCTS UCTS UCTS (CEP)
2. Train services: frequency & standard	Usangu Catchment . District. Village.	a. Routine statistics. b. Field observations. c. Social survey questionnaire: village estimates.	2 A 2	2 A 2	MoT???Regional/District Offices/UCTS UCTS UCTS (CEP)
2. Number of airports/airstrips	Usangu Catchment . District.	a. Routine statistics. b. Field observations. c. Social survey questionnaire: village estimates.	2 A 2	2 A 2	MoT???Regional/District Offices/UCTS UCTS UCTS (CEP)
2. Plane services: frequency & standard	Usangu Catchment . District. Village.	a. Routine statistics. b. Field observations. c. Social survey questionnaire: village estimates.	2 A 2	2 A 2	MoT???Regional/District Offices/UCTS UCTS UCTS (CEP)

Issue: Domestic water supplies (primary)

This is an important issue because currently a major reason for diverting a large proportion of river water during the dry season is simply to maintain domestic water supplies. Increased numbers of wells and piped supply systems for settlements seems a logical component of any development planning in Usangu, especially in the rice areas.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Number of functioning wells/boreholes	District. Social survey villages.	a. District water authorities data on number of wells etc per villages/hamlets. b. Social survey questionnaire, focus groups:	A 2	A 2	MoW/UCTS UCTS (CEP)
1. Number of functioning piped or other water distribution systems	District. Social survey villages.	a. District water authorities data on number of villages/hamlets with piped or other supply systems. b. Social survey questionnaire, focus groups:	A 2	A 2	MoW/UCTS UCTS (CEP)

5.5 Socio-cultural Issues

Issue: Land tenure/security (primary)
The allocation of land rights and their subsequent security are major issues in Usangu, especially between cultivator and pastoralist impact groups.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Land rights	Social survey villages.	a. Social survey questionnaire, focus groups: distribution of land rights amongst the different impact groups.	2	2	UCTS (CEP)
2. Security of tenure	Social survey villages.	a. Social survey questionnaire, focus groups: security of land rights amongst the different impact groups.	2	2	UCTS (CEP)

Issue: Social equity (primary)
An important current negative trend resulting from the rapid development in much of Usangu Lowlands in recent decades is that while the condition of the poor has improved that of the rich seems to have improved much more. Recent events such as the Game Park affect some social groups (pastoralists) much more than others. A central aim of the Usangu EMP should be to reduce social inequity.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Land rights	Social survey villages.	a. Social survey questionnaire, focus groups: distribution of land rights amongst the different impact groups.	2	2	UCTS (CEP)
1. Land values	Social survey villages.	a. Social survey questionnaire, focus groups: distribution of land value amongst the different impact groups.	2	2	UCTS (CEP)
1. Access to water, including water rights	Social survey villages.	a. Social survey questionnaire, focus groups: distribution of water availability amongst the different impact groups.	2	2	UCTS (CEP)
1. Income	Social survey villages.	a. Social survey questionnaire, focus groups: distribution of income amongst the different impact groups.	2	2	UCTS (CEP)
1. Livestock	Social survey villages.	a. Social survey questionnaire, focus groups: distribution of livestock amongst the different impact groups.	2	2	UCTS (CEP)
2. Credit availability	Social survey villages.	a. Social survey questionnaire, focus groups: distribution of credit availability amongst the different impact groups.	2	2	UCTS (CEP)

Issue: Social cohesion/conflict (primary)

Social conflict has increased in recent decades in Usangu, notably between the cultivator and pastoralist impact groups. This trend is likely to be exsacerbated by the new Game Reserve forcing livestock to move elsewhere in the Catchment.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Numbers of disputes	Usangu Catchment. Social survey villages.	a. Numbers of relevant court cases. b. Social survey questionnaire, focus groups: estimate of significant disputes.	A 2	A 2	Court authorities??/UCTS UCTS (CEP)
1. Severity of disputes	Districts/wards. Social survey villages.	a. Relevant court cases: all defined as severe disputes. b. Social survey questionnaire, focus groups: estimate of severity.	A 2	A 2	Court authorities??/UCTS UCTS (CEP)
1. Causes of disputes	Districts/wards. Social survey villages.	a. Causes of relevant court cases. b. Social survey questionnaire, focus groups: identification of causes.	A 2	A 2	Court authorities??/UCTS UCTS (CEP)
2. Specific major disputes	Districts/wards. .	Spontaneous "trouble-shooting" visits/interviews with concerned groups at critical times in specific major disputes.	As required		UCTS (CEP)

Issue: Social attitudes (primary)

Previous negative trends in the people's attitudes, especially towards Government ought to be improving following the widespread administrative decentralisation. In Usangu the Strategy Process is seen as a major exercise in participatory planning, resulting in a popularly acceptable EMP, improving social attitudes further as improved quality of life results for most people. However, others may be negatively affected. As a rule people are instinctively negative: the questionnaire will need to be subtle in this respect.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Perception of changes, positive & negative, in Usangu Catchment.	Social survey villages.	a. Social survey questionnaire, focus groups: estimation of types and degree of changes perceived by different impact groups.	2	2	UCTS (CEP)
1. Perception of reasons for changes in Usangu Catchment.	Social survey villages.	a. Social survey questionnaire, focus groups: identification of reasons for change perceived by different impact groups.	2	2	UCTS (CEP)

Issue: Gender (primary)
Special emphasis should be given to any changes in the roles and status of women in the Usangu Catchment.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Social status of women	Social survey villages.	a. Social survey questionnaire, focus groups: estimation of women's social status perceived by women/men.	2	2	UCTS (CEP)
1. Political status of women	Usangu Catchment Social survey villages.	a. Legal political status of women: voting, participation, governing rights. b. Social survey questionnaire, focus groups: actual role & degree of women's participation in village government perceived by women/men.	A 2	A 2	Legal bodies??? /UCTS UCTS (CEP)
1. Amount and type of work by women	Districts. Social survey villages.	a. Routine annual statistics on female employment. b. Social survey questionnaire, focus groups: estimation of amount and type of women's work perceived by women/men.	A 2	A 2	District Social Welfare Depts??? /UCTS UCTS (CEP)
1. Amount of family time for women	Social survey villages.	a. Social survey questionnaire, focus groups: estimation of family time perceived by women/men.	2	2	UCTS (CEP)
1. Amount of leisure time for women.	Social survey villages.	a. Social survey questionnaire, focus groups: estimation of women's leisure time perceived by women/men.	2	2	UCTS (CEP)
1. Earning power of women.	Social survey villages.	a. Social survey questionnaire, focus groups: estimation of women's social status perceived by women/men.	2	2	UCTS (CEP)

Issue: Health (primary)
Changes in health patterns, and especially in the incidence of waterborne diseases, could result from changes in environmental management. AIDS information is needed to allow better understanding of demographic data.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Life expectancy	Districts/wards.	a. Collection and analysis of official data (from national census?).	10	10	
1. Infant mortality	Districts/wards.	a. Collection and analysis of official data (from national census?).	10	10	
1. Incidence of Malaria	Districts/wards. Social survey villages.	a. Collection and analysis of routine health data. b. Social survey questionnaire, focus groups:	A 2	A 2	District Health Authority??/UCTS UCTS (CEP)
1. Incidence of Bilharzia	Districts/wards. Social survey villages.	a. Collection and analysis of routine health data. b. Social survey questionnaire, focus groups:	A 2	A 2	District Health Authority??/UCTS UCTS (CEP)
1. Incidence of AIDS	Districts/wards. Social survey villages.	a. Collection and analysis of routine health data. b. Social survey questionnaire, focus groups:	A 2	A 2	District Health Authority??/UCTS UCTS (CEP)
1. Incidence of Other Major Ailments	Districts/wards. Social survey villages.	a. Collection and analysis of routine health data. b. Social survey questionnaire, focus groups:	A 2	A 2	District Health Authority??/UCTS UCTS (CEP)
1. Nutrition levels	Districts. Social survey villages.	a. Collection and analysis of routine health data. b. Social survey questionnaire, focus groups:	A 2	A 2	District Health Authority??/UCTS UCTS (CEP)
1. Numbers of hospitals, health centres, clinics, etc	Districts/wards. Social survey villages.	a. Numbers of hospitals, health centres, clinics, etc b. Social survey questionnaire, focus groups:	A 2	A 2	District Health Authority??/UCTS UCTS (CEP)

Issue: Cultural values (primary)

Rapid development and associated changes have weakened cultural values, especially along the Tanzam highway in the main settlement zone. However, in the more isolated and less developed north and west tradition is still strong. Even in the developed areas decentralisation is allowing the re-emergence of grass-roots values by focusing government at District and Village levels.

Indicator	Monitoring Location	Monitoring Methodology	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Formal religion	Social survey villages.	Social survey questionnaire, focus groups: estimation of diversity, type, strength of different religions.	2	2	UCTS (CEP)
1. Role of traditional forms of authority.	Social survey villages.	Social survey questionnaire, focus groups: estimation of type and strength .	2	2	UCTS (CEP)
1. Non-religious traditions and beliefs (e.g. Mama N'giriama)	Social survey villages.	Social survey questionnaire, focus groups: estimation of type and strength .	2	2	UCTS (CEP)

Issue: Lifestyle: quality of life (primary)

Quality of life is an individual and highly subjective perception for each person. A more objective, collective appraisal can be obtained by applying the EMES findings to those issues/indicators deemed by the local people to be important in assessing quality of life. The list of indicators given might therefore need to be amended and could differ for each impact group (or each individual, for that matter). Quality of life is likely to be perceived primarily in terms of human issues. but certain biological and physical issues could be important to local people where they affect livelihood.

Indicator	Monitoring Location	EMES Findings	Schedule Mn	Schedule Ev	Monitoring Responsibility
1. Incomes 1. Employment 1. Land security 1. Health 1. Education: schools, training, awareness, etc (to be added to EMES) 1. Social conflict 1. Social attitudes 1. Social equity 1. Gender issues (women) 2. Cultural values 1. Transport communications 1. Domestic water supplies 1. Energy supplies (to be added to EMES) 2. Agro-industrial/service industries 1. River flows 2. Wetlands recharge/extent (pastoralists) 2. Regional climatic change 2. Grasslands extent/availability (pastoralists) 1. Usangu Game Reserve (pastoralists, fishermen)	Social survey villages	a. Selection and weighting of relevant indicators by villagers using social survey questionnaires, focus groups. b. Application of EMES findings above to the selected/weighted indicators to estimate quality of life.	2	2	UCTS (CEP)

Table 2.1 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 2.2 Agroecological Divisions (AEDs)

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

Figure 2.1 Environmental Monitoring and Evaluation System (EMES) Preliminary Framework

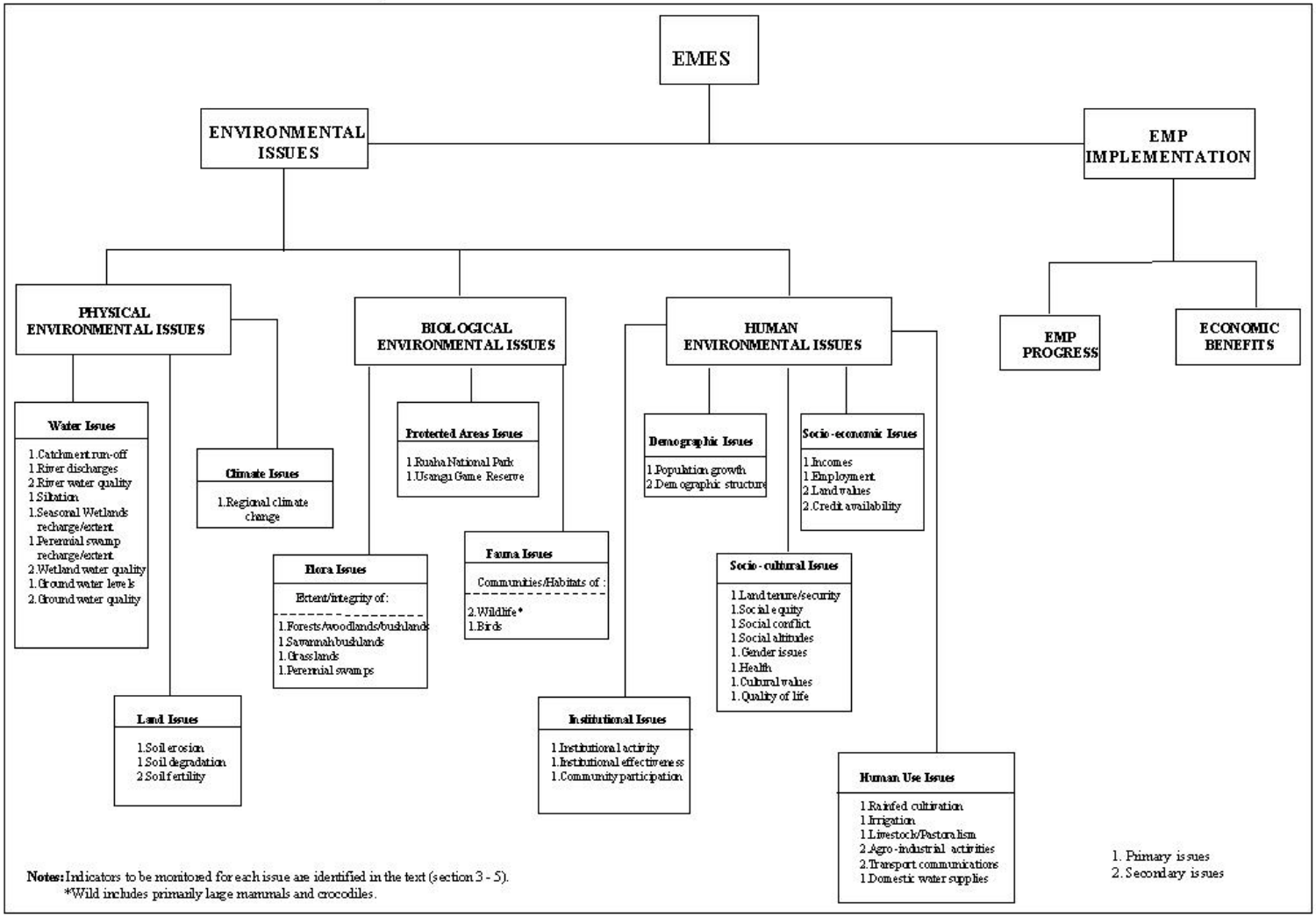

Figure 2.2 Agro-ecological divisions (AEDs)

GIS FIG

Figure 2.3 Preliminary EMES institutional framework

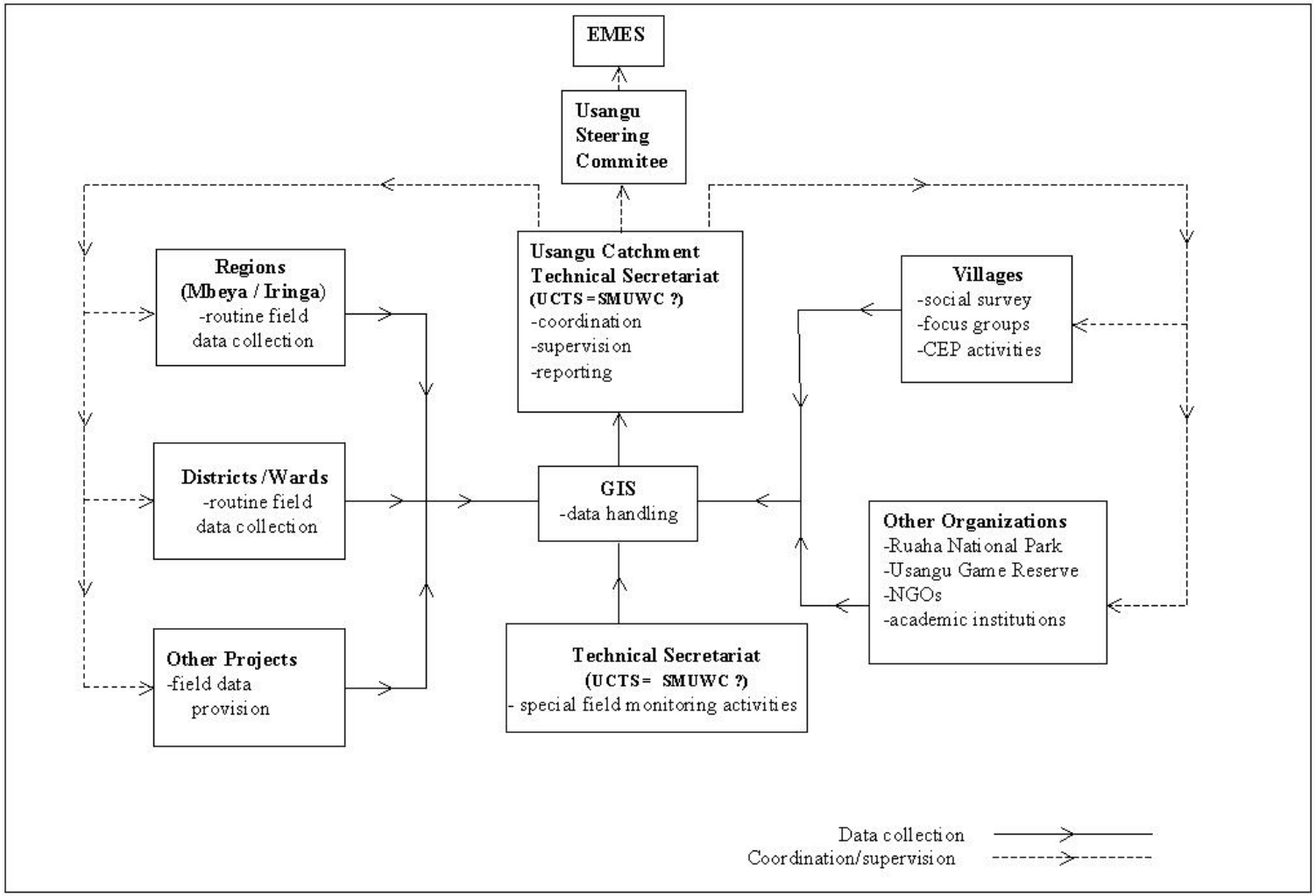

Figure 2.4 EMES Operation