Checklist to Assist Preparation of Small-scale Irrigation Projects in Sub-Saharan Africa

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Preamble

BACKGROUND

Based on predicted rates of population growth, by the year 2025 the demand for food in most countries of Sub-Saharan Africa is likely to be between two and a half and three times that of today. In the majority of countries the potential for development of irrigation is limited. The main contribution to increased production must thus, in general, come from rainfed agriculture.

In over half of the Region's countries, meeting the growth in demand will require cultivation of more than 50% of their remaining undeveloped land with potential for rainfed cropping as currently identified by the Food and Agriculture Organisation (FAO). At this level of usage, however, development becomes increasingly constrained by factors such as forest preservation, use of land by pastoralists and endemic disease, and in such cases development of even limited irrigation potential assumes increasing importance. Furthermore, even in those countries with ample potential for rainfed cropping from a national perspective, uneven distribution of that potential is likely to require development of irrigation in the less favoured parts or for special crops.

There is a general perception that irrigation developments in Sub-Saharan Africa have failed to live up to expectations. This perception of poor performance has derived mainly from experience with larger scale developments. For a variety of reasons, costs and hence funding requirements of large-scale irrigation developments in Africa tend to be relatively high compared to those in other parts of the world, while failure to achieve predicted production levels and declining world prices for agricultural products have led to lower than anticipated returns.

In the case of small scale village level schemes, however, with the bulk of the development work being undertaken by the prospective beneficiaries, funding requirements can be reduced substantially. The time required for implementation is also much shorter. Here too, however, problems have been experienced, in many cases as the result of an overly top down approach and/or poor project preparation. Nevertheless, well prepared schemes, satisfactorily integrated into the local agricultural economy, can through provision of subsistence and cash crops bring considerable benefit to the communities concerned. It is now generally accepted that future development of irrigation in the Region is likely to be mainly at village or community level.

While there is a need to improve the standard of preparation of such schemes, the potential returns are unlikely to support full feasibility study. It is to address this problem that the present Checklist has been developed by the International Commission on Irrigation and Drainage (ICID) Working Group on Construction, Rehabilitation and Modernisation of Irrigation Projects.

SCOPE

Experience has shown that a participatory approach, enabling the prospective beneficiaries to contribute to the development of a proposed scheme, thereby generating a sense of involvement, is essential for long term sustainability. Typically, the participatory process comprises the following stages:

Farmers request assistance for the development of irrigation from the relevant Authority

An assessment of the proposed scheme is made by the Authority in conjunction with the Farmers

Following a favourable assessment, establishment by the Farmers of a scheme membership association and management committee. If required by the rules of the Authority, a security fund is set up to meet a proportion of the capital cost of the necessary irrigation infrastructure. Contributions may be either financial or in terms of pledged labour

Design meetings with the Authority to discuss and finalise the scheme layout and the operation and maintenance requirements

Implementation agreement between Farmers and the Authority specifying respective tasks. Security fund arrangements finalised

Loan agreement between the Farmers and Credit Agency for balance of infrastructure cost.

Organisation by the management committee of scheme operation and maintenance

Hand over to Farmers of completed infrastructure

Repayment of loan by instalments

The Checklist is designed to allow rapid assessment of potential farmer and community managed surface irrigation projects, and in accordance with the participatory approach, would be employed in responding to the farmers' initial request for assistance in order to confirm (or otherwise) that there are no immediately apparent major constraints to the proposed development. Given a generally favourable assessment, any aspects needing further investigation would be dealt with in the course of the design process.

A particular concern in the Sub-Saharan African context is the lack of resources, both human and material, and while elements of the Checklist require input to be provided by specialists, field use of the Checklist is targeted at agricultural extension officers and junior graduate staff, with equipment requirements kept to a minimum.

With the emphasis on low-input schemes, the Checklist covers surface irrigation from streamflows and shallow wells. Except where the volume of water stored is so large that the quantity it is proposed to abstract is in comparison negligible, abstraction from natural lakes should not be contemplated without detailed study, as to do so could risk upsetting the often fragile balance between inflow, rainfall, deep percolation, outflow and evaporation upon which the ecosystem depends. Although elements of the Checklist remain applicable, a more rigorous approach, particularly with regard to economic aspects, is also required for high input schemes such as sprinkler and drip.

While it is anticipated that schemes to which the Checklist is applied are normally unlikely to exceed 100 ha in extent, this figure is not intended to be limiting. At the opposite end of the scale, small irrigated vegetable plots, grouped into communal village gardens and supplied with water from a hand pumped well, are of increasing interest across Africa, especially to women. The total area irrigated usually amounts to less than a hectare, and with the irrigated plots close to the well, water is distributed in hand carried containers. Although for this type of development, some elements of the Checklist are superfluous, the basic conditions needed for sustainable development are essentially the same as for larger, more formal schemes.

An important element of project assessment is the comparison of benefits and costs. An indication of the benefits which might be expected to derive from the proposed scheme may be obtained from the estimated increase in output value above that at present. Estimation of costs, however, requires preparation of a preliminary design for the necessary engineering works which is time consuming and requires specialist input, and is thus beyond the scope of a rapid assessment of this type. An initial estimate is, however, made of the general magnitude of the infrastructure works necessary and indicative limits suggested if the works are to lie generally within the construction capabilities of the farmers and high costs avoided. It must be emphasised, however, that contravention of a limit does not necessarily mean that a scheme will be uneconomic or vice versa.

Intended primarily to indicate the existence (or otherwise) of a satisfactory "enabling environment", the Checklist does not cover design aspects, details of which may be obtained from standard reference works.

THE CHECKLIST

The term "Checklist" may be misleading, suggesting in the context of feasibility study, a list of items to be considered in reaching an assessment of a project's viability. The present document, while it may be used as such, aims also to provide guidance as to the making of that assessment.

The document comprises four parts:

1. **Project Proposal** listing principal features of the scheme as outlined by the proposers.

2. **Preparatory Data Sheets** for completion, where appropriate by specialists, in the Authority's headquarters compiling background and technical data which will serve as a briefing kit, and be checked and amplified, during a subsequent field visit to the site of the proposed scheme. Guidelines as to appropriate parameters and methodologies are appended. Inter alia, in view of possible lack of data locally, the guidelines draw attention to the availability of relevant international climatological and hydrological databases. Much of the data entered in the Preparatory Data Sheets is of regional applicability rather than project specific and is thus likely to be relevant to more than one project.

3. **Field Data Sheets**, for use in the field by extension officers/junior engineers, designed to check and amplify through participatory discussion with farmers promoting the project the information in the Preparatory Data Sheets. Information collected is entered in a tabular format with any necessary calculation processes set out step by step. As with the Preparatory Data Sheets, cross-referenced guidelines as to the implications of each item of data are provided.

4. **Checklist Summary**, to be completed by the field team before leaving the site summarising the existence or otherwise of possible constraints to the proposed development as determined by comparison of information from the Field Data Sheets with listed parameters.

Four categories are used: "Not a Constraint", "Minor", "Major Constraint" and "Not Known", the last drawing attention to areas which, should the scheme otherwise appear viable, need further investigation.

The objective of the Checklist is to improve the likelihood of sustainable development rather than to achieve an optimal scheme. In this light, and to keep the document as simple as possible, tried and tested rules of thumb rather than classic rigorous analyses have be used where appropriate. Attention is drawn in the accompanying guidelines to any limitations to the approach adopted.

Table PB1 shows the linkages between the two sets of Data Sheets and the Checklist.

TABLE PB1 - Linkages between checklist components

Preparatory Data Sheet	Field Data Sheet	Checklist Summary
P1 Topographic P2 Previous Investigations P3 Irrigation Schemes in the Locality		
P4 Enviromental Aspects	F2 Enviromental Aspects	C1 Enviromental Aspects
P5 Socio-Economic Aspects	F1 Socio-Economic Background (Village/Community)	
P6 Geology and Soils	F3 Topography and Soils	C2 Topography and Soils
P7 Climate P8 Agriculture P9 Sub-Catchment WaterDemands	}F4{ Agriculture } { }F5{ Water Demand	C3 Agriculture
P10 Hydrology of Supply Source P11 Hydrogeology of Supply Source	F6 Surface Water Resources F7 Groundwater (Shallow) Resources F8 Supply and Demand Balance	} } }C4 Water Resources } }
	F9 Irrigation Infrastructure	C5 Irrigation Infrastructure
	F10 Economic Indicators	C6 Economic Indicators
	F11 Development and Operation	C7 Development and Operation

USE OF THE CHECKLIST

Designed specifically for appraisal of small-scale irrigation projects, parts of the document may also be used for appraisal of elements of more comprehensive rural development projects. While the document has been drawn up primarily for the assessment of new developments, with only minor adaptation it may be applied to extension or rehabilitation of existing schemes.

Should it become apparent from the Preparatory Data Sheets that there are major constraints to the proposed development under consideration, unless field checks are deemed necessary, it may be decided not to proceed with the field visit.

At the conclusion of the field visit, the findings in the Checklist Summary should be agreed with the participants prior to the departure of the field team. Where major constraints have been revealed, discussion may suggest modifications to the proposed scheme allowing these to be overcome or circumvented. Subsequently, following completion of any laboratory tests on samples collected during the field visit, the findings should be confirmed at district/provincial headquarters and the farmers formally notified as to whether the scheme will be taken further or not.

In addition to its primary purpose of facilitating project assessment, the Checklist may also be used as a training tool for officers familiar only with rainfed agriculture, in order that they might recognise and bring to farmers' attention potential for increasing production through irrigation. Consideration may also be given to its use as course material for students studying irrigation and agricultural development related topics at universities and training colleges.

STATUS

Drawn up with the support of the United Kingdom Overseas Development Administration (now Department for International Development), a draft of the Checklist was approved by the Working Group at the ICID Executive Council Meeting in September 1996, following which it was distributed to a number of ICID National Committees and authorities for testing in the field.

By the time of the Executive Council Meeting in September 1997, a number of reports had been received confirming its usefulness not only with regard to irrigation, but also for rural development projects generally.

It is also being used in connection with the FAO Special Programme on Food Security. At the Executive Council Meeting, approval was therefore given to amendment of the document in the light of comments and suggestions received up to that time, and to publication for general dissemination. It is anticipated, however, that the Checklist will continue to evolve as further experience is gained in its use in the field.

The Checklist is published in English and French. A Portuguese translation is planned.

ACKNOWLEDGEMENTS

The International Commission on Irrigation and Drainage acknowledges particularly the support to this project provided by the Department for International Development of the British Government. Grateful acknowledgement is also made of the advice and assistance provided by those consulted in the course of the preparation of the Checklist and to those who have reported on its use in the field. FAO have been especially supportive and sponsored the translation of the Checklist into French.

PART 1: Project proposal

The Project Proposal should list principal features of the project as put forward by the proposers. A sketch map, based on the largest scale mapping to hand, should be attached showing the location of the propose irrigated area, source and abstraction point in relation to main topographic features.

Date		d/m/y ______
Project Name		Specify______
Location (village, district)		Specify______
Local agricultural extension office		Specify______
Project proposer (e.g. farmers, village committee etc.)		Specify______
Approved in principle by village committee		Y/N ______
Membership of committee	: Male	No ______
	: Female	No ______
Area to be irrigated		ha______
Current status/use (e.g. rainfed farmed, forest etc.)		Specify______
Proposed method of irrigation (surface, sprinkler, drip)		Specify______
Proposed crops	: Wet season	Specify______
	: Dry season	Specify______
Water source (well, stream, river. Where appropriate give name)		Specify______
Existing right to abstract water for irrigation		Y/N ______
If right officially registered, give date and reference		Specify______
Method of abstraction (e.g. pump, gravity diversion)		Specify______
Abstraction site identified		Y/N ______
Sketch map attached		Y/N ______

PART 2: Preparatory data sheets

GUIDELINES

Introduction

The purpose of the Preparatory Data Sheets is to provide background and technical data for the team undertaking the field visit. Because of the relative complexity of some of the information, and the need to access the records of a variety of authorities, it is likely that it will be found most convenient for the information needed to be collected by specialists and staff in the Authority's headquarters. Information relating to the immediate locality of the proposed irrigation development will as far as possible be checked during the field visit.

Completion of the Preparatory Data Sheets will also serve to identify possible problems or areas where knowledge is lacking. Such data requirements should be used to focus attention during the field checking stage.

Topics are grouped into sections as follows:

P1 Topographic Data
P2 Previous Investigations
P3 Irrigation Schemes in the Locality
P4 Environmental Aspects
P5 Socio-Economic Aspects
P6 Geology and Soils
P7 Climate
P8 Agriculture
P9 Sub-Catchment Water Demands
P10 Hydrology of Supply Source
P11 Hydrogeology of Supply Source

Guidelines relating to each section of the Preparatory Data Sheets are given below. To facilitate reference, where derived data such as that relating to climate and hydrology is used, after checking, during the field visit for the determination of crop water requirements or to confirm adequacy of the water supply, provision has been made for duplicate entry in the Field Data Sheets. In such cases, the Field Data Sheet section number is given.

Should a constraint become apparent during completion of the Preparatory Data Sheets which would be likely to have a major adverse effect on the success of the proposed scheme, the field visit stage should not be proceeded with unless confirmation is required.

P1 Topographic Data

P1.1 Project Location

Give the names and grid reference according to the official national survey map.

P1.2 Communications

Give distances to main communications links.

P1.3 Survey Maps

Scale. With the proposed schemes under consideration generally less than 100ha in extent, it is important to obtain the most detailed maps available. The relationship between map scale and the area on the ground represented by one square centimetre is as follows:

Map Scale	ha/sq cm	Map Scale	ha/sq cm
1:250,000 1:100,000 1:50,000	625 100 25	1:25,000 1:10,000	6.25 1.00

Vertical Interval. Steepness of slope and variability of terrain both have important consequences for location of the irrigation delivery system, selection of irrigation method and water control, including possible soil erosion. In general slopes steeper than 1 in 20 exclude the land from surface irrigation unless some form of terracing is possible.

P1.4 Air Photographs

Depending upon scale (and age) air photographs provide much useful information, particularly when paired photographs are examined under a stereoscope, and in the absence of suitable topographical maps, paper photocopies of photographs can be used as a base for map preparation. Photographic information will, however, relate to the time and season the photograph was taken. If the photographs are old, it is possible that the site may have changed as the result, for example, of land clearing or soil erosion. Nevertheless examination can reveal:

- surface drainage patterns, rivers and streams
- wet areas, lakes and possibly swamps
- land use, cultivation, roads, tracks and villages
- eroded land, especially gullies
- rock outcrop
- vegetation

Information obtained from air photographs should be checked during the field visit, and in areas where thick bush or forest has prevented identification, it will be necessary to cut traces to allow examination.

P1.5 Satellite Imagery

Generally the available scales are not suitable for the detail required for the present purpose, although they may provide a regional overview.

P1.6 Base Map

From the largest scale topographic map available or a photocopy of the relevant air photograph(s), prepare from the information on the Project Proposal a simple sketch map showing roads, location of village(s), proposed irrigation site(s), the water source and the site of the proposed offtake. The elevation of the offtake and the upper and lower elevations of the proposed irrigation site(s) should also be noted. At least four copies of this base map should be made available to the team completing the Field Data Sheets.

P2 Previous Investigations

Reports on previous investigations carried out in the locality, while not necessarily relating to the project under consideration, or even to irrigation, may still contain relevant data or references. Access to previously collated data can save a considerable amount of time and effort. Attention is drawn in the appropriate sections of this document to relevant regional data bases set up under the auspices of international agencies.

P2.1 Available Documentation

Reports either assessing resources generally or more specifically in relation to development proposals may have been prepared by government authorities, by international agencies such as the Food and Agriculture Organisation (FAO), United Nations Development Programme (UNDP) or United Nations Environment Programme (UNEP), or by consultants on their behalf. Unless there is a central national repository for information, and that information is readily retrievable, considerable effort has to be made to gather together such information from a variety of sources. In addition to concerned government departments, consultants reports are often held by aid agencies. Research organisations, both international, for example those of the Consultative Group on International Agricultural Research (CGIAR) network, and within the country may hold relevant information. Information may also be obtained from census findings, from university theses and non-governmental organisations (NGOs).

P2.2 Relevant Aspects

Particularly valuable are investigations relating to irrigation proposals, performance of ongoing schemes, and research/trials of irrigated crops. Also to rural development projects with regard to determining the context into which the proposed irrigation project must be integrated. Environmental impact assessments may highlight features to be taken into account. Other investigations may include, for example, information on water resources, geology, soils and health.

P3 Irrigation Schemes In The Locality

Ongoing irrigation schemes in the locality are likely to be set within the same agronomic and socio-economic context, and can provide a good indication of the likelihood of success of the proposed development. Successful schemes can also usefully serve as a demonstration and a source of advice to farmers new to irrigation. Sources of information include completion and performance assessment reports. In appropriate cases, schemes should be visited and discussions held with management and farmers.

P3.1 Scheme

A summary of the principal characteristics will indicate the relevance of the schemes to that proposed.

P3.2 Agronomic Aspects

Details of cropping patterns will point to the appropriateness of particular crops, and by implication, the availability of necessary inputs and markets. Yield levels will give an indication of the benefits to be expected from provision of irrigation.

P3.3 Operational Aspects

Successful irrigation requires a high degree of co-operation between those involved. Key areas are efficient and equitable control of the water supply, and good maintenance, both of which are facilitated by the existence of an effective water users association. Experience on other schemes will indicate whether the necessary levels of organisation and co-operation are likely to be achieved.

P3.4 Reported Problems

Where problems have been reported, it will be necessary to consider whether these are likely to be experienced also by the proposed project. Appropriate formulation of the project may lessen the risk of repetition, but where local conditions generally have been shown to severely inhibit successful development, it may be inappropriate to proceed.

P4 Environmental Aspects

Although less likely with small localised development, it is important to recognise potential negative impacts on the natural environment.

P4.1 Fauna, P4.2 Flora

At this stage, information should be obtained on gazetted wildlife and forest reserves, and on the possible presence of rare or endangered species whose habitat requirement matches the agro-ecological zone of the proposed development. Note should also be made of wetland habitats, both within the area of the project and downstream, which could be impacted. Natural resource mapping, forest authorities, and natural history departments will all hold information.

P4.3 Archaeological Remains

Information should be obtained from heritage bodies on any listed archaeological remains in the vicinity of the proposed scheme.

P5 Socio-Economic Aspects

It is essential to determine the appropriateness of the proposed development to the local socio-economic context. Socio-economic factors include labour availability and individual incentive. Pastoralists, for example, may be unwilling to adapt to sedentary agriculture because the social and economic cost of such a change may be too high, although the economic value may be obscure to outsiders. Some of the information required may be available from census data.

Prior knowledge of the socio-economic context and administrative structure will also facilitate identification of key informants and interest groups. Correct identification of stakeholders in irrigation development is crucial to participation in development and hence to sustainability and to reduction of potential conflict in the early stages of establishing an acceptable development.

P5.1 Demography

Available figures on local demography tend to be dated and in a fast growing population it may be only marginally useful to update old figures. Improved communications, can also give rise to rapid change. However, applying national growth rates to old figures can be a starting point. Labour availability may be affected by the existence of seasonal jobs elsewhere.

Gender. It is common in rural areas for men to out-migrate more than women. Agricultural jobs traditionally done by men may present a constraint to production either because it is socially difficult for women to assume responsibility or due to the additional workload which would be put on to women who may be already heavily committed. An estimate of the percentage of women headed households in the main growing seasons can give an indication of the likelihood of labour problems of this type arising.

Age. Older smallholders may have difficulty in marshalling resources and in assimilating extension and technical issues. Special provisions may be necessary to assist older people to get the best advantage from the proposed development. It is therefore helpful to get some idea of the age composition of the rural community and the role played by different age groups in cultivation, resource management and decision making.

P5.2 Wealth Indicators

In addition to providing information on the potential cost of hired labour, knowledge of the general prosperity of the area provides an indication of the possible impact of the proposed scheme on the local economy. Also of the availability of resources to fund any necessary infrastructure and farm inputs. In some areas a substantial proportion of rural household income derives from remittances.

P5.3 Health

It is important to consider the general health of the populations and the implications with regard to the increased labour demand which will accompany irrigation development. Development of irrigation may risk increasing the incidence of waterborne disease. Such risk can, however, be reduced by appropriate design to minimise vector breeding environments and operating regimes should aim to minimise human contact with irrigation water. A baseline indication of prevalence of water-borne disease is important for monitoring the impact of irrigation. The existence of a hospital or dispensary in the locality will also facilitate treatment and the implementation of prophylactic measures.

P6 Geology And Soils

At this stage, geological information will be derived mainly from geological maps and reports. Two types of geological maps are generally produced: solid geology and superficial deposits. The solid geology indicates the nature of the underlying rock strata whilst the superficial or unconsolidated maps represent the near surface material. Occasionally both solid and superficial deposits may be combined on one sheet.

Soils are derived from geological materials, which may be consolidated or unconsolidated, by the action of climate and vegetation as modified by topography. Soils are not necessarily derived from the underlying solid geological strata. Unconsolidated material such as wind blown sand, loess, volcanic ash and alluvium are also important sources of soil parent material. Nevertheless, geological maps can be important indicators as to soil quality. Position in the landscape also affects soil properties (P6.2.2). Terrain maps are available in several Sub-Saharan countries and these also provide important clues to soil types.

Soil maps are produced at various scales. In most countries, coverage at the national level is still incomplete. The international soil database (FAO-UNESCO 1974) covers Africa in three sheets, VI-1,2,3. It is very small scale at 1:5,000,000. Several countries have, or are producing, related maps using the same legend at 1:1,000,000. Even this scale is difficult to relate to a small irrigation scheme. The legend which accompanies each map sheet describes soils within a specific unit. Units consist of groups of soils, the dominant soil within each unit is given a textural class(coarse, medium, fine) and a slope class (level to gently undulating, 0-8%; rolling to hilly, 8-30%; steeply dissected to mountainous, greater than 30%). A highly technical soil classification is used and assistance is required from a professional soil scientist.

P6.1 Soil Origin

Geological deposits of various types provide the basic material from which soils are formed. The type of rock or unconsolidated deposit, modified by its position within the landscape, affects various soil characteristics such as pH, texture, cation exchange capacity, fertility and drainability. It is possible from a knowledge of the geochemistry and other rock characteristics to predict in a general way the chemical and physical characteristics, and to indicate potential soil fertility problems.

Typical characteristics of soils derived from a range of parent materials are summarised below. Further information on potential fertility status is given in Table P6.1.

P6.1.1 Rock

Igneous

Granite. Slightly acid to neutral pH, Deficient in nutrients except potash. Deficient in micronutrients.

Other Igneous Rocks:

Acidic. Medium to fine grained, slightly acidic. Deficient in nutrients.

Basic. Fine textured, neutral to alkaline. Deficient in phosphate.

Ultrabasic. Fine textured, alkaline. Deficient in phosphate. May contain toxic trace elements.

Sedimentary

Sandstones. Sandy, slightly acid to slightly alkaline, generally deficient in potash and phosphate, and in micronutrients, particularly copper and zinc.

Limestone/Chalk. Loams or clays. Poor fertility status in potash and phosphate, and most micronutrients. Soils mainly alkaline.

Shales. Loams or clays, moderate fertility in both nutrients and micronutrients. Occasionally toxic levels of selenium, especially if soil reaction is alkaline.

P6.1.2 Unconsolidated Material

Soils may be formed on material transported from elsewhere:

Volcanic Ash. Derived soils often very suited to irrigation. Good physical characteristics and ease of cultivation. Occasionally highly erodible, especially pumice tuffs with low water retention.

Windblown Sand. Normally unsuitable for surface irrigation due to excessive irrigation water losses, poor fertility and erodibility by wind.

Alluvium. Very variable textures, stratified soils. Medium to fine textures generally suitable for irrigation. Surface drainage may be a problem due to run-off from higher land or from overtopping of river banks. Deposition of fine material under swamp conditions may result in formation of Vertisols.

Colluvium. Lower slopes and depressions often receive fine material washed downwards by water and very fine textured soils (cracking clays or Vertisols) may develop.

Peat. Surface layer formed in swamps (especially under Cyperus papyrus or similar). Usually underlain by very fine textured, poorly drained clays. Generally not suitable. Drainage may result in development of acid-sulphate conditions (pH3.0). Cultivation also creates vulnerability to wind erosion of the peaty topsoil when dry.

P6.2 General Land Features

P6.2.1 Terrain

It is important to describe the land features as they might affect the water conveyance system and the irrigated area(s). Water has to be conveyed along a contour to command the irrigated areas. The canal may have to cross streams and gullies along the route and this information can be marked on a copy of the base map for subsequent checking in the field. Hilly land or closely dissected terrain should be avoided if possible as it adds to construction costs, as do shallow, rocky or coarse textured soils.

P6.2.2 Physiographic Position

In the arid and semi-arid conditions prevailing in many parts of Africa, fairly distinct landscapes have emerged which contain particular sequences of soil whose properties can be predicted according to their position in the landscape. Well drained, imperfectly drained and poorly drained soils, all of which may have developed from the same parent material under the same climatic conditions, may be closely associated in the field, their only distinguishing characteristic being their topographic position. Such soil toposequences, often described in soil reports, provide an invaluable indication of the types of soil likely to be present and their position within the landscape. Recognition of different elements within the landscape, often shown by changes in vegetation, will help locate sampling sites for field investigations, as discussed in Annex A.

P6.2.3 Vegetation

An assessment of vegetation cover can be made from air photographs. Under semi-arid conditions the land may be covered with natural vegetation (but most probably grazed) or partly farmed. The following classification may be used:

Cover	Description
Grassland	Dominant grass, a few trees or bushes.
Savannah	Grass with trees but sufficiently dispersed to allow people or vehicles to pass easily.
Thick bush	Trees and bushes growing so close together that the ground cannot normally be seen. Difficult to penetrate on foot, impossible by vehicle.
Forest	A mixture of tall trees with bush understory.
Cultivated land	Easily recognisable by the rectangular outline of the cultivated fields.

P6.3 Soil Characteristics

At the preparatory stage this information can be obtained from existing data. All that is needed is identification of the likely type(s) of soil within the project area, and a brief review of the physical and chemical descriptions of these soils as background material for the field visit and to help selection of the required laboratory analyses. In the absence of specific data, information deduced from knowledge of the soil's geological origin (see above) should be entered. Landscape, vegetation or soil boundaries apparent from aerial photos should be marked on a copy of the sketch map.

P7 Climate Data

In order to establish the suitability and irrigation need of the proposed crops, information is required on temperature, rainfall and potential evapotranspiration (consumptive use of water). The national meteorological service should be visited to check the existence of relevant data. Information relating to other developments in the region may also be available.

Irrigation schemes tend to be located in areas where the climatic conditions can vary both within any one year and between years. Annual rainy seasons may begin and end early or late, and the total rainfall in a season may vary widely from year to year. The patterns of change of temperature and evaporation, both within and between years vary less than those for rainfall. As a general guide, the longer the period of continuous records available, the more accurately mean monthly values can be estimated, and variations between totals for the same month in different years can be predicted.

If the available information is from raingauge and climate measurement stations some distance from the proposed scheme, it will be necessary to transpose the data, for example by interpolation, to the site under consideration. In a number of countries national climate maps have been prepared using long term mean monthly values of temperature, rainfall and in some cases, potential evapotranspiration. These data can be used with actual data from the nearest stations to give a good indication of the month by month climate at the site of the proposed scheme.

Where there is a lack of local applicable data, international climate databases may be used. CLIMWAT, for example, was developed by FAO to provide international data sets for use with the CROPWAT method for computing the water requirements of irrigated crops. For Africa, CLIMWAT provides data for 853 stations in 47 countries. For each station monthly mean values are presented for the following climatic variables, together with the period of years over which those means have been calculated:

- rainfall
- maximum and minimum temperature
- humidity
- run of wind
- sunshine hours and solar radiation

In addition, values are listed of computed monthly mean reference evapotranspiration and effective rainfall (see P7.3 and P7.2.1). The CLIMWAT database is contained in diskettes supplied with FAO Irrigation and Drainage Paper No 49.

Databases developed using Geographical Information Systems (GIS) are becoming increasingly accessible. Under such systems, interpolated data is usually provided for intersection points of a latitude and longitude based grid, or may be presented in contour form on maps. Such databases include the Global Resource Information Database (GRID) Programme of UNEP which provides monthly mean values for rainfall, maximum and minimum temperatures, and potential evapotranspiration data based on a half-degree grid.

Data entered on the Data Sheets should be in accordance with the hydrological year. Relating to the annual climate cycle, the start of the year is often taken as the month in which the major wet season normally begins.

P7.1 Temperature

Information on temperature is needed primarily to determine crop suitability. It is possible to estimate evapotranspiration from temperature alone, but more satisfactory estimates can be obtained by using either a range of climatic measurements or by using evaporation pans (see P7.3)

P7.1.1 Base Data

Temperature data required are mean monthly maxima and minima, and overall mean monthly values. As mentioned above, temperature pattern is considerably less variable than that of rainfall.

P7.1.2 Transposition to Site

Transposition of temperature values from the nearest field stations to the site of the proposed project needs care. On flat terrain, data may be weighted according to the distance of the station concerned. In mountainous country, however, the professional judgement of meteorologists will be needed to allow for the effects of altitude and aspect (the direction in which the irrigated area faces). As a rough guideline, mean temperature falls by approximately 0.6 degC for each 100m increase in altitude.

P7.2 Rainfall

Where rainfall is less than the consumptive use of the crop, irrigation will be needed if the crop is to thrive. Comparison of rainfall with consumptive use (P7.3) thus forms the basis for determination of the irrigation requirement.

P7.2.1 Base Data

While for the present purpose, use of monthly figures is satisfactory, it is necessary to be aware that the monthly totals may derive from only a few (or even a single) isolated heavy storms between which there may be lengthy periods without precipitation. Account may be need to be taken of this in determining dependable effective rainfall.

Rainfall intensity. Intensity of rainfall is one of the determinants of catchment erosion, and hence whether a particular surface water source is likely to carry a heavy sediment load. Data on rainfall intensity is obtained from recording raingauges. The network of these is however usually much less dense than that for daily gauges.

P7.2.2 Transposition to Site

Data may be used to derive isohyets or be weighted according to distance. The aspect of the proposed site can be important if prevailing rain-bearing winds come from one particular direction. When transposing absolute maximum intensity values from an existing station to the scheme site, the similarity of local weather patterns likely to produce intense rainfall must be checked.

Dependable and effective rainfall. Small irrigation schemes are commonly designed to provide sufficient water to meet crop water requirements with a reliability of 80%. To determine irrigation water demand, estimates are therefore required of the reliability of expected rainfall. In addition, because of losses due to surface runoff, evaporation and deep percolation, only a proportion of the rainfall enters the soil and is retained within the root zone for use by the crop. The proportion remaining is termed "effective rainfall". The topic is discussed fully in FAO Irrigation and Drainage Papers No 25 "Effective Rainfall" and No 46 "CROPWAT: A Computer Program for Irrigation Planning and Management".

In the FAO CROPWAT Paper, The concept of "dependable rain" is presented which combines monthly rainfall having an 80% probability of exceedance (i.e. that likely to occur in the particular month under consideration in four years out of five) with the effective rainfall concept through the following formula:

$P_{dep} = 0.6P_{tot} - 10$ (for $P_{tot} < 70$ mm/month)
$P_{dep} = 0.8P_{tot} - 24$ (for $P_{tot} > 70$ mm/month)

where P_{dep} and P_{tot} are respectively monthly mean dependable rainfall and monthly mean measured rainfall in mm.

P7.3 Evapotranspiration

Consumptive use of water by a crop is a function of the growth stage of that crop and of reference evapotranspiration, reference evapotranspiration (Eto) being defined as "the rate of evapotranspiration from an extensive surface of 8 to 15 cm tall, green grass cover of uniform height, actively growing, completely shading the ground and not short of water".

P7.3.1 Base Data

In most countries the most widely available data from which reference evapotranspiration may be derived are pan evaporation measurements, although order-of magnitude estimates can be made from temperature data using the Blaney-Criddle method. Methods of calculation are described in FAO Irrigation and Drainage Paper No 24. More accurate estimates can be obtained by using the Penman Method, also described Paper No 24. However, this method requires more climate data, values being needed for air temperature and humidity, solar radiation (which can be derived from hours of sunshine), and wind run. In a number of countries the agricultural authorities have produced maps showing monthly or seasonal Eto.

P7.3.2 Transposition to Site

Across flat or undulating country, evapotranspiration rates do not vary greatly unless there are major changes in local climate linked to local geography (e.g. the coastline of the sea or a large lake). Reference crop evapotranspiration for the proposed scheme may be obtained by interpolation between existing stations, or where available, from maps. Transposition in mountainous areas is more difficult, but lower monthly mean temperatures, reduced sunshine hours and increased cloud cover will all result in lower evaporation rates.

P8 Agriculture

Knowledge of the principal agricultural activities in the region can provide a useful indication as to the suitability of proposed cropping patterns, and by implication, marketability. Agricultural census data, extension records and land use maps are normally obtainable from the agricultural authority. The general level of agricultural activity gives a useful indication of the skill levels and artisan abilities that may be available locally and an indication of the level of agricultural infrastructure to be expected.

P8.1 Principal Crops

Information on crops grown on any irrigation schemes in the locality is entered in Section P3. Rainfed crops, if they are important to family security, or if they earn high revenue, are also of interest as they may be powerful competitors for resources.

P8.2 Livestock

Livestock may play an important role in the existing agricultural economy. An existing livestock base is important to irrigation to provide manure and possibly animal traction. The presence of cattle and oxen generally indicates a wealthier community than one which has only sheep, goats and poultry. A poor community may be short of resources to farm an irrigated plot. Large herds may be indicative of nomadic farming systems where out-migration has far reaching implications. Development of irrigation may reduce the area available for free range grazing, although crop residues may provide an alternative.

P9 Sub-Catchment Water Demands

Wherever a new scheme is planned whose water supply is to be obtained from a surface source, there will almost certainly be existing established demands for water upstream and downstream of the chosen abstraction point. A formal system of water rights may be in operation, or local people may have an agreement by traditional custom over the way in which water for irrigation is allocated. Proposed changes in water demand must be fully discussed with the national authority responsible for regulating abstractions.

Quantifying existing abstractions is difficult. Rural water users are generally unwilling to provide information to outsiders as to how much water they actually use. Even where water rights apply, some users may regularly abstract more or less than their entitlement, whilst other users may hold no rights at all. It is important when assessing the adequacy of the proposed water source that account is taken of these demands of other users. Where a system of water rights is in operation, existing users may be legally entitled to abstract more water than they currently use.

P9.1 Demands Upstream of Proposed Abstraction Site

Discharges based on measurements at the proposed abstraction site will be net of upstream use. The earlier years of long term records may, however, reflect a lower level of upstream abstraction than at present, and some adjustment may be necessary. It must also be borne in mind that at times of lower than normal flow, the proportion of the available discharge abstracted by upstream users could rise significantly.

Discharge at the abstraction site will also be decreased by any future upstream development.

P9.2 Demands Downstream of Proposed Abstraction Site (Net of d/s Inflows)

Account must be taken of the demands of downstream users to ensure that sufficient water remains for these to be met after abstractions for the proposed project. It will also be necessary to ensure a minimum downstream flow to maintain the aquatic ecosystem, and if appropriate, downstream wetlands.

Streamflows downstream of the proposed development will be augmented by irrigation return flows and drainage, and by tributary inflows. It is not possible to define a precise distance downstream of the proposed abstraction site along which existing and possible future demands for water should be quantified. If the stream from which water is to be abstracted joins a river or tributary with a significantly larger flow a short distance downstream of the proposed abstraction point, it is unlikely that existing demands will need to be checked downstream of that confluence.

P9.3 Total Equivalent Non-Project Demand at Abstraction Site

Future increases in demand on the source upstream of the proposed abstraction site, taken together with existing and any planned additional demands downstream, both net of downstream inflows, will give the equivalent demand at the abstraction point to be deducted from the supply when assessing the water available to the project. Where discharges at the abstraction site have been naturalised (P10.2.2), the equivalent demand should also include existing demands upstream.

P10 Hydrology Of Supply Source

Clearly a key element in the assessment process is the establishment of the availability and reliability of the proposed water supply. This section considers supplies from streams and rivers. Supplies from shallow wells are considered in Section P11.

Other factors to be considered are the possibility of potentially damaging floods, protection against which can be costly, and of high sediment loads which if deposited in the conveyance system could lead to an increased maintenance requirement, or to loss of capacity in any storage provision. Wear on pump components could also be increased.

In assessing the suitability of a proposed stream or river source for irrigation water supply, the degree of precision required will be linked to how closely the demand matches the flow. If small quantities of water are to be abstracted from a large river, only approximate calculations will be needed. However, for small streams, greater precision is required, especially where demand is high in relation to the mean flow rate.

Many countries have developed their own hydrological procedures for irrigation planning. However, for situations where appropriate nationally accepted procedures may be lacking, attention is drawn to the ongoing FRIEND (Flow Regimes from International Experimental and Network Data) programme, a major component of the world-wide United Nations Economic and Social Council (UNESCO) International Hydrological Programme. For the Sub-Saharan Region of Africa a basic aim of the programme is the development of regional time series hydrological data bases, so that data for rainfall and streamflow can be archived and accessed for further use in uniform ways within a group of adjacent countries. FRIEND also aims to provide a comparative evaluation of different hydrological methods, and to provide hydrological techniques which are applicable on a regional basis.

Within Sub-Saharan Africa, work is divided regionally between three groups:

Southern Africa FRIEND, which includes the 11 member nations of SADC; this programme has a Co-ordination Centre at the University of Dar-es-Salaam, Tanzania.

FRIEND-AOC (West and Central Africa), with a Co-ordination Centre in Abidjan, Côte d'Ivoire

Nile FRIEND. Being co-ordinated at the University of Dar-es-Salaam, this programme is in the formative stage, but is likely to include the countries of the Nile Basin.

While the priorities of each group differ, regionalisation of low flows represents a research theme in all three programmes. Within Southern Africa FRIEND, using data sets for catchments ranging between 10 km^2 and 100,000 km^2, attention is directed towards the development and recommendation of techniques, at this stage primarily in the context of drought assessment, for estimating flow duration curves and low flow frequency curves at ungauged locations. Research is also being undertaken into techniques for estimating flood frequency as a function of the mean annual flood. Results from these elements of the programme are expected to be available in late 1997 as are the results of the FRIEND-AOC programme. It is anticipated that results from Nile FRIEND will become available in 1999.

P10.1 Catchment Upstream of Proposed Abstraction Site

The proportion of precipitation resulting in runoff is determined by the physical features of the catchment. Relief and land cover, together with rainfall intensity, are also important determinants of erosion, and hence sediment load. For land cover, relative erodibility is indicated below. An indication of the susceptibility to erosion of the catchment as a whole may be obtained from the weighted mean.

Cover	Description	Relative Erodibility
Natural vegetation	Cover >80%. Forest, savannah, permanent pasture	0.001- 0.05
Degraded forest	Savannah woodland, rough grazing, perennial crops	0.05 - 0.50
Cropland	Annual crops, scrap woodland	0.50 - 0.80
Bare soil	Cultivated land 0% cover, overgrazed land	0.80 - 1.00

P10.2 Discharge

P10.2.1 Base Data

In most countries the Hydrological Department produce a yearbook listing the data recorded at discharge and level gauging stations on a daily basis over the previous year. In general, however, unless set up to provide information at the site of a specific proposed development, gauging programmes have tended to concentrate on the larger rivers and their major tributaries. These data are increasingly becoming available in electronic form.

Runoff is a reflection of precipitation, which as mentioned earlier (P7) may vary widely in amount and timing both within any one year and between years, and the longer the period of continuous records available, the more accurately mean monthly values can be estimated, and variations between totals for the same month in different years can be predicted. Small irrigation schemes are commonly designed to provide sufficient water to meet crop water requirements each month with an annual reliability of 80%.

While monthly flow figures represent the aggregate discharge during the period, flows in flashy streams and rivers may fluctuate widely from day to day, and in extreme cases the monthly flow may largely derive from one or two short duration floods. It is thus necessary to be aware that the quantity of water effectively available for run-of-river diversion (except possibly for spate irrigation, which is outside the scope of this document) may be substantially less than that indicated by the monthly figure, and in such cases, allowance must be made accordingly.

Data entered on the Data Sheets should be in accordance with the hydrological year.

P10.2.2 Transposition to Site

Where discharge records for the particular stream or river are available, the discharge at the abstraction site may be obtained by interpolation. In many cases, however, small-scale irrigation schemes are likely to be based on minor ungauged streams. While over large catchments, the impact of individual events becomes diffused in relation to the whole, this is not the case with small catchments, and as the result, transposition between catchments differing widely in size must be approached with caution.

Where there is a lack of applicable data, it may be possible to derive estimates of discharge at the site from regional data. Mention has been made earlier of the FRIEND project which includes development of methods of estimating low flows and flood frequencies at ungauged sites.

When transposing or deriving data, account must be taken of the effect on base data flow regimes of existing abstractions. This may be achieved by naturalising the measured discharge to include the amount of any existing abstractions upstream less any related return flow.

At sites where data has been transposed or derived synthetically, consideration should be given to installation during the field visit, should other aspects of the proposed scheme be found generally satisfactory, of a staff level gauge and arranging for it to be read on a regular basis.

P10.3 Water Rights of Project Villages

Information on existing water rights held by the communities or individuals whose land it is proposed to irrigate should be obtained from the responsible authority.

P11 Hydrogeology Of Groundwater Supply Source

For an irrigation scheme dependent upon groundwater, an estimate must be made of the sustainable yield of the potential source.

Wells may be broadly classified as open wells, hand dug, where the diameter is sufficient to allow access for construction and maintenance, and small diameter tube wells bored or sunk from the ground surface. The primary concern of the Checklist is with shallow, self-help, low cost wells.

P11.1 Geology

The geology of the project area has been considered earlier (P6), where the distinction was drawn between rock and unconsolidated material. The geology not only affects the availability of water, in terms of aquifer properties, but also the ease with which a well or tubewell can be installed. The national geological survey will hold geological maps, together with other information, possibly including hydrogeological maps and reports on geophysical water resource surveys relevant to well siting and potential yield. The records of regional development authorities whose responsibilities include water supply should also be checked for information. Regional rainfall records should be studied in relation to reliability of aquifer recharge.

Alluvial aquifers, formed from material carried down by rivers, may under favourable conditions yield several litres a second to shallow wells. The loose, unconsolidated material may however present difficulties during well installation. Where a river carries a heavy silt load, water drawn fro the alluvium some distance from the channel will normally carry much less sediment than water from the river itself. Although there may be little surface water in seasonal sand rivers, there may be more permanent flow in aquifers beneath the bed.

Basement aquifers. Much of Africa is covered by hard, crystalline basement rocks which do not provide good aquifer storage in their undisturbed state. Some water may however occur in fissures or in the weathered surface zone. However, yields are typically less than 1 l/s.

Sedimentary aquifers. Storage capacity and yield potential depend on the porosity and permeability of the rock strata. Given sufficient recharge, coarser material such as sandstones can provide yields ranging up to a few litres a second. However, areas of sedimentary rocks where the water table is sufficiently high to allow abstraction from shallow wells are relatively small, and often away from present areas of human habitation.

To put these figures into perspective, even small schemes require large amounts of irrigation water. A requirement of 1mm across 10ha, with no allowance for losses, would amount to 100m^3. To supply this in one day with a pump running for 12 hours would require a pumping rate of 2.3 l/s.

P11.2 Existing Wells

The best preliminary indication of potential well yields is likely to be obtained from records of existing wells in similar material in the vicinity of the project. However, except where aquifers are very high yielding, a new well sited too close to an existing well may lower water levels and reduce yields.

P11.3 Estimated Yield Potential

From the information available, an estimate should be made of the yield to be anticipated from a well appropriately sited in the project area. Because of possible interference effects between wells, minimum spacing and area of influence should also be given, and a first estimate made of the number of wells in the project area which the aquifer could support. It is essential that investigations to confirm aquifer yield potential are carried out at the design stage.

TABLE P6.1 - Soil Forming Materials - Fertility Status

Rock	Soil pH	Macronutrient Deficiencies Ca	Mg	K	P	Micronutrient Deficiencies Cu	Zn	Mn	Fe	Toxicities
Igneous:										
Granite	< 6.5	•	•		•	•	•	•	•	
Acid	< 6.5	•	•	•	•	•	•			
Basic	> 7.0				•					
Ultrabasic	> 7.0				•					Cr, Ni, Mg
Sedimentary:										
Sandstone	< 7.0			•	•	•	•	•	•	
Limestone/ Chalk	> 7.0			•	•	•	•	•	•	
Shales	< 7.0				•	•				Mo, Se
Unconsolidated :										
Volcanic ash	Variable according to whether acid or basic igneous material									
Windbl'n sand	< 7.0	•	•	•	•	•	•	•	•	
Alluvium/ Colluvium	< 7.0				•	Variable according to source material				
Peat	< 6.5				•	•	•	•	•	

Notes: *(i) An asterisk (*) denotes a possible deficiency*
(ii) Guidelines only, subject to chemical analysis
(iii) Assume all soils deficient in nitrogen and sulphur
(iv) Soils derived from serpentines (ultrabasic) particularly infertile
(v) Peat occurs in valley bottom, poorly drained swamp lands underlain by clay - potential acid sulphate conditions

REFERENCES & SOURCES

The references listed below have been selected either to provide further background information or to amplify aspects of the text. For convenience, contact addresses of international database co-ordinating bodies are also given.

Particular attention is drawn to two guideline documents relating to small-scale irrigation development. The FAO Guidelines (1) have been drawn up for the benefit of staff supervising the irrigation components of the Special Programme for Food Security, an area of special focus of which is Sub-Saharan Africa. The HR Wallingford Guidelines (2), based on case studies, put forward considerations to be taken into account by provincial design engineers when developing smallholder schemes in the Region. As with the Checklist, both Guidelines stress the importance of socio-economic factors to sustainability and emphasise the need for a participatory approach. Table RS1 is provided to facilitate cross-referencing between the three documents.

General

1 Special Programme for Food Security: Guidelines for Water Management and Irrigation Development (Draft). FAO March 1996

2 Smallholder Irrigation: Ways Forward. Guidelines for Achieving Appropriate Scheme Design. Vols. 1 and 2. Chancellor and Hide, HR Wallingford August 1997

3 Introduction to Irrigation. FAO Irrigation Water Management Training Manual No 1. Brouwer, Goffeau and Heilbloem, FAO 1985

Environment

4 The International Commission on Irrigation and Drainage (ICID) Environmental Checklist. Mock and Bolton, ICID 1993

Socio-Economic

5 Towards Interactive Irrigation Design. Ubels and Horst, Wageningen Agric. University 1994

6 Stakeholder Analysis for Natural Resource Management in Developing Countries. Grimble and Man-Kwun Chan, Natural Resources Forum Vol. 19 No 2, 1995

7 Economics of Tropical Farming Systems. Upton, Cambridge University Press 1996

8 A Handbook for Mainstreaming a Gender Perspective in the Water Resources Management Sector. Publications on Water Resources No 6, Swedish International Development Agency, 1997

9 Socio-Economic and Gender Analysis (SEAGA). Sector Guide: Irrigation, FAO/ILO, Draft 1997

Geology And Soils

10 Diagnosis and Improvement of Saline and Alkali Soils. United States Department of Agriculture (USDA) Handbook 60, 1954

11 Soil Survey Manual. USDA Agricultural Handbook 18, 1956

12 FAO-UNESCO Soil Map of the World 1:5,000,000. UNESCO, 1974

13 Soil Survey Investigations for Irrigation. FAO Soils Bulletin 42, 1979

14 Water Quality for Agriculture. FAO Irrigation and Drainage Paper No 29 rev. 1. FAO 1982

15 Guidelines: Land Evaluation for Irrigated Agriculture. FAO Soils Bulletin 55, 1985

16 Agricultural Salinity Assessment and Management. American Society of Civil Engineers Manual 71, 1996

Climate

17 Effective Rainfall in Irrigated Agriculture. FAO Irrigation and Drainage Paper No 25. Dastane, FAO 1975

18 CLIMWAT for CROPWAT - A Climatic Database for Irrigation Planning and Management. FAO Irrigation and Drainage Paper No 49. Smith, FAO 1993

19 The GRID Programme. United Nations Environment Programme, PO Box 30552, Nairobi, Kenya (fax 00 2542 226831)

20 Environment Information Management Service, Sustainable Development Dept, FAO, Viale delle Terme di Caracalla, 00100 Rome, Italy (fax 00 396 57053152/57055155)

Water Demand

21 Crop Water Requirements. FAO Irrigation and Drainage Paper No 24. Doorenbos and Pruitt, FAO 1984

22 CROPWAT - A Computer Program for Irrigation Planning and Management. FAO Irrigation and Drainage Paper No 46. Smith, FAO 1992

Hydrology

23 Water Measurement Manual (Third Edition). United States Bureau of Reclamation 1997

24 Southern Africa FRIEND Co-ordination Centre: Dept. of Civil Engineering, University of Dar-es-Salaam, PO Box 35131, Dar-es-Salaam, Tanzania (fax 00 255 5143029; e-mail WATER@USDM.AC.TZ)

25 FRIEND - AOC Co-ordination Centre: BP V.83, Abidjan, Côte d'Ivoire (00 225 211120; e-mail msakho@hydro.gire.ci)

26 Nile FRIEND Co-ordination Centre: Dept. of Civil Engineering, University of Dar-es-Salaam, PO Box 35131, Dar-es-Salaam, Tanzania (fax 00 255 5143029; e-mail WATER@USDM.AC.TZ)

Hydrogeology

27 Self Help Wells. FAO Irrigation and Drainage Paper No 30. Koegel, FAO 1977

28 The Hydrogeology of Crystalline Basement Aquifers in Africa. Wright and Burgess, Geological Society, London 1992

29 Community Gardens Using Limited Groundwater Sources; Development of Crystalline Basement Aquifers in Semi-Arid Areas. Ministry of Lands, Agriculture and Rural Development (Zimbabwe), British Geological Survey and Institute of Hydrology (UK) 1995

Irrigation Infrastructure

30 Water Lifting Devices. FAO Irrigation and Drainage Paper No 43. Fraenkel, FAO 1986

TABLE RS 1 - Cross-references to fao and hr wallingford guidelines

ASPECT	ICID CHECKLIST	HR GUIDELINES	FAO GUIDELINES
Background and scope	Preamble	Ch 1	Ch1, Ch 2
Project identification and development	Part 1	Ch 2	Ch3, Ch4, Ch5
Collect existing physical and socio-economic data	Part 2: P1 - P11	2.1 Ch 3	As below
Detailed physical data collection and field investigations:	Part 3:		Annex
Socio-Economic Background	F1	3.3, 3.5	A7
Environmental Aspects	F2	4.5	-
Topography and Soils	F3	3.2	A4
Agriculture	F4	3.3, 4.1, 4.4	A6
Water Demand	F5	3.1.2	A6
Surface Water Resources	F6	3.1.1, 3.1.4	A5
Groundwater (Shallow) Resources	F7	3.1.1, 3.1.4	A5
Supply and Demand Balance	F8	3.1.3	-
Irrigation Infrastructure	F9	5.1	A2, A3
Economic Indicators	F10	4.2, 4.3	A10
Development and Operation	F11	3.3, 3.4, 5.3	A8, A9
Design for Sustainability	-	5.1, 5.2	-
Monitoring and Evaluation	-	Vol 2	A11

Notes: *FAO Guidelines Reference 1*
HR Wallingford Guidelines Reference 2

Part 2.3.1 - PREPARATORY DATA SHEET

P1 Topographic Data

				1	2	3
P1.1	Project location:			1	2	3
		Village(s)	name			
		District	name			
		Grid reference	E,N			
		Elevation	masl			
P1.2	Communications:			1	2	3
		All weather road - distance	km			
		Rail link - distance	km			
P1.3	Survey Maps:			1	2	3
		Scale	1 to			
		Vertical (contour) interval	m			
		Sheet	No			
		Series	specify			
		Date	year			
P1.4	Air photographs:			1	2	3
		Scale	1 to			
		Series	specify			
		Date	mth/yr			
P1.5	Satellite imagery			1	2	3
		Type	specify			
		Scale	1 to			
		Date	mth/yr			
P1.6	Base Map		sketch	to be attached		

P2 Previous Investigations

				Ref. No 1	Ref. No 2	Ref. No 3
P2.1	Avaiable Documentation:			Ref. No 1	Ref. No 2	Ref. No 3
		Source (eg Min of Agriculture etc.)	specify			
		Title	specify			
		Author (eg Ministry, consultants etc.)	name			
		Level (eg recce, feasibility etc.)	specify			
		Date	year			
P2.2	Relevant Aspects:			Ref. No 1	Ref. No 2	Ref. No 3
		Location of investigation	specify			
		Topics (eg soils, irrigation, rural development etc.)	specify			
		Recommendations re any proposed schemes (eg proceed/no action)	specify			

Note: Where appropriate, information obtained should be entered in the relevant sections of the Preparatory Data Sheet

Project Name

Proposal Date d/m/y

Proposed irrig. area ha

P3 Irrigation schemes in the locality

P3.1 Scheme:

		Scheme 1	Scheme 2	Scheme 3
Name	specify			
Location	specify			
Sponsor (eg Govt, NGO, community)	specify			
Date implemented	year			
Area	ha			
Type (surface, sprinkler, drip)	specify			
Water source (eg river, well etc.)	specify			
Method of abstraction (eg gravity, pump, hand lift etc.)	specify			

P3.2 Agronomic Aspects:

Principal crops -		Scheme 1	Scheme 2	Scheme 3
Crop 1 ………	dates of	P H	P H	P H
Crop 2 ………	planting	P H	P H	P H
Crop 3 ………	and	P H	P H	P H
Crop 4 ………	harvest	P H	P H	P H

Average yield -				
Crop 1 ………	kg/ha			
Crop 2 ………	kg/ha			
Crop 3 ………	kg/ha			
Crop 4 ………	kg/ha			

P3.3 Operational aspects:

		Scheme 1	Scheme 2	Scheme 3
Effective water users association	Y/N			
Night irrigation	Y/N			
Satifactory level of water control	Y/N			
Satisfactory level of maintenance	Y/N			
Water charge/ha	currency			

P3.4 Reported problems

		Scheme 1	Scheme 2	Scheme 3
Pests ans diseases	specify			
Other	specify			

P4 Environmental aspects

P4.1 Fauna:

		1	2	3
Reserves	name			
Migration routes/stages	specify			
Rare or endangered species	specify			
Wetlands/aquatic ecosystems	location			

P4.2 Forest/flora:

		1	2	3
Reserves	name			
Rare or endangered species	specify			
Wetlands/aquatic ecosystems	location	see above		

P4.3 Archaeological Remains:

		1	2	3
Local importance	specify			
National importance	specify			

P5 Socio-economic aspects

P5.1 Demography:

		Village 1		Village 2		Village 3	
Village	Name						
Population (total)		Under 16	Over 50	Under 16	Over 50	Under 16	Over 50
	No						
Households (total)	No						
Female headed household	No						
Main adult occupation - agriculture	%						
- merchant	%						
- other	%, specify						

P5.2 Wealth indicators

		Village 1	Village 2	Village 3
Average household income	currency			
Huoseholds having remitted income	No			
Average rural daily wage - male	currency			
- female	currency			
Children in school	%			
Domestic services - piped water	✓			
- electricity	✓			
- sanitation	✓			

P5.3 Health

		Village 1	Village 2	Village 3
P5.3.1 Hospital/dispensary	Y/N			
P5.3.2 Nutrition level	(G good, F fair, P poor)			
P5.3.3 Infant mortality/1000 live births	No			

P5.3.4 Water related diseases:

Malaria	days lost			
Schistosomiasis	/year/			
Onchocerciasis	person			
Other ………				

P6 Geology and soils

P6.1 Soil origin

P6.1.1 Rock

Igneous	✓	Granite	Other igneous: Acidic	Basic	Ultrabasic	
Sedimentary	✓	Sandstone	Limestock/Chalk	Shame		
Other	specify					
P6.1.2 Unconsolidated material	✓	Volcanic ash	Windblown Sand	Alluvium	Colluvium	Peat

P6.2 General Land Features:

P6.2.1 Terrain	✓	Flat	Ondulating	Hilly	Dissected		
P6.2.2 Physiographic position	✓	River terrace	Valley Bottom	Valley Slope	Swamp	Lake Shore	Coastal Plain
P6.2.3 Vegetation (from air photo)	✓	Grassland	Savannah	Thick bush	Forest	Cultivated	

P6.3 Soil Characteristics (from previous reports):

Texture	✓	Sand	Sandy loam	Loam	Claim loam	Clay
Colour	specify					
pH	specify					
Salinity	specify					
Alkalinity	specify					
Fertility	specify					
Erosion	✓	Gully	Rill	Sheet		

P7 Climate

P7.1 Temperature

P7.1.1 Base Data:

Name of station	name													
Latitude/longitude	specify													
Length of record	years													
Quality of record	✓	Good	Moderate	Poor										
Month (hydrological year)		1	2	3	4	5	6	7	8	9	10	11	12	Mean
Temperature - mean monthly max	deg C													
- mean monthly	deg C													
- mean monthly min	deg C													

P7.1.2 Transposition to Site:

Method used	specify													
Temperature - mean monthly (F4.2.1)	deg C													

P7.2 Rainfall

P7.2.1 Base Data:

Name of station	name													
Latitude/longitude	specify													
Length of record	years													
Quality of record	✓	Good	Moderate	Poor										
Month (hydrological year)		1	2	3	4	5	6	7	8	9	10	11	12	Total mm
Rainfall - mean monthly	mm/mth													
- max recorded intensity	mm/hr													

P7.2.2 Transposition to Site:

Method used													
Rainfall - mean monthly (F4.2.1)	mm/mth												
- dependance (effective 80% reliable) (F5.2)	mm/mth												
- max recorded intensity	mm/hr												

P7.3 Evapotranspiration Eto

P7.3.1 Base Data:

Method of estimated used:

- evaporation pan	type													
- from climate measurements	equation													
- from evaporation/consumptive use maps	source													
Name of station	name													
Latitude and longitude	specify													
Length of record	years													
Quality of record	✓	Good	Moderate	Poor										
Month (hydrological year)		1	2	3	4	5	6	7	8	9	10	11	12	Total mm
Eto mean monthly	mm/mth													

P7.3.2 Transposition to Site:

If transposed, method used	specify													
From compsuntive use maps	Y/N													
Eto mean monthly (F5.1)	mm/mth													

Part 2.3.5 - PREPARATORY DATA SHEET

P8 Agriculture

			Crop 1	Crop 2	Crop 3
P8.1	Principal Crops				
P8.1.1	Rainfed (for irrigated crops see P3)				
	Cereals	specify			
	Roots & tubers	specify			
	Vegetables	specify			
	Fruit	specify			
	Other	specify			
P8.1.2	Pests and Diseases				
	Major pests	specify			
	Pest control programmes	specify			
	Major diseases	specify			
	Disease control programmes	specify			

			Camels	Cattle	Sheep	Goats	Poultry	Other
P8.2	Livestock							
P8.2.1	Principal types:							
	Free range	✓						
	Stall fed	✓						
P8.2.2	Major diseases	specify						
	Disease control programmes	specify						

P9 Sub-catchment water demands

P9.1 Demands u/s of Proposed Abstaction Site

Month (hydrological year)

			1	2	3	4	5	6	7	8	9	10	11	12	Total m3
P9.1.1	Existing u/s:														
	Drinking (human & livestock)	m3/mth													
	Irrigation	m3/mth													
	Industrial	m3/mth													
	(a) Total	m3/mth													
P9.1.2	Additional planned u/s														
	Drinking (human & livestock)	m3/mth													
	Irrigation	m3/mth													
	Industrial	m3/mth													
	Unused water right net of planned	m3/mth													
	(b) Total	m3/mth													

P9.2 Demands d/s of Proposed Abstaction Site (net of d/s inflows)

Month (hydrological year)

			1	2	3	4	5	6	7	8	9	10	11	12	Total m3
P9.2.1	Existing d/s:														
	Drinking (human & livestock)	m3/mth													
	Irrigation	m3/mth													
	Industrial	m3/mth													
	Min flow requirement	m3/mth													
	(c) Total	m3/mth													
P9.2.2	Additional planned d/s:														
	Drinking (human & livestock)	m3/mth													
	Irrigation	m3/mth													
	Industrial	m3/mth													
	Unused water right net of planned	m3/mth													
	(d) Total														

Month (hydrological year)

			1	2	3	4	5	6	7	8	9	10	11	12	Total m3
P9.3	Total Equivalent Non-Project Demand at Abstraction Site (b+c+d) (F5.3)	m3/mth													

Note: Where transposed discharges at the abstraction site (P10) have been naturalised, the total equivalent non project demand should also include existing demands u/s.

P10 Hydrology of supply source

P10.1 Catchment u/s of Proposed Abstraction Site:

Lenght	km							
Area	km2							
Mean Slope	1 in...							
		Bare soil	Cropland (irrigated)	Cropland (other)	Degraded forest	Natural vegetation	Exposed rock	Other
Ground cover	%							
Susceptibility to erosion (F6.1)	estimate							

P10.2 Discharge
P10.2.1 Base Data

Name of station	name			
Latitude and longitude	specify			
Lenght of record	years			
Quality of record	✓	Good	Moderate	Poor

		Month (hydrological year) 1	2	3	4	5	6	7	8	9	10	11	12	Total m3
Discharge - mean monthly	m3/mth													
- max monthly over record	m3/mth													
- min monthly over record	m3/mth													
- 80% monthly reliable	m3/mth													
Mean annual flood	m3/s													
Maximum recorded flow	m3/s													

P10.2.2 Transposition to Site (F6.3)

Method used	specify													
Discharge - mean monthly														
- max monthly over record	m3/mth													
- min monthly over record	m3/mth													
- 80% monthly reliable	m3/mth													
Mean annual flood	m3/s													
Maximum recorded flow	m3/s													

P10.3 Water Rights of Project Villages (see Project Proposal):

Drinking (human & livestock)	m3/mth		Traditional	Legal	None
Irrigation	m3/mth		Traditional	Legal	None

P11 Hydrogeology of supply source

P11.1 Geology

(P6.1.2)	Unconsolidated material	specify	
(P6.1.1)	Rock	specify	

P11.2 Exsisting Wells (F7.1, F7.2, F7.3)

		Well No 1	Well No 2	Well No 3	Well No 4			Well No 1	Well No 2	Well No 3	Well No 4
Source of information	specify					Rest level below ground	m				
Location - grid reference	E,N					Aquifer (alluvial, water basement etc.)	specify				
Ground level at well-head	masl					Abstraction - method	specify				
Ownership (private, communal)	specify					- period pumped	hrs/day				
Type (open, tube etc.)	specify					- mean yield	m3/day				
Diameter	cm					Water quality (EC)	dS/m				
Depth below ground	m										

P11.3 Estimated Yield Potential (F7.4)

		Month (hydrological year) 1	2	3	4	5	6	7	8	9	10	11	12	Total m3
Well yield potential	m3/day													
Reccommended well type	specify													
Extent of aquifer under project	ha													
Project wells supportable by aquifer	No													

PART 3: Field data sheets

GUIDELINES

Introduction

The purpose of the Field Data Sheets is threefold: to check on the ground, as far as is feasible in the course of a short visit, and if necessary amend, the information entered in the Preparatory Data Sheets; to obtain more detailed information on the physical and socio-economic contexts which will determine the parameters of the proposed development than will be available from existing documentation; and from the information assembled, to allow completion of the Checklist Summary which will highlight any aspects likely to have an adverse effect on the project's sustainability.

Provided staff have familiarised themselves with the Field Data Sheets prior to visiting the site of the proposed development, it should be possible for them to be completed by a team of two familiar with the general area in no more than three days. Where calculation is necessary, this has as far as possible been set out in tabular form, and while it would be facilitated by the use of a pocket calculator, this is not essential.

On some aspects, for example in order to obtain an indication of the magnitude of the necessary infrastructure (diversion weir, head canal etc.) estimates are required of slope, height and distance. These would be improved by the use of a tachometric level, or failing that, a clinometer or Abney level. Other equipment required are spades to allow investigation of the soil profile, plastic bags and labels for collection of samples for analysis, and a compass. If levels of acidity/alkalinity are to be determined in the field, a pH meter will be needed. To investigate the quality of the water source a conductivity meter would be useful, and clean, watertight 1 litre plastic bottles should be available for the collection of samples for chemical analysis.

It is important when working through the Field Data Sheets that this is done in close collaboration with the farmers promoting the project, the community authorities and others within the community who might be affected so that full benefit may be gained from their local knowledge and account be taken of their various interests. Only by doing this is the project likely to achieve consensus and to be satisfactorily integrated into the local agronomic and socio-economic context. It is necessary, however, to be aware that pressure groups may select the information they offer.

Early awareness of the private and institutional background will facilitate identification of key informants and interest groups and allow the field team to decide how best to assemble a representative group(s) with whom to compile the Data Sheets. To this end, the field visit starts with enquiries relating to socio-economic aspects.

Topics in the Field Data Sheets are grouped in sections as follows:

- **F1** Socio-Economic Background
- **F2** Environmental Aspects
- **F3** Topography and Soils
- **F4** Agriculture
- **F5** Water Demand
- **F6** Surface Water Resources
- **F7** Groundwater (Shallow) Resources
- **F8** Supply and Demand Balance
- **F9** Irrigation Infrastructure
- **F10** Economic Indicators
- **F11** Development and Operation

Except for Section F1 Socio-Economic Aspects which covers general aspects relating to the village or community as a whole in order to explore the general context within which the proposed development will take place, the Data Sheets are concerned specifically with the proposed area to be irrigated.

Guidelines on each section of the Field Data Sheets are given below. These are crossed referenced to the relevant sections in the Preparatory Data Sheets (e.g. P3) against which data obtained should be checked. In some instances, for example with regard to climatic and hydrological data, to facilitate reference the form of the Field Data Sheets allows for copying of this information. While it is anticipated that the bulk of the information required will be obtained in discussion with the farmers and community concerned, suggestions are made in the Guidelines as to possible additional local sources of information.

Where in the case of particular aspects insufficient information is available to determine their likely impact on the development, this should be noted on the Checklist. Should other aspects be unfavourable, further investigation may be unnecessary.

F1 Socio-Economic Background (P5)

It is essential to determine the compatibility of the proposed development with the local socio-economic context. In this section information to be obtained relates to the village/community as a whole. Key aspects include land tenure and labour availability. Locally, district and provincial offices may hold data, and NGOs active in the area may help by either giving the benefit of their experience or by sharing material.

F1.1 Demography

Local demography is normally recorded in local government ministries but may also be available in local service facilities such as schools or clinics if the site is remote. In addition to information on the local population generally, an understanding should be obtained of the age and gender composition of typical families. However, it can be difficult to take account of urban or other seasonal migration, and to come by gender dis-aggregated figures.

F1.2 Land Ownership

Development of irrigation may require changes in land tenure. In addition to a possible need for land consolidation, the availability of grazing land and sources of firewood and other products may be reduced. To be acceptable, any changes in tenure must be developed within the context of the community landholding and use as a whole.

F1.3 Labour

Introduction of irrigation will significantly increase the labour requirement over that required for rainfed cropping. The two major increases in labour demand stem from increases in inputs/crop and from extension of the cropping season.

Identification of surplus labour capacity is difficult as people tend to expand their activities to fill their available time. People can seldom identify accurately how much over-capacity exists. Families will differ in their capacity to provide extra labour. However, slack and busy periods can readily be identified and putting this information in calendar form gives a basis for further discussion (F4.5). In assessing labour availability account must be taken of seasonal out-migration. It is also important to encourage discussion of alternatives to the accepted allocation of labour.

F1.4 Health

A baseline indication of prevalence of water-borne disease is important for monitoring the impact of irrigation. Designers will be aware of the need to minimise vector breeding environments and operating regimes should aim to minimise human contact with irrigation water. It is also important to consider the general health of the populations and the implications of the increased labour demand which will accompany irrigation development.

F2 Environmental Aspects (P4)

Information on aspects of possible relevance may be obtained from older members of the community, and local key informants such as chiefs, healers and teachers. Villagers may have specialised local environmental priorities beyond current government policy. Conversely, it is necessary to be aware that information may be stifled by groups keen to embark on irrigated agriculture.

F2.1 Fauna, F2.2 Forests/Flora

Enquiries should be made as to the presence or otherwise of possible rare or endangered species identified in the Preparatory Data Sheets. Where there are defined migration or wild life access routes to, for example, water it may be possible to leave passage through the irrigated area. In the case of rare plant species, it may be feasible to reserve small areas within the project. The existence of wetland ecosystems which could be impacted, both within and downstream of the project area, should be noted.

F2.3 Archaeological Remains

Archaeological remains in and adjacent to the area to be irrigated identified in the Preparatory Sheets should be inspected to ascertain whether they are likely to be affected by the project. Any un-listed remains should be identified for local, district or national assessment.

F2.4 Social, Recreational and Religious uses

Human non-agricultural uses such as sport or ceremonial use may be important in a small number of cases. Burial grounds in particular may be a constraining factor.

F3 Topography And Soils (P6)

It is essential from the outset to recognise any properties, physical and chemical, which might make the soils of the command area either unsuitable for irrigated agriculture, or require special measures and/or agronomic techniques if the development is to be sustainable. Such problems might include erosion risk, low fertility, salinity, alkalinity and poor drainage. The most suitable soils for irrigation are deep, have a uniform medium texture (loam to clay loam), and are well drained with a pH in the range 4.5-8.5.

Whilst some of the criteria indicated in this section may appear conservative, it has to be recognised that the various operations required to develop an irrigation scheme can in aggregate make a very considerable demand on the farmers time.

F3.1 General Land Features

F3.1.1 Area of Block

Where the area to be irrigated is in more than one block, information should be entered separately for each block.

F3.1.2 Physiographic position

Position in the landscape is important both for command purposes and, in the case of low lying areas (alluvial flood plain, swamp, mangrove, lake shore), possible need for flood protection or drainage.

F3.1.3 Vegetation

Clearance costs increase with the size and density of vegetation. Large trees may be left if few in number. Thick bush may be more of a clearance problem than forest. Swamp vegetation, unless mangrove, is not generally a problem consisting mainly of tall grass and reeds with the occasional bush or tree in better drained sites.

F3.2 Land Surface

Depending on the slope and form of the land surface the volume of material to be moved in forming the level plots required by surface irrigation may be substantial. An average cut and fill of even 10 cm involves movement of 500 m3 of soil per hectare. A man may be expected to move between 1 and 2 m3/day.

F3.2.1 Slope

Fall. Uniform slopes of up to 1 in 50 (2%) require little land levelling. Slopes between 1 in 50 and 1 in 20 (5%) require more specialised irrigation techniques, possibly more earth movement and terrace construction. Slopes in excess of 1 in 20 require specialist advice on suitability.

Slope characteristic.

Smooth	Minor irregularities up to 15 cm
Undulating	Irregularities between 15 cm and 50 cm (cracking clays) and potentially up to 5m (sand sheets)
Hummocky	Areas occupied by termite or ant mounds. Mounds may be up to 3m high and the area of land occupied may range from less than 1% to over 30%
Dissected	Areas crossed by gullies at least 15cm deep and more than 30 cm wide, and drainage channels. The occasional gully e.g. 100m or more apart, is possibly not a problem, as depending on size, it could be left or filled in.

Land smoothing. Volumes of earth movement may be roughly estimated as:

Smooth and undulating slopes:

Irregularity cm	Volume m3/ha	Irregularity cm	Volume m3/ha
10	250	30	750
15	375	40	1000
20	500	50	1250

Hummocky slopes (removal of termite and ant mounds):
Volume (m^3/ha) = 20 x n x d^2 x h where n is the number of mounds in a 20m x 20m representative area, and d and h the mound average diameter and height, both in metres.

Dissected slopes:
Volume of fill (m^3) = w x D x L /2 where w and D are the width and depth of the gully, and L the length of the gully in the area to be irrigated, all in metres. To obtain the average fill requirement per hectare, total the volume needed to fill all gullies and divide by the area to be irrigated.

F3.2.2 Surface condition

Rock Outcrop. Scattered rock outcrop is more of a problem than if concentrated in one area. Distance between outcrops should not be less than 100m. Rock outcrop indicates presence of shallow soils. Soils in the vicinity of outcrops should be inspected and areas where the depth is less than 50cm rejected. The proportion of rock outcrop + soil less than 50cm deep in any block should not exceed 10%.

Stones. For hand tillage it is necessary to remove stones larger than 10cm down to a depth of 20 cm. Stones below this depth are of less significance unless horizontal stone layers ("stone lines" caused by removal of fine material by termites) are present which can give rise to excessive losses from irrigation channels.

Volume of stone to be removed may be estimated as follows:
Volume (m^3/ha) = 100 x l x b x h where l, b and h are the length, breadth and height in m of a rectangular pile of stones removed from the top 20 cm of a 10m x 10m representative area.

Salt Crust. Any area with a surface encrusted with salt is most unlikely to be suitable for irrigation development. Specialist advice is needed in such a situation.

F3.2.3 Erosion

Sheet erosion. Caused by heavy rain breaking down the soil structure, the particles then being carried away by surface flow. Normally only cultivated land is affected.

Rills. Small, shallow washout channels up to 15 cm deep which can be eliminated by normal cultivation methods.

Gullies. Large, well established channels, at least 15 cm deep and more than 30 cm wide, usually impossible to cross by vehicles or farm machinery. The occasional gully e.g. 100m or more apart, is possibly not a problem, as depending on size, it could be left or filled in. The presence of gullies indicates a lack of control of water flow. It is important to establish the cause as protection may be needed in the form of a cut-off drain or protection bund.

F3.3 Soil Properties

Land which may currently be under cultivation and provide satisfactory crop yields under rainfall may not be suitable for irrigation due to limited internal drainability.

The physical and chemical characteristics which either themselves determine suitability for irrigation or indicate potential problems brought about by other characteristics (e.g. colour is influenced by internal drainage which is regulated by texture, drainage barrier or high water table) are outlined below. A brief guide on procedures to use to detect soil changes and to describe and sample soils is given in Annex A.

In some cases there may be more than one soil type in a block, in which cases the information obtained should relate to the dominant soil type i.e. occupying 50% or more of the block. However, information on other soil types representing 20% or more of an area should be entered separately, on an additional sheet if necessary.

Each different soil type has to be inspected to a depth from the surface of 2m (or to rock if less) by means of a pit. In areas of uniform soil, one pit should be dug every 50 ha. The sequence of soil strata (or horizons) from the surface is termed the soil profile. Full details should be recorded on a separate sheet (see Annex A, Table A2). From this sheet, key characteristics of the top four horizons extending downwards to a depth of at least 1m should be entered on to the Data Sheet.

F3.3.1 Area

The area of the dominant soil type (and others where the area exceeds 20%) should be determined from the topographic map, air photograph or estimated in the field.

F3.3.2 Field Observations

Depth. Few crop roots penetrate deeper than 1 metre, but for crops under irrigation, in order to maintain proper drainage should deep percolation exceed the natural rate of drainage, the depth of soil should be not less than about 1.5m. As soil depth decreases, so does the amount of water held in a form available to the plant roots. Generally 50cm is the minimum depth of soil suited for surface irrigation, and then only if the rock or other horizon below that depth is fractured or fragmented sufficiently to allow excess irrigation water to drain away.

Texture. Soil textures have been grouped into five units:

- Sand (Q). Not suitable for surface irrigation due to high surface infiltration rates, poor water holding capacity and susceptibility to erosion by wind and water.

- Sandy Loam (L). Only marginally suitable due to relatively low water holding capacity, fairly high surface infiltration rate and susceptibility to water erosion. Not suitable for rice due to high infiltration rates.

- Clay (V). Except for paddy rice, only marginally suitable due to restricted internal drainage and difficulty of cultivation using hand tools. Red clay soils (highly weathered oxidised material) often have high surface infiltration rates and are not suitable for rice unless local experience has shown hat they can be successfully puddled.

- Loam (M), Clay Loam (H). Best suited to smallholder cultivation since they have the best water retention characteristics and generally good internal drainage as well as being easier to till using hand tools. The relatively good internal drainage of many of these soils means they are only marginally suitable for rice unless puddling is practised to reduce the infiltration rate or there is a high and fresh groundwater table which would prevent deep percolation of irrigation water. In such a situation the soils would be imperfectly drained and/or mottled (see below).

Colour, Internal drainage. Soil colour is a useful indicator of drainage status. Internal drainage status is classified as follows:

- Freely Drained (F). Soil which below the surface layer has uniform red, brown or yellow colours to at least 1m depth with no grey layers or rusty mottles.

- Impeded Drainage (I). Soil which contains a sub-soil layer, within 1m depth, restricting the free downward movement of water. This layer may be greyish with rusty mottles and concretions, or yellow or pale brown having distinctive rust coloured mottles.

- Poorly Drained (P). Dominant grey, green or blue colours throughout the subsoil with abundant rust coloured mottles or concretions. Poorly drained soils are not suitable for irrigation (except for rice) unless the cause of the drainage problem (persistent surface flooding, drainage barrier or high watertable) can be solved.

White colours in the subsoil may be due to accumulation of calcium carbonate, often appearing as white nodules. Carbonates may be identified in the field by the reaction of the soil to a dilute solution of hydrochloric acid (see Annex A). A vigorous reaction may indicate a concentration sufficiently high to impact on the characteristics of the soil and in such cases, additional technical guidance should be sought. If in doubt, the material may be tested in the laboratory.

F3.3.3 Laboratory test results

A number of key indicators depend upon the soil chemistry and must be determined in a laboratory from samples taken in the field. For this purpose, 500 gm samples must be collected from each of the top four horizons of the soil profile, extending downwards to at least one metre depth.

Acidity/alkalinity

- pH < 4.5. Very acid soils, often associated with high levels of exchangeable aluminium which is toxic to most crops. Soils with pH about 3 are associated with acid sulphate soils. Very acid soils require special and often expensive measures, such as copious applications of crushed limestone, to bring the pH to a level suitable for crops. In addition their overall fertility status is very low. Such soils are not suitable either for ordinary crops or rice.

- pH 4.5 - 8.5. The optimum range for growth of ordinary crops and rice. Plants are able to cope, in varying degrees, with different pH levels within this range.

- pH 8.5 - 9.0. Marginal for development of most crops as there is likely to be sufficient exchangeable sodium present to require pre-treatment, although this may be justified if other factors are favourable.

- pH > 9.0. Very alkaline soils with high levels of exchangeable sodium requiring extensive pre-treatment to reduce the pH. Since pre-treatment of such soils is time consuming and expensive, requiring special practices including the application of large quantities of finely ground gypsum, they should be excluded from any proposed scheme.

Salinity. Excessive salts hinder crop growth, both through restricting the uptake of water through the root system and through toxicity. Soil salinity may be categorised according to the electrical conductivity measured in deciSiemens/metre (dS/m) of a 1:5 by volume soil water extract (see Annex A). The table below assesses crop reaction against a range of $EC_{1:5}$ values:

Conductivity $EC_{1:5}$ (dS/m)	Designation	Crop Reaction
<0.4	Salt free	Negligible except for most sensitive crops
0.4 - 0.8	Slightly saline	Yields of many crops restricted
0.8 - 1.6	Moderately saline	Only tolerant crops yield satisfactorily
> 1.6	Strongly saline	Only v. tolerant crops yield satisfactorily

Salinity is often associated with poor drainage and any soils with an $EC_{1:5}$ greater than 0.4 dS/m should be thoroughly examined and additional technical advice sought.

Alkali hazard. As mentioned earlier, soils with pH above 8.5 usually have exchangeable sodium present. The presence of sodium in significant quantities can have an adverse effect not only on many crops but also on the physical structure of the soil. The variable used to determine suitability for irrigation is the exchangeable sodium percentage (ESP - see Annex A for further details).

Soil permeability to water generally decreases with increasing ESP. Soils with ESP greater than 15 usually require treatment with a material such as gypsum which reduces the ESP and increases permeability.

F3.4 Drainage

F3.4.1 Limiting layer (drainage barrier)

Layers which limit downward movement of water result in a perched water table which may be seasonal or permanent. Any such problem which occurs under rainfed conditions will be increased under irrigation. Layers occurring within 1.5m of the surface need careful assessment and if within 1m, specialist drainage advice.

F3.4.2 Depth to water table

It is important to establish the drainage characteristics of the soil and site under natural conditions. Water tables will rise under irrigation, possibly resulting in waterlogging and/or salinisation in the longer term. Existing shallow water tables need to be identified. The water table will be lowest before the start of the rainy season, and highest at the end. A rise in the water table of at least 1m may be expected. If under current conditions the water table at the beginning of the rains is within 2m of the surface, provision of a drainage network may be necessary prior to the commencement of irrigation especially if the water quality is poor. Paddy rice is not affected by high watertables provided the groundwater is not saline.

F3.4.3 Surface flooding

Information on frequency, magnitude and period of inundation have to be determined, and the water source identified. Frequency may be categorised as:

Frequent	Several times each year
Infrequent	Once every 2 or 3 years
Rare	Less than 1 year in 5
Very rare	Less than 1 year in 20

Depending upon the severity of the problem, further hydrological and/or engineering studies may be needed.

F4 Agriculture (P3,P8)

Knowledge of existing agricultural activities in the proposed irrigated area is necessary to provide a base line against which the compatibility of the proposed development may be judged and its impacts assessed.

Most potential smallholder irrigators will currently be involved in rain-fed farming, forestry etc., so that reductions in returns from these activities will reduce the overall gains from irrigation.

Agricultural activities are likely to be gender oriented and it is important to ensure participation in the discussions of representative social and age groups of both men and women.

F4.1 Land Ownership

Knowledge of ownership and tenure of land in the area to be irrigated can provide a useful indication as to the likely distribution of benefit resulting from the proposed project, and also whether the development can be accommodated within the present system without undue disruption. Consolidation of land to permit a contiguous irrigated area should be encouraged on grounds of economy and efficiency. Where the local community cannot agree a policy for consolidating land, then there must be doubt as to their ability to work together in operating and maintaining a scheme. Experience shows that schemes where irrigation infrastructure is routed around farm boundaries are notoriously difficult to operate and sustain.

Impact of land tenure on cultivation practices is strong and may determine the crop to be cultivated, available labour and distribution of benefit. It is essential that the community is agreed on ownership and the conditions attached thereto. Failure to address this issue fully can threaten sustainability of the project once it is in operation.

F4.2 Present Cropping Pattern

Climate is a key determinant of the cropping pattern, and for ease of reference climate data should be entered from the Preparatory Data Sheets. Crop and livestock calendars are essential to understanding the relative timings of the associated agricultural activities and of occupancy of the land. They are usefully depicted in shading so that conflicts and gaps are readily identified when cross-referring between the dry land and irrigated calendars (when cross-referring, check the start month is standardised).

F4.3 Constraints

Constraints experienced under the present cropping pattern, unless remedial action is taken, are likely to continue to be experienced in the future. Lack of labour, inputs and agricultural services would be particular causes for concern.

F4.4 Marketing

The nearest market may not be the most popular or may not be the one that will be relevant for the proposed irrigated crop. Alternative arrangements may be in place, such as an established network of traders or wholesalers. Checkout the information from nearby irrigation schemes.

Beware of assuming that existing networks are able and willing to incorporate the new development. Demand for new products should be critically assessed. It is important that people have a realistic idea of possibilities and pitfalls . Enquire from both farmers and merchants.

Market prices are required in order to determine the values of the outputs from the present and proposed cropping patterns (F10).

F4.5 Proposed Cropping Pattern

The proposed irrigated cropping pattern will depend not only on agronomic and marketing factors, but also on issues such as the relative importance of irrigated and rainfed production to family food security. Importance given to cash generation, for example for school fees, should also be taken into account. Discussion of these general issues can assist farmers to focus on what they want of their scheme prior to preparation of more detailed crop proposals.

In drawing up the proposed cropping pattern, reference should be made to Section P3.2 for seasons and lengths of growing period of irrigated crops. The cropping pattern should be arranged so that there is a period of at least one month, preferably at the end of the dry season, when the canal system can be shut down for maintenance.

Ensuring adequate availability of labour at peak periods is particularly important. In some communities it may be important to time irrigated cultivation so that peaks in labour demand coincide with children's' holidays from school. In others, conflict with other agricultural tasks will dictate timing of irrigation. A population which comprises a large proportion of old people and/or very young children may have difficulty in providing for peak labour demand unless there is a reliable outside source of casual labour. Where the work force is predominantly one gender, care should be taken to consider likely impact on sustainability.

The whole question of labour availability should be explored with the potential beneficiaries. Based on experience, a rough guide to labour requirements for gravity fed surface irrigated land is given below:

Crop Type	Labour Requirement - No/cropped ha
Subsistence (cereals, pulses)	3 - 5
Rice	5 - 6
Horticultural (vegetables, fruit)	4 - 6

Assuming an average labour requirement of 5 workers/cropped ha, the approximate monthly labour requirement may be obtained by multiplying this figure by the cropped area. In the first instance, hired labour is likely to be drawn from the community rather than from further afield. Information on current periods of surplus and shortage in the community as a whole is given in F1.

Seasonal out-migration not only affects labour availability, but also has implications for cash flows and decision making in the household. It is important to predict the difficulties that may arise and to adjust operation, maintenance and agricultural planning accordingly. Alternatively, by drawing the attention of potential beneficiaries to possible problems, the community may be encouraged to evaluate out-migration versus irrigation.

Should taking these various factors into account, potential conflicts and bottlenecks become apparent, adjustments to timing of irrigation and area to be cultivated can be explored. As a general guide, plans that rely on use of over 80% of any available factor should be closely examined as they will be vulnerable to unforeseen changes.

The proposed cropping pattern as developed will be used to determine the project water demand (F5), and will also provide the basis for estimation of the benefits likely to result from the development (F10).

F5 Water Demand (P7,P9,F4)

Irrigation demand on the water source is made up of the consumptive use of the crop, i.e. the water needed for crop growth, less any contribution from rainfall, and increased to allow for losses during conveyance from the source to the plant and from the field.

F5.1 Consumptive Use

Consumptive use of water by a particular crop is conventionally determined from the reference evapotranspiration (P7), the requirement of a standard crop under the applicable climatic conditions, and a crop factor relating to the growth stage of that particular crop. Typically, crop factors range from about 0.4 during initial development of the crop after sowing, to about 1.1 with full ground cover, and falling again as the crop approaches maturity. Strictly, therefore, in order to derive overall crop water requirement it is necessary to consider separately each individual crop in the cropping pattern and its proportion within that pattern. This is time consuming, and for present purposes it is sufficiently accurate to assume that all crops throughout their growing season will consume water at the reference evapotranspiration rate i.e. a crop factor of 1.0. On this basis, it is sufficient to know only the total area under irrigated crops each month (F4).

For paddy rice, all months from the start of land preparation to harvest should be included. For other crops only the period from sowing to harvest is required.

F5.2 Project Water Requirement

Net irrigation requirement. Consumptive use less dependable (80% reliable effective) rainfall.

Irrigation efficiency. The overall efficiency of distribution, from water source to the soil in which the plant is growing, is typically 40% for surface (channel) irrigated schemes and 60% for schemes fed from groundwater sources.

Irrigation requirement. The amount of irrigation water in mm depth needed each month is calculated by dividing the net irrigation requirement by irrigation efficiency. In terms of volume (m3) the monthly abstraction requirement is:

depth (mm) x cropped area (ha) x 10

Other requirements. In addition to supplying water for irrigation, advantage may be taken of the project conveyance system to supply drinking water for people and livestock.

F5.3 Total Equivalent Non-Project Demand

In assessing the adequacy of the proposed water source, account must be taken of the demands, both existing and planned, of other users drawing from upstream and downstream of the proposed abstraction site. Where appropriate, such demands should include flows necessary to support the aquatic ecosystem of the resource and of any wetlands downstream. In the absence of further information, the demands estimated in P9 should be taken.

F6 Surface Water Resources (P10)

The purpose of this section is to check the estimates of water quantity derived in the Preparatory Data Sheets. In addition, information is required on water quality to ensure the suitability of the source for irrigation.

F6.1 Water Quality

The main aspects of water quality to be determined are that the salinity is within acceptable limits and that it does not contain levels of sodium, chloride and trace elements, notably boron, which if sufficiently high could adversely affect crop growth or the structure of the soil.

Conductivity. A rapid indication of salinity can be obtained by measuring the conductivity of the water (ECw) by means of a conductivity meter:

Conductivity ECw (dS/m)	Crop Reaction
< 1	Suitable for most plants under most conditions
1 - 3	Harmful to more sensitive crops
> 3	Harmful to most crops.

Chemical analysis. To determine the chemical content of the water, a sample for laboratory analysis must be taken from the source close to the proposed abstraction site. Samples should be collected in 1 litre plastic bottles, each of which should be labelled with the site at which the sample was collected, the name of the river or stream, the date and time when the sample was collected, and the name of the person by whom it was collected.

Sediment deposited in the irrigation system will require to be removed as part of the regular maintenance programme. With high concentrations of sediment in the diverted water, this can involve considerable effort. Susceptibility of the catchment to erosion, indicative of the likely sediment load, was considered in the Preparatory Sheets.

Floating vegetation. Enquiries should be made as to whether at some seasons of the year there are large quantities of floating vegetation which could cause serious blockage problems.

F6.2 Channel Characteristics

Characteristics of the river/stream channel, in addition to being necessary for sizing the abstraction works, can provide a useful check on discharge, particularly flood magnitude (and on the likelihood of flooding).

F6.3 Discharge

Data derived in P10 should be entered into this section of the Field Data Sheet which is set out to allow data obtained during the visit to be entered directly underneath so facilitating comparison. Significant differences should be reported to headquarters, but for the purposes of the field visit the locally obtained information, if indicating lower discharges, should be given priority when carrying out the supply and demand balance.

Observations and enquiries should include the following:

Discharge at time of visit. The velocity of flow in the channel may be gauged from the time of travel of a float dropped in the centre of the channel between two points a known distance apart.

The discharge may then be estimated as:

$Q_{visit} = b \times d_{mean} \times V \times F$ m^3/s (multiply by 2.6 for values in million m^3/month)

where Q_{visit} is the discharge, b and d_{mean} are the observed width and average depth of the water channel in metres, and F a factor (0.8) to make allowance for the average velocity across the channel section being less than that on the surface.

Should a current meter be available, and the stream shallow enough to be waded, the velocity of flow may be measured directly. The meter should be positioned 0.4 of the depth of the channel above the bed. In this case, the reduction factor is not needed.

Flood flows. An approximate indication of flood flows may be obtained from flood marks, often in the form of lines of debris deposited along channel banks at the highest level reached by the flood:

$Q_{flood} = B \times (H_{flood}+d_{mean}) \times Vflood$ m^3/s (multiply by 2.6 for values in million m^3/month)

where Q_{flood} is the estimated flood discharge, B is the width between the banks of the river or stream, H the height of the flood mark above the current water level, both in metres, and V_{flood} the velocity of flow during the flood (m/s).In the absence of other information assume V_{flood} = 2.5m/s.

Reported flows. Enquiries should be made, particularly of older people, as to how discharge in the river has varied:

- From month to month in a "normal" year
- In particular months over the past year (or few years), especially the proportion of discharge contributed by sudden, short duration floods
- In extreme ways in their lifetime

Particular note should be taken of periods of the year when the stream is reported as either having a very small flow or no flow at all. Also of the timing, magnitude and damage resulting from historic floods. Estimation of flood discharge as proposed above may not be feasible if there was substantial depth of overbank flooding.

Should the proposed project generally appear satisfactory and likely to proceed, it would be useful to install a water level staff gauge in the vicinity of the proposed abstraction site and to arrange for it to be read on a regular basis. The data obtained will allow further checking of transposed or derived figures, assist scheme operation, and provide information for other schemes which may be planned in the area.

F7 Groundwater (Shallow) Resources (P11)

The purpose of this section is to check the estimate of potential yield for shallow wells derived in the Preparatory Data Sheets. It must be emphasised that this estimate is indicative only and that more detailed investigation will be required in the design phase.

F7.1 Water Quality

As discussed in F6 above. Unless conductivities differ significantly between wells, one typical sample for analysis is sufficient.

F7.2 Well Details

Data derived in P11 should be entered into this section of the Field Data Sheet which is set out to allow data obtained during the visit to be entered adjacent to facilitate comparison. Significant differences and information on any wells which have fallen out of use should be reported to headquarters. Data should also be obtained on any wells in addition to those for which details are given in the Preparatory Sheets. The positions of all wells should be marked on the base map.

F7.3 Yield

Reported yields. Enquiries should be made of well users as to how wells behave over the year in terms of quantity and reliability of yield. Also concerning seasonal variations in rest level. and in particular as to whether wells have dried up. Reports of interference between wells should also be noted.

Yield test. It may be possible to carry out a yield test on a selected well. After noting the level of the rest level, the well is pumped for a short period and the quantity of water abstracted measured. The time taken for the water to return to its original level is then noted. For example, if 2m3 are pumped out, and the water level takes 4 hours to recover, then the yield will be 0.5m3/hour. During abstraction, the water must either be discharged some distance from the well or into storage containers, otherwise it will infiltrate back to recharge the aquifer around the well. With an open well of fairly uniform diameter, the volume of water removed can be estimated by multiplying the fall in water level by the cross-sectional area.

F7.4 Aquifer Yield Potential

For the purposes of the field visit, should the locally obtained information indicate lower yields, the estimated potential yield of any new wells should be reduced accordingly.

F8 Supply And Demand Balance (F5,F6,F7)

The purpose of this section is to determine the adequacy of the water resource to meet the demands upon it, both with regard to quantity, and to rate of abstraction. Should the balance show demand to exceed supply, consideration should be given to amending the cropping pattern to reduce demand over critical periods.

F8.1 Surface Source

In the wet season(s) discharge in the stream/river is likely to exceed the abstraction requirement. With run-of-river abstraction, any water in the stream/river surplus to requirements is lost to the project. It is in the dry season that the resource is most likely to be inadequate. Should the balance indicate this to be the case, provided on an annual basis supply exceeds demand, the situation might be eased by provision of storage to carry over surplus water from the wet to the dry season. An approximate indication of the storage requirement may be obtained from the cumulative sum of the monthly deficits over the period of shortage. Should seasonal storage appear a realistic possibility, detailed studies will be necessary.

With run-of-river abstraction, the rate of offtake may also be a controlling factor. In Africa, it is generally not customary to irrigate at night. Abstraction of water over a 12 hour period for example, rather than 24, effectively doubles the required rate of offtake, which may as the result exceed the flow in the stream/river. Should this be the case, the choice then has to be made between reducing the demand/irrigated area, night irrigation, or provision of night storage to carry over water for use in the daytime.

It should be borne in mind that similar considerations may apply to the other sub-catchment demands.

F8.2 Groundwater Source

With abstraction from wells, while seasonal storage is not an issue, in addition to the period each day over which irrigation water is required, the rate of pumping will be controlled by the need to avoid excessive drawdown. Should storage be necessary, the capacity will be determined by the pumping regime.

F9 Irrigation Infrastructure (F6,F8)

The works needed to abstract the irrigation requirement from the source and convey it to the area to be irrigated comprise either a gravity diversion structure consisting of a weir and offtake, or a lifting device as appropriate, and a head canal. Provision of regulating storage may be necessary to allow irrigation to continue when there is insufficient flow.

Section F9 sets out to establish that the physical works required fall within limits of magnitude and construction requirements appropriate to farmer managed small-scale irrigation schemes. The proposed limits are based on general experience, but should be amended in the light of local conditions. This section also provides a basis for discussions on allocation of construction and operation and maintenance inputs in Section F11 Development and Operation.

In assessing the magnitude of the physical works, it must be born in mind that even for a 100ha scheme, the maximum irrigation demand on the source, assuming daytime irrigation only, is unlikely to greatly exceed 200 l/s. The size of the works are commensurate, with a water depth in the head canal of no more than 0.5m and height of a gravity diversion structure, unless there is a requirement for extra head to gain command or reduce excavation, less than 1.0m.

F9.1 Abstraction Site

To reduce the risk of damage from erosion, or even by-passing, any permanent structures must be sited on a stable reach. Bank and bed material should be either rock or soil with a high proportion of clay. Provided the bank is stable, the outside of a bend is to be preferred as this will lessen the risk of blockage of the intake by sediment and reduce the quantity of sediment taken off into the head canal.

F9.2 Gravity Diversion Structure

The diversion structure will comprise a weir and an offtake. An adjustable undershot gate should be provided at the end of the weir adjacent to the offtake to allow for passage/sluicing of sediment. In principle, construction of the weir should not significantly increase the risk of overbank flooding upstream. To achieve this, however, particularly in a situation where hydrological data may be lacking, the length of a weir with a fixed crest may need to be substantially longer than the width of the flood channel. In these circumstances, a multi-bay stoplog type weir is to be preferred, which when the stoplogs have been removed, causes minimal obstruction of the channel and hence has little effect on flood levels. The design of the weir should, however, still accommodate the passage over the weir, without overtopping the banks, of moderate sudden floods which might occur without warning and before the stoplogs can be removed.

On small streams, where frequent rebuilding of the diversion structure is acceptable, temporary weirs of sticks, grass, mud and other materials may be sufficient. In such cases, there is little risk of additional overbank flooding as the weirs are normally rapidly washed away, clearing deposited sediment at the same time.

For the offtake structure, a metal or precast concrete pipe through the bank with a gated control at the upstream end would be appropriate. A screen may be required to exclude floating weed or debris.

Weir Height. Because of the hydraulic forces involved, magnitude and cost increase rapidly with height. In addition, the higher the weir crest, the greater the possibility of aggravating overbank flooding. The weir height should thus be kept as low as possible consistent with command and excavation of the Head Canal.

Weir Length. Unless it is necessary to lengthen the weir to reduce the depth of water over the crest when passing a flood, the length of the weir will normally approximate to the distance between the stream/river banks. A shorter weir would add to the risk of overbank flooding.

Bank height above crest indicates both the depth of excavation required for the Head Canal and the surcharge, and hence flood, which can be passed over the weir crest without increasing the risk of overbank flooding.

F9.3 Well

Wells may be broadly classified as open wells, where the diameter is sufficient to allow access for construction and maintenance, and small diameter tube wells bored or sunk from the ground surface. The concern of the Checklist is with shallow, low cost wells. In this context, aquifers are likely to be located in either unconsolidated or weathered material.

Large diameter open wells. Typically 1.2m to 1.5m in diameter, and usually dug by hand, often by skilled, local village based teams. Wells may be lined with pre-cast concrete rings, galvanised iron culvert pipes, or concrete placed behind a mould insitu.

It has been found that the yield of wells in weathered basement can be substantially increased by drilling boreholes horizontally into the basement from the bottom of the well. Typically, four boreholes 120mm in diameter and up to 40m long are drilled radially out from a 2m diameter well. Such wells are known as **collector wells.** In one example, sustainable yields were increased from 0.3 l/s to 2 l/s. However, to carry out this work a special horizontal drilling rig is required operated by a specialist contractor.

Tubewells essentially consist of a tubular casing, the lower end of which slotted to allow water to enter the well from the aquifer. To prevent entry of fine particles a screen may be necessary. A wide variety of materials can be used for the casings, from iron pipes to bamboo stems.

Methods of sinking shallow tubewells in unconsolidated or weathered materials include:

Hand auger. The equipment is simple, but slow to use as depth increases and cannot normally be used below the water table.

Driving (well point). A pipe with a pointed end section and some form of well screen already attached to the lower end, is driven down. Fast and simple, but special well points and heavy duty drive pipe needed.

Water jetting. A high velocity water stream is piped to the lower end of the casing where it washes away material allowing the casing to sink into the ground, the washed out material being carried by reverse flow to the top of the casing. The technique is fast, but the equipment more complex. Not suitable with stones and large gravels.

Hydraulic percussion. A pipe with a cutting bit is raised and lowered with the hole filled with water. A check valve causes displacement of cut material from the bottom of the hole up a central tube. Not suitable with stones and large gravels.

Bail-down. A long cylindrical bucket with a checkvalve at the bottom is raised and lowered with the hole partly filled with water The bucket is raised to the surface for emptying when full of slurry.

In the absence of other information, it should be assumed for the purposes of the field visit that any new well sunk for the project will be of similar type and depth to current existing wells.

F9.4 Pump

When abstracting from incised channels, where construction of a weir would give rise to unacceptable overbank flooding, or from rivers across which the construction of a weir would be a major undertaking, pumping is likely to offer a more economical solution than gravity diversion. Pumping will also be necessary for supply from wells.

The output of traditional manual lifting devices and hand pumps, even at a head as low as one metre, is seldom sufficient to supply an area of more than 0.5 ha. Furthermore, the high labour input limits the time the farmer has available for husbandry of his crop. The advent of cheap, portable petrol and paraffin driven pumps of between 1 and 3 kW, allows the lifting of larger quantities against higher head. Typically, a 2.5 kW pump operating against a head of 10m has an output in excess of 40 m^3/h, or with a pump duty of 6 hours/day, sufficient for some 3ha. As the result, except for garden and on-farm watering, manual methods are generally being superseded.

For larger outputs, with a high daily duty, diesel fuelled pumps are appropriate. These may be either skid mounted or permanently installed. Where large outputs are required, consideration should be given to splitting the capacity between two or more pumps. This gives greater flexibility with regard to the quantity pumped, and in the event of one pump breaking down, by increasing the pump duty, allows at least some of the shortfall to be made good.

Abstraction from tubewells where the head exceeds the practical suction lift (about 5m) will require a borehole pump.

While it is likely that internal combustion engined pumps will be the most appropriate, it is not intended to rule out pumping plant powered by other means which may be considered at the design stage. In particular, electricity, where available and the supply reliable, may provide an attractive option.

Entry channel. If the low water channel is not adjacent to the river bank, it will be necessary to excavate a channel each year to allow water to reach the pump. Where the distance is large, this can be a substantial undertaking.

Maximum pumping rate is derived from the peak daily irrigation demand divided by the proportion of the day over which it is proposed to pump.

Static lift is defined as the difference between lowest water level from which it is wished to pump, and the level of the pump discharge. Discharge should be higher than the water level in the canal so that the canal can not drain back through the pump when stopped.

Length of the rising main, the pipe between the pump and the point of discharge should be kept to a minimum, as in addition to the direct cost, head losses through friction in the pipe adversely affect both pump output and fuel consumption. With a long rising main, it may also be necessary to take measures to protect the pipe against pressure surges.

Availability of spares and supplier support is a key factor governing the selection of pumping plant. It is essential that there is a proven dealer network capable not only of supplying the plant itself, but also able to supply support in the form of advice, spare parts, and repair. Without such a network, repeated experience has shown that within a relatively short time the plant is likely to become unserviceable and the scheme risk abandonment. Existing schemes in the area may provide a good indication of the level of support to be expected.

Availability of fuels and lubricants. In remoter areas, supplies of fuel may be unreliable and it is important to ensure that supplies are likely to be available, and at a reasonable price.

F9.5 Storage Provision

Seasonal storage. The water demand of a fully irrigated crop over the growing season can typically range between 5000 m^3/ha and 10,000 m^3/ha or more. Thus while with regulation of the flow through storage, there may be sufficient water in hydrological terms to meet the demand from the proposed cropping pattern, the volume of storage required for even a few hectares, other than for supplementary irrigation, can be substantial, particularly when account is taken of the need to provide for evaporation losses which if water is stored through the dry season may exceed 50% of the stored water.

The most appropriate retaining structure for small-scale irrigation reservoirs is a low earth embankment. Although commonly limited to 4m or 5m in height, the volume of earthworks is considerable, and the fill necessary to create a reservoir to provide, for example, 100,000 m^3 of water for irrigation in the dry season, could typically amount to 15,000 m^3 or more. Such dams are normally constructed in a single dry season in order to avoid having to take measures to prevent damage to the partly constructed dam by floods. Construction of such dams is thus under normal circumstances not amenable to labour intensive methods of construction.

Earth dams are vulnerable to damage from overtopping, and a spillway must be provided to discharge in a controlled manner water which can not be stored in the reservoir. This is normally a concrete or masonry weir sited at the head of a dug channel on one of the abutments. Where there is a risk of erosion cutting back to the reservoir, it may be necessary to provide the channel with a concrete or masonry lining.

Shallow reservoirs can rapidly lose capacity through deposition of sediment. To limit the flow, and hence sediment, entering the reservoir, the upstream catchment should be as small as possible commensurate with there being sufficient runoff to fill it with the requisite degree of reliability. This also reduces the required flood discharge capacity of the spillway. A catchment limit of 5 sq km has been used for some developments.

Even on small catchments, provision of reservoir storage will add substantially to the cost of the development, and if it is desired to proceed a more comprehensive study of both the technical and economic aspects will be required.

Night storage. Required only to store water for less than 24 hours supply, storage capacities required for night storage are relatively small. For example, for a 12 hour period a storage of some 40 m^3/ha could be needed. However, to limit seepage losses an impermeable lining may be necessary, and unless the full depth of the storage can be sited to command the irrigated area, it will be necessary to pump the stored water back to the conveyance system downstream.

F9.6 Head Canal

Nominally a small earth-dug channel normally no more than a few hundred metres in length conveying water abstracted from the source to the command area, a number of factors can add considerably to the magnitude of the work required. Principal factors affecting the route of the head canal are the location of the abstraction site relative to the command area, the topography to be traversed and the hydraulic slope of the canal relative to the ground surface.

Fall from weir crest to highest field must be sufficient to allow for head losses at the entrance of the Head Canal, command of the highest field (together typically about 0.5m), and for friction and other losses along the length of the canal (normally between 1 and 4 m/km; the smaller the canal, the steeper the required gradient).

Terrain. The flatter the ground slope, the longer the distance from the offtake needed for the canal to gain command. Having gained command, the canal will then tend to follow the contour to minimise excavation. Over-steep slopes may require concrete or masonry drop structures to prevent erosion, and steep **cross-falls** can substantially increase the amount of excavation or require the channel to be flumed or piped. The crossing of natural drainage channels will require provision of **cross-drainage** works; smaller channels may be piped or culverted, but it may be necessary to provide an aqueduct at larger crossings. Provision must also be made for the crossing of the canal by existing access routes, all adding to the complexity and cost of the work required.

Material is important with respect to ease of excavation and to loss of water from the canal through seepage. Losses from gravels and sandy materials are likely to be unacceptably high and the channel will require lining, considerably increasing the cost. In each soil type traversed, a pit should be dug on the line of the canal to a depth of 1.0m (or rock if less) to enable inspection of the profile for permeable horizons (gravel, sand, sandy loam).

Availability of Route. Land traversed by the head canal, being outside the irrigated area, will receive no benefit from the development. It needs to be confirmed that the land required for the alignment will be made available. Project beneficiaries may need to compensate the relevant landowners.

F10 Economic Indicators (P3,F4)

The difference between the present situation without the proposed project and the future situation assuming implementation will give an indication of the value of the project to the potential beneficiaries. However, benefits are not easily measured and do not have a direct relationship to financial surplus which normally indicates farmers ability to support fees.

Overestimation of benefits must be avoided. On a large scale, overestimation leads to inability to repay development loans or even production loans and, at best, leads to dis-satisfaction and reduces co-operation and thus sustainability.

F10.1 Present Situation

If production figures are available, use average figures taken over a number of years so that good and bad climatic effects are included. When seeking figures locally, check that informants are likely to be objective and are familiar with a range of local farming situations. Account should be taken of the range of results in different years and of the range between farmers. Present production should include revenue not only from crops and livestock, but also that from other activities which may be foregone as the result of the proposed development. Corresponding production costs should also be determined. For crops, information is likely to be available on the various inputs, but for livestock and other activities only an indication of overall costs is likely to be obtained. Present production should include to the extent appropriate that from any downstream wetlands impacted by the project.

Where existing production details are not readily available, then the discussion should focus on the probability of positive and negative impacts on other enterprises. Even if the projected return to irrigation is high, a large number of negative impacts implies a high degree of change to the existing farming system which may not be feasible or acceptable. It is worthwhile to check carefully who is participating. Potential losers are often missing, but they may be important to sustainable development and it may be possible to ameliorate their losses through careful planning.

F10.2 Proposed Situation

Irrigated yields should be based on those obtained on other irrigation schemes in the locality. To estimate crop production costs, experience shows that for typical smallholder developments it may be assumed that costs/unit of land for crops already grown, now to be irrigated, will be at least four times present cost or the same percentage of expected revenue as costs calculated in F10.1 (whichever is the greater). For new crops, find local costs/hectare from extension material or from existing schemes. For production costs relating to livestock and other activities, assume the same percentage of revenue as at present.

F10.3 Benefits

The difference between the present net revenue and that from the proposed project provides an indication of the resulting benefit. Expressing the benefit in terms of benefit/ha allows comparison between schemes and with authority guidelines. Acceptable levels of benefit will depend on the financial and social policy of the implementing authority, and guideline levels, against which the benefit may be judged, should be entered into the Checklist Summary before the field visit.

F11 Development And Operation

This section is intended to draw the farmers' attention to likely obligations in the event of the project proceeding, and to obtain a first indication of their acceptability.

F11.1 Water Users Association (WUA)

Irrigation requires a high degree of co-operation between those involved, and a water users association (WUA) comprising the potential beneficiaries should be in place before work begins, although it may be that organisational details cannot be finalised until later in the process when design and cost have been determined/progressed. Definition of membership rights and obligations attached to membership should be clear at the start and at least a preliminary objective should be in place. Gender composition of active members is likely to be important and should reflect the productive labour situation.

The size of the basic unit of organisation can be crucial. Groups larger than twenty may experience difficulty in operating but in general the most important determinant is shared interest. A common basis for farmer groups is a common lateral or farm channel. Where there is more than one group, each group should be represented on the management committee.

F11.2 Provision of Construction Inputs

The objective of this section is to explore the potential extent of the farmers' input or financial contribution to the construction of the necessary infrastructure. To set the discussion in context, an indication of the general magnitude of the financial and labour inputs required is needed. in the absence of specific cost estimates, average per hectare figures for similar developments undertaken by the implementing authority may be used. The size of the commitment will, however, depend not only on the cost of the works but also on authority policy and factors such as the amount of subsidy made available. The tentative nature of any responses at this stage must be recognised. Any financial contribution is likely to be borrowed.

F11.3 Operation and Maintenance

There are no major works and operation and maintenance of the whole project should be within the capacity of the WUA, with advice from the authority when necessary. Costs incurred are normally met from water charges and farmers may be required to contribute labour.

F11.4 Credit Availability

Credit needs fall into two categories: medium-term credit to fund the farmers' contribution to the cost of project development, and short-term credit to cover seasonal production costs. Farmers may be unfamiliar with credit and concepts such as security for loans, group loans, calculation of interest and basic farm record keeping may not be fully understood. Where this is the case, it is recommended that selection and use of credit schemes is included in extension advice and in training programmes.

Development Loans. Development loans may be available to the WUA/farmers through government, from development banks or in conjunction with NGOs. In all cases it is important that the terms of the loan are clearly understood and that it is well within the capacity of the members both to repay the loan and to improve their economic position. Farmers who find themselves working hard only to service a loan, are unlikely to complete repayment. Deposit systems are sometimes used to test farmer commitment to projects. Development loans are normally recouped through water charges.

Production Loans. Farmers who have not irrigated before may initially require production loans in order to make the best use of their irrigation water. Rural savings and credit groups mobilising local savings may provide an effective low cost source of short-term funding. Rural co-operatives may also have a role.

F11.5 Farmer Training

Farmers unfamiliar with irrigated agriculture will require training in its techniques. Even in areas where irrigation is already established, enquiries into critical aspects of water management may reveal a low level of knowledge. Training will also be necessary where the proposed development introduces new concepts, for example cash as opposed to subsistence agriculture, and crops new to the area.

Agricultural. Extension services should attempt to provide specialist irrigation advice. Experience shows that even experienced farmers improve performance overall when good quality extension advice is readily available. Farmers should be encouraged to participate in selection of advice packages and to gain first hand experience of existing irrigation, where possible. If visits to existing schemes can be organised before plans are finalised, farmers will benefit from the experience and become more interactive with designers as a result. It is of crucial importance that the extension and training offered is targeted effectively. The method of delivery may need to be made more appropriate for women and older farmers.

Water Management. Farmers new to irrigation will require training on application methods, control and monitoring of water in the system, strategies for avoiding crises and maintenance requirements. Training should be interactive where possible. The community may choose to nominate a candidate for training who is then paid for services rendered to the community where required.

Business Practices and Marketing. Marketing has been found to be crucial to obtaining high gross margins. Farmers growing new products are likely to be at a disadvantage in unfamiliar markets and will need help initially to make contacts and establish themselves. Training should include business development, simple accounting and critical assessment of contracts. Extension services could help farmers avoid early mistakes.

TABLE F9.1 - Discharge over weir

Head m	Unit Discharge m3/s/m	Discharge m3/s Crest Length m				
		5	10	15	20	25
0.25	0.2	1	2	3	5	6
0.50	0.6	3	6	10	13	16
0.75	1.2	6	12	18	23	29
1.00	1.8	9	18	27	36	45
1.50	3.3	17	33	50	66	83
2.00	5.1	25	51	76	102	127
2.50	7.1	36	71	107	142	178

Head: *upstream depth of water over weir crest*
Freeflow condition Coefficient of discharge 1.8

Part 3.2.1 - FIELD DATA SHEET

F1 Socio-economic Background (Village/Community) (P5)

F1.1 Demography

(a) Households	No			
		Female		Male
Persons/households: all persons	No			
(b) Workers/household	No			
Main adult occupation - Farming	%			
- principal non-farming	%, specify			
- other	%			
Approx range of adult incomes/day				
- high	currency			
- low	currency			
Propn of income from out-migration	%			
Educational facilities	✓	Primary	Secondary	Tertiary
- Vocational	specify			

F1.2 Land ownership

Land use		1	2	3	4
Estimated Area	ha				
Proportion in private ownership	%				
Proportion in communal ownership	%				

F1.3 Labour

Month (hydrological year)

			1	2	3	4	5	6	7	8	9	10	11	12
F1.3.1	Female - Total (axb)	No												
	- out-migration: proportion	%												
	- balance remaining	No												
	- purpose of out-migration	specify												
	- estimated surplus capacity	%												
	Male - Total (axb)	No												
	- out-migration: proportion	%												
	- balance remaining	No												
	- purpose of out-migration	specify												
	- estimated surplus capacity	%												

F1.4 Health

			None	Minor	Major
F1.4.1	Disease level, water related:				
	Malaria	✓			
	Schistosomiasis	✓			
	Onchocerciasis	✓			
	Other ………	name, ✓			

F2 Environmental Aspects (P4)

Should a more detailed investigation of particular aspects be required, reference should be made to the ICID Environmental Checklist

			1	2	3
F2.1	Fauna				
	Migration routes	species			
	Rare or endangered species	specify			
	Economic source	specify			
F2.2	Forest/flora				
	Rare or endangered species	specify			
	Economic/medicinal source	specify			
F2.3	Archaeological remains	specify			
F2.4	Social/recreational/religious uses	specify			

Part 3.2.2 - FIELD DATA SHEET

F3 Topography and Soils (P6) Where land to be irrigated is in more than one block, enter information for each block. Enter information for all soils types exceeding 20% of Block Area. Use extra sheets if necessary.

			Block 1						
F3.1	General Land Features								
F3.1.1	Area of Block	ha	A						
F3.1.2	Physiogeographic position	✓	River Terrace	Valley Bottom	Valley Slope	Terraced Land	Swamp	Lake Shore	Coastal Plain
F3.1.3	Vegetation	✓	Cultivated	Grassland	Swamp	Savannah	Forest	Thick bush	Mangrove
F3.2	Land Surface								
F3.2.1	Slope								
	Fall	1 in…		%					
	Slope characteristic	✓	Smooth	Undulating	Hummocky	Dissected			
	Height difference	cm							
	Land smoothing	m3/ha							
F3.2.2	Surface Condition	✓	Termite, Ant Mounds	Rock Outcrop	Stones	Salt Crust			
	Proportion of Block	%		B		C			
	Volume	m3/ha							
F3.2.3	Erosion	✓	Sheet	Rill	Gully				

			Block 1 Soil Type 1(Dominant)	Block 1 Soil Type 2	Block 1 Soil Type 3	Block1 Area of minority soils type (<20%)
F3.3	Soil Properties					
F3.3.1	Area	ha				
	As proportion of Block	%	D	E	F	G

			Horizon 1	Horizon 2	Horizon 3	Horizon 4	Horizon 1	Horizon 2	Horizon 3	Horizon 4	Horizon 1	Horizon 2	Horizon 3	Horizon 4
F3.3.2	Field observation													
	Depth	cm	0-				0-				0-			
	Texture	Q,L,V,M,H												
	Colour	Specify												
	Internal drainage	F,I,P												
	Calcium Carbonate (reaction to acid)	specify												
F3.3.3	Laboratory test results													
	Acidity/alkalinity	pH												
	Salinity (EC1:5)	dS/m												
	Alkali hazard	ESP												

			Soil Type 1 (Dominant)				Soil Type 2				Soil Type 3			
F3.4	Drainage:													
F3.4.1	Limiting layer (drainage barrier)	depth cm												
F3.4.2	Depth of water table - observed	cm												
	- pre-rains	cm												
	- post rains	cm												
F3.4.3	Surface flooding - river	✓	Frequent	Infrequent	Rare	Very Rare	Frequent	Infrequent	Rare	Very Rare	Frequent	Infrequent	Rare	Very Rare
	- rainfall	✓	Frequent	Infrequent	Rare	Very Rare	Frequent	Infrequent	Rare	Very Rare	Frequent	Infrequent	Rare	Very Rare

F4 Agriculture (P3, P8)

F4.1 Land Ownership (Proposed Irrigated Area

F4.1.1 Land Use

	Unit	Cltivated/fallow	Grazing	Forest	Other	Total	
(a) Estimated area	ha					(d)	Total=total of the area of all soil blocks
(b) Privately owned - prop'n of area	%						
- area (axb/100)	ha					(e)	
- owners	No					(f)	(Beware counting same owner more than once)
(c) Communal owned - Prop'n of area	%						
- area (axc/100)	ha					(g)	
- owners	No	(h)	Assume number of owners of communal land equal to number of householdd (see F1.1 (a))				
		Private (e/f)		Communal (g/h)			
Irrig area - average land/owner	ha						

F4.1.2 Willingness to reliquish land from uses to irrigation

	Unit		
Number of people affirming support	No		
Asserted by whom	specify		
were these people representative of all groups impacted?	Y/N		

F4.2 Present Cropping Pattern

F4.2.1 Climate

Month (hydrological year)

	Unit	1	2	3	4	5	6	7	8	9	10	11	12
(P7.1.2) Mean monthly temperature	dec C												
(P7.2.2) Mean monthly rainfall	mm/mth												

F4.2.2 Crop Calendar

Indicate land preparation (LP), sowing/transplantig (S/T), growing period (G), harvest (H)

	Unit	Area ha	Mean yeld kg/ha	1	2	3	4	5	6	7	8	9	10	11	12
Crop 1………															
Crop 2………															
Crop 3………															
Crop 4………															
Total area under crops/month	ha														

F4.2.3 Livestock Calendar

Indicate period free range (FR), stall fed (SF)

	No	lean Annual)fftake No	1	2	3	4	5	6	7	8	9	10	11	12
Tipe 1………														
Tipe 2………														
Tipe 3………														
Tipe 4………														

F4.3 Constraints

Crops - general	✓✓ maior, ✓ minor	Climate	Soils	Labour	Disease	Pests	(Soils included as check on information in F3)
- inputs	✓✓, ✓	Seed	Fertiliser	Chemicals			
- other	✓✓, ✓	Ag services - see below		Markets - see below			
- why not previously irrigated?	specify						
Livestock - general	✓✓, ✓	Climate	Soils	Labour	Disease	Pests	
- other	✓✓, ✓	Ag services - see below		Markets - see below			
Agricultural Services	✓✓, ✓	Extension	Pest control	Veterinary	Agric. contractors		

F4.4 Marketing

F4.4.1 Market details:

Location	name			
Distance	km			
Ease of access	✓	Good	Moderate	Poor

F4.4.2 Demand and prices:

		Crop 1	Crop 2	Crop 3	Crop 4	Crop 5	Crop 6	Crop 7	Crop 8
Principal crops	specify								
Demand - good	✓								
- variable	✓								
- poor	✓								
Price range - high	currency								
- low	currency								

		Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7	Type 8
Livestock and livestock products	specify								
Demand - good	✓								
- variable	✓								
- poor	✓								
Price range - high	currency								
- low	currency								

F4.5 Proposed Cropping Pattern

Month (hydrological year)

			1	2	3	4	5	6	7	8	9	10	11	12
F4.5.1	Climate (see F4.2.1 above)													
(F4.2.1)	Mean monthly temperature	deg C												
(F4.2.1)	Mean monthly rainfall	mm/mth												

F4.5.2 Crop Calendar

		Area ha	Mean yeld kg/ha	Indicate land preparation (LP), sowing/transplantig (S/T), growing period (G), harvest (H)
Crop 1………				
Crop 2………				
Crop 3………				
Crop 4………				
Crop 5………				
Crop 6………				
(i) Total area under crops/month (Compare with F4.1.1 d above)	ha			

F4.5.3 Approx. labour requirement (5xi) man mth

F4.5.4 Contraints

General ✓✓ maior, ✓ minor

Diseases/Pests, Inputs and Agricultural Services as F4.3

F4.5.5 Livestock Calendar

	No	Annual Offtake No	Indicate period free range (FR), stall fed (SF)	Note: land will not be available for free rangewhen undercrops
Type 1………				
Type 2………				
Type 3………				
Type 4………				

F4.5.6 Contraints

General ✓✓ maior, ✓ minor

Diseases/Pests, Inputs and Agricultural Services as F4.3

Part 3.2.5 - FIELD DATA SHEET

F5 Water Demand (P7, P9, F4)

Month (hydrological year)

			1	2	3	4	5	6	7	8	9	10	11	12
F5.1	Consumptive Use													
(F4.5.2)	(a) Total area under irrigated crops, proposed cropping pattern	ha												
(P7.3.2)	(b) Evapotranspiration Eto	mm/mth												
	(c) Crop factor (use 1.0 unless specified)													
	(d) Crop consumptive use (bxc)	mm/mth												

Ref	Item	Unit	1	2	3	4	5	6	7	8	9	10	11	12	Total m3
F5.2	Project Water Requirement														
(P7.2.2)	(e) Dependable rainfall	mm/mth													
	(f) Net irrigation requirement (d-e)	mm/mth													
	(g) Irrigation efficiently		In absence of other information use 0.4 for surface, 0.6 for groundwater source												
	(h) Irrigation abstraction rqt (f/g)	mm/mth													
	(i) Irrigation abstraction rqt (10xaxh)	m3/mth													
	(j) Other abstraction rqts	m3/mth													
	Total abstraction requirement (i+j)	m3/mth													

Month (hydrological year)

Ref	Item	Unit	1	2	3	4	5	6	7	8	9	10	11	12	Total m3
F5.3 (P9.3)	Total equivalent Non-Project Deman	m3/mth													

F6 Surface Water Resources (P10)

F6.1	Water Quality		
	Conductivity	dS/m	
	Sample taken for analysis	✓	
(P10.1)	Catchment erosion susceptibility	specify	

Month (hydrological year)

Ref	Item	Unit	1	2	3	4	5	6	7	8	9	10	11	12
	Floating vegetation	✓												

F6.2	Channel characteristics									
	Bed material	✓	Rock	Clay	Silty Clay	Sandy Clay	Silt	Sand	Gravel	Cobbes
	Bed gradient	I in…								
	(a) Water channel - width	m								
	(b) - max water depth	m								
	(c) - mean water depth	m								
	- water velocity	m/s								
	Distance from bank of channel edge	m								
	(e) Width between banks	m								
	(f) Bank height above water level (WL)	m								
	(g) Height of flood marks above WL	m								

Month (hydrological year)

			1	2	3	4	5	6	7	8	9	10	11	12
F6.3	Discharge													
F6.3.1	As Trasposed (P10.2.2):													
	- max monthly over record	m3/mth												
	- min monthly over record	m3/mth												
	- mean monthly	m3/mth												
	- 80% reliable	m3/mth												
	- mean annual flood	m3/s												
	- max recorded flow	m3/s												
F6.3.2	As observed:		Enter observed/reported figures in relevant month											
	Channel flow (axcxdx0.8x2.6)	m3/mth												
	Flood flow (c+g)xex2.5	m3/s												

Part 3.2.6 - FIELD DATA SHEET

		Unit	Month (hydrological year) 1	2	3	4	5	6	7	8	9	10	11	12
F6.3.3	As reported													
	Negligable flow - normal year	indicate												
	- dry year	indicate												
	- wet year	inidcate												
	Flood height above observed WL:													
	(h) - normal year	m												
	(i) - historic max (year ....)	m												
	Flood flow:													
	- normal year (c+h)xex2.5	m3/s												
	- historic max (c+i)xex2.5	m3/s												
	Flood damage:													
	- normal year	specify												
	- historic max	specify												
F6.3.4	Agreement of transposed flows with observed/reported	✓	Good	Moderate	Poor									
	Transposed 80% flows with low flows reduced to accord with observations/reports													

F7 Groundwater (Shallow) resources (P11)

Exsisting Weels (less than 20m deep)

Identified in Preparatory Data Sheet — Additional Wells Identified in tha Field

		Unit	Well No 1 P11.2	Well No 1 Fiel check	Well No 2 P11.2	Well No 2 Fiel check	Well No 3 P11.2	Well No 3 Fiel check	Well No 4 P11.2	Well No 4 Fiel check			Well No 5	Well No 6
F7.1	Water Quality													
(P11.2)	Conductivity	dS/m												
	Sample taken for analysis	✓												

		Unit	Well No 1 P11.2	Well No 1 Fiel check	Well No 2 P11.2	Well No 2 Fiel check	Well No 3 P11.2	Well No 3 Fiel check	Well No 4 P11.2	Well No 4 Fiel check			Well No 5	Well No 6
F7.2	Well Details													
	Location - grid reference	E,N												
	Ground level at well-head	masl												
	Ownership (private, communal)	specify												
	Type (open, tube etc.)	specify												
	Diameter	cm												
	Depth below ground	m												
	Aquifer (alluvial, water basement etc.)	specify												
	Method of abstraction	specify												
	Period pumped	hrs/day												

		Unit	Well No 1 P11.2	Well No 1 Fiel check	Well No 2 P11.2	Well No 2 Fiel check	Well No 3 P11.2	Well No 3 Fiel check	Well No 4 P11.2	Well No 4 Fiel check			Well No 5	Well No 6
F7.3	Yield													
F7.3.1	As observed:													
	Rest level below ground	m												
	Yield test	m3/day												
F7.3.2	As reported:													
	Rest level below ground - mean	m												
	(normal year) - pre rains	m												
	- post rains	m												
	Yield - normal year, pre rains	m3/day												
	- normal year, post rains	m3/day												
	- dry year, pre rains	m3/day												

F7.4 Aquifer Yield Potential

(P11.3) Well type — specify ______ Min spacing m ______ Area of influence ha ______ (c) Project wells supportable by aquifer No ______

		Unit	Month (hydrological year) 1	2	3	4	5	6	7	8	9	10	11	12	Total m3
(P11.3)	Well yeld - estimated potential	m3/day													
	(a) Well yield - potential reduced if needed to accord with observations/reports	m3/day													
	(b) Monthly well yield (a x 30)	m3/day													
	Estimated aquifer potential (b x c)	m3/day													

Part 3.2.7 - FIELD DATA SHEET

F8 Supply and Demand Balance (F5, F6, F7)

F8.1 Stream/river

F8.1.1 Balance - Case 1 Abstraction Continuos

Month (hydrological year)

				1	2	3	4	5	6	7	8	9	10	11	12	Total m3
(F6.3.4)	(a)	Supply - 80% reliable as transposed/checked	m3/mth													
(F5.3)	(b)	Non-project demand	m3/mth													
	(c)	Supply avaiable to project (a+b)	m3/mth													
(F5.2)	(d)	Project demand	m3/mth													
	(e)	Surplus/deficit (c-d)	m3/mth													

F8.1.2 Storage Need - Seasonal

In cases suffering periodic deficits, but on an annual basis supply exceeds demand, regulatory storage may be appropriate

		1	2	3	4	5	6	7	8	9	10	11	12
Cumulative seasonal deficit (e1+e2+…)	m3												

(Whrn the cumulative total indicates surplus, the deficit in that month is taken as zero, and no account is taken of this surplus in any subsequent months of deficit)

Storage requirement (max cum deficit) m3 ________ Note: based on 80% problable flows, this figure is indicative only, and in addition does not include losses due to evaporation and seepage

F8.1.3 Balance - Case 2 Project abstraction less than 24 hours/day ________

			1	2	3	4	5	6	7	8	9	10	11	12
(f)	Abstraction duration - project	hrs/day												
(c)	Supply avaibale to project (a-b)	m3/mth												
(g)	Equivalent project demand rate (dx24/f)	m3/mth												
(h)	Surplus/deficit (c-g)	m3/mth												

F8.1.4 Storage Need - Overnight

In cases where there is otherwise sufficient water, but the duration of the abstraction period is such as to require a rate of abstraction exceeding the flow in the stream/river, overnight storage maybe appropriate

Storage requirment (max monthly deficit hxf/720) m3 ________

F8.2 Groundwater Source

F8.2.1 Balance - Case 1 Abstraction continuos

Month (hydrological year)

				1	2	3	4	5	6	7	8	9	10	11	12	Total m3
(F7.4)	(i)	Monthly well yield as checked	m3/mth													
	(j)	Estimated aquifer potential	m3/mth													
(F5.2)	(d)	Project demand	m3/mth													
		Surplus/deficit (j-d)	m3/mth													
		Number of wells required (d/i)	No													

F8.2.2 Case 2 Project abstraction less than 24 hours/day ________

			1	2	3	4	5	6	7	8	9	10	11	12
(k)	Abstraction duration - project	hrs/day												
(l)	Eqivalent project demand rate (dx24/k)	m3/mth												

Where there is otherwise sufficient water, but the duration of the abstraction period is such as to require a rate of abstraction giving rise to excessive drawdown, temporary storage or additional wells will be necessary

Part 3.2.8 - FIELD DATA SHEET

F9 Irrigation Infrastructure (F6, F8)

F9.1 Abstraction Site

Physical characteristics:

Bed material	✓			Rock	Clay	Silty Clay	Sandy Clay	Silt	Sand	Gravel	Cobbles
Bank erosion and material	✓	Eroding		Rock	Clay	Silty Clay	Sandy Clay	Silt	Sand	Gravel	Cobbles
Stram alignment with respect to offtake site	✓	Outside	Straught	Inside							

F9.2 Gravity Diversion Structure

(F8.1)	(a)	Peak abstraction rate (higher of F8.1.1 or F8.1.3g)	m3/mth		l/s ____ (a/2600)
	(b)	Weir height above lowest bed	m		
	(c)	Weir length	m		(width between banks)
	(d)	Bank height above lowest bed	m		((F6.2b+F6.2f) - b)
(F6.3)	(e)	Mean annual flood	m3/s		
	(f)	Flow passed over weir without overtopping banks (ie at depth (d) - see Table F9.1)			% mean annual peak flow (100 x f/e)

F9.3 Well

(F7.4)		Type	specify	
		Depth	m	
		Min spacing/distance from existing wells	m	
(F8.2.1)	(g)	Number	max No	

F9.4 Pump

		Entry channel (surface supply)			
		- Length	m		
		- Max depth of excavation	m		
		Static lift	m		
		Length of rising main	m		
(F8.1)	(h)	Max pumping rate (equiv dmd rate) (higher of F8.1.3g and F8.2.2l)	m3/mth		l/s (i) ____ (h/2600) For groundwater, max rate/well l/s ____ (i/g)
		Operation and maintenance			
		- Availability of spares & support	✓		
		- Availability of fuels and lubrificants	✓		

F9.5 Storage Provision

	Stream/river			
(P10.1)	- reservoir catchment	km2		
(F8.1.5)	- seasonal	Y/N		Volume m3
(F8.1.4)	- overnight	Y/N		Volume m3
(F8.2.2)	Groundwater	Y/N		Volume m3 Dependant upon well characteristics

F9.6 Head Canal

	Depth of excavation at offtake	m		(d + 0.5)
(j)	Length	km		
(k)	Fall weir crest of highest field	m		
	Mean gradient	m/km		(k - 0.5/j)

		1	2	3	4	5	6		Total	% of Total Lenght	No/km
Reach	m - m	0 -								100	
Terrain - S smooth, U undulating, D dissected								D only			
- crossfall	1 in ...							Stepper than 1 in 5			
- drainage, access crossings	No							All			
- other structures	specify							All			
Material - soil type (identified F3?)	specify										
- permeable horizons	Y/N							Y only			
- depth to rock	m							< 0.5m			
Availability of route - cultivated	Y/N							Y only			
- owners willing to make available	Y/N							Y only			

F10 Economic Indicators (P3, F4)

F10.1 Present situation
F10.1.1 Output Value, Input Costs
(F4.2.2) Crops
(F4.4.2)

	Area ha (a)	Unit yield kg/ha (b)	Output Value Production kg (c)=axb	Price/kg (d)	Value currency (e)=cxd		Input Costs Labour (n)	Inputs (o)	Unit Cost/ha Ag services (p)	Marketing (q)	Total (r)=Σ(n-q)	Cost currency (s)=arx	Cost % of output (t)=100s/e
Crop 1 ………													
Crop 2 ………													
Crop 3 ………													
Crop 4 ………													
Sub-total				A							D		

(F4.2.3) Livestock and livestock products
(F4.4.2)

	Productive No (f)	Value/ Animal (g)	Value currency (h)=fxg	(Overall costs including labour, grazing, fodder, veterinary, transport etc.)	Cost/ Animal (u)	Cost currency (v)=fxu	Cost % of output (w)=100v/h
Type 1……… sold/slaughtered							
products							
Type 2……… sold/slaughtered							
products							
Type 3……… sold/slaughtered							
products							
Type 4……… sold/slaughtered							
products							
Sub-total		B			E		

Other Activities

	Production (j)	Unit price (k)	Value currency (l)=jxk	(Overall costs)	Unit cost (x)	Cost currency (y)=(x)xj	Cost % of output (z)=100y/l
1 ………							
2 ………							
3 ………							
Sub-total		C			F		
Total output value / input costs, present situation			Total Value A+B+C			Total cost D+E+F	

F10.2 Proposed situation
F10.2.1 Output Value, Input Costs
(F4.5.2) Crops
(P3.2)
(F4.4.2)

	Area ha (a')	Unit yield kg/ha (b')	Output Value Production kg (c')=a'xb'	Price/kg (d')	Value currency (e')=c'xd'		Input Costs 1. % output txe'/100 (n')	2/. Present cost/ha x 4 4xr (o')	Cost (p')=a'xo'	3. Cost from records Unit cost/ha (q')	Cost (r')=a'xq'	Selected Cost* currency
Crop 1 ………												
Crop 2 ………												
Crop 3 ………												
Crop 4 ………												
Crop 5 ………												
Crop 6 ………												
Sub-total				G							J	

* Selected cost (r'), or larger of (n') and (p')

(F4.5.5) Livestock and livestock products
(F4.4.2)

	Productive No (f')	Value/ Animal (g')	Value Currency (h')=f'xg'	Cost wxh'/100 currency
Type 1……… sold/slaughtered				
products				
Type 2……… sold/slaughtered				
products				
Type 3……… sold/slaughtered				
products				
Type 4……… sold/slaughtered				
products				
Sub-total		H		K

Other activities	Production (j')	Unit price (k')	Value currency (l')=j'xk'		Cost zxl'/100 currency
1 ………				(overall costs)	
2 ………					
3 ………					
Sub-Total		I		L	
		Total Value G+H+I			Total Cost J+K+L
Total Output value, input costs, proposed situation					

F10.3 Benefits

			Present situation		Proposefd Situation
Present and proposed situations:					
Total value	currency	A+B+C		G+H+I	
Total input costs	currency	D+E+F		J+K+L	
Value added (total value less costs)	currency				
Net benefit					
(proposed value added less present)	currency				
(F4.1.1) Project Area	ha				
Net benefit/hectare	curr/h				

F11 Development and Operation

F11.1 (P3.3) Water Users Association (WUA)

Intention to estabilish	Y/N		
Membership	✓	All holders of land under command	Other - specify
Constitution	✓	Democratic	Other - specify
Legal status	✓	Legal entry with binding powers	Other - specify

F11.2 Provision of Construction Inputs

(a) Cost/ha excluding labour	curr/ha	*	(b) Labour requirement/ha	man days	*
(c) Project area	ha				
Project cost excluding labour/ha	currency		Project labour rqt (bxc)	man days	
Community willing to provide	Y/N			Y/N	
Need for credit	Y/N				

* In absence of other information, use Authority average.

F11.3 Operation and Maintenance

		Headworks/Well, Head Canal: Water Control	Headworks/Well, Head Canal: Maintenace	Distibution to Farm Offtake: Water Control	Distibution to Farm Offtake: Maintenance
Annual cost excluding labour/ha	curr/ha	*	*	*	*
Annual labour requirement/ha	man days	*	*	*	*
Responibility	✓	WUA	WUA	WUA	WUA
	specify	Other	Other	Other	Other
		On-Farm			
	✓	Farmer	Farmer		
Night irrigation	Y/N				

F11.4 Credit Availability

		Short Term (Production)	Medium Term (Irrig development)
Source	specify		
Term	specify		
Interest rate	%		
Collateral	specify		

F11.5 Farmer Training

Type		Agricultural			Water Management			Business/Marketing		
Level of currency knowledge	✓	High	Moderate	Poor	High	Moderate	Poor	High	Moderate	Poor
Training facility	specify									
Distance from project	km									

ANNEX: GUIDELINES FOR SOIL AND SITE DESCRIPTION

A1 Introduction

These notes are provided for the guidance of non-specialist staff who may be called upon to conduct the soil and site studies required for the determination of the suitability of land for irrigation development.

Most countries have official soil survey procedures and specified requirements, and may have criteria for land classification. Generally procedures for soil classification are directed towards taxonomic soil classification and most irrigable land classification systems are intended for large schemes and intensive field surveys. Such procedures should be used if considered appropriate, suitable for use by non-specialists and adaptable for rapid small scale irrigation suitability assessment.

The procedures outlined below are as far as possible basic and non-technical. They are intended to guide and encourage the non-specialist to collect soil and site information and interpret the data. Chemical analyses are kept to the minimum consistent with those required for a practical first approximation of suitability or otherwise. Specialist help should be sought in areas where constraints are indicated.

Considerable importance should be given to the knowledge of local farmers in terms of soil variation, susceptibility to flooding and tillage characteristics.

A2 General Procedures

Discuss the general characteristics of the site with village elders. Identify differences in vegetation growth and try to find out if the differences are due to site effects e.g. an area where water collects after rain, or if due to human activity such as previous cultivation, burning etc. Also ask if locals are aware of any differences in the soils within the project such as colour or difficulty of cultivation (often an indication of clay soils). Check on areas which are flooded - frequency of flooding, depth of water and how many days the water stays on the soil surface. Ask about rocks - surface exposures or depth of rock below surface. Check the location of village wells. Mark any information on an air photograph, topographic map or a sketch map.

Mark the approximate boundaries of the proposed irrigation scheme on the map. Starting from the boundary on the highest elevation, make a series of traverses downslope to the lowest boundary. Traverses should be parallel and about 200 m apart. Use a compass to keep on a straight line. Mark any changes in vegetation, slope or soil colour, presence of rocks, depressions etc. on the map. Use a clinometer to measure slopes. A chain or rope will have to be used if only a sketch map base is available to measure distances from project boundary to any observable site or soil change. Soil boundaries can be drawn by linking the observed changes along the traverses.

Each different soil has to be inspected to a depth of two metres (or to rock if within the two metre depth) by excavation of a pit of approximate surface dimensions of 2m x 1m and 2m deep. In areas of uniform soil, dig one pit every 50 ha.

A3 Description of Soil

Choose one side of the pit and carefully scrape away any loose material which has fallen onto the face to reveal the natural soil. A careful inspection should reveal a sequence of layers from the surface downwards distinguishable by colour or texture (see below), stones (stone lines are common in many African soils), cuirass (murram) or iron concretions (round pea sized rusty coloured hard objects). Some layers may be distinguishable by mottles - spots or string like rust coloured markings. Mark the position where one layer ends and the next one starts.

Measure the depth from the surface of each layer (e.g. 0-20, 20-50, 50-90, 90-150) in centimetres down to the 2 m depth or to hard rock. Each layer should be described for:

A3.1 Colour

Munsell Soil Colour Charts are useful to maintain consistency of colour description and should be used if available. The top layer of soil is generally dark brown or black due to accumulation of organic matter and roots from vegetation. Subsoil colours are more variable but commonly red, yellow or light brown. Colour is a useful indicator of the drainage status of a soil. Potential problems may arise if a bleached, whitish or greyish layer with rust mottles appears below the dark topsoil, especially if the layer is underlain by a finer textured (clayey) layer. Another indicator here could be a thin layer (2-3 cm thick) of iron concretions appearing at the junction of the two layers. This would be a good example of perched water conditions caused by the clay layer impeding downward movement of water i.e. a drainage barrier.

Classify the internal drainage of the soil as follows:

Freely drained (F) - a soil which below the surface layer has uniform red or brown or yellow colours to at least one metre depth, no grey layers, no rusty mottles.

Impeded drainage (I) - a soil which contains a subsoil layer within one metre depth, restricting the free downward movement of water. This layer may be greyish with rusty mottles, concretions or another light coloured layer such as yellow or pale brown but having distinctive rust coloured mottles.

Poor drainage (P) - dominant grey or green or blue colours throughout the subsoil with abundant rust coloured mottles or concretions.

White colours in the subsoil may be due to accumulation of calcium carbonate. Often the carbonate occurs as white nodules in a matrix of soil. A simple field test may be used to identify carbonates in the soil. A 10% solution of hydrochloric acid from a plastic squeeze bottle is dripped onto the suspect material. The intensity of the reaction, ranging from little or none to extremely vigorous emission of gas and bubbles, is indicative of the quantity present. If in doubt, the material may be tested in the laboratory.

A crust of carbonate on the surface renders the site unsuitable for development. Otherwise, calcium carbonate has little physical effect upon suitability for irrigation unless it has resulted in the formation of a hard layer restricting drainage or its concentration, as indicated by the extreme vigour of the reaction to acid, is so high that it impacts on other characteristics such as water holding capacity. In such cases, additional technical guidance should be sought.

A3.2 Texture

Soil texture is the most stable characteristic of soils and exerts a considerable influence on moisture retention, surface infiltration rate, permeability and capillary flux. In the absence of definitive measured data it is possible to predict a range of soil physical properties from defined soil texture units. Some typical attributes are given in Table A1.

Soil scientists classify soil texture in terms of the proportions of sand, silt and clay, and between 12 and 16 soil texture classes are commonly reported in soil reports. For practical purposes it is much more convenient to group soil texture classes into five units. USDA (1956) recognised and defined the following groupings:

Symbol	Description	Grouped Texture Classes
Q	Coarse texture	Sand, loamy sand
L	Moderately coarse texture	Sandy loam, fine sandy loam
M	Medium texture	Very fine sandy loam, loam, silt loam, silt
H	Moderately fine texture	Clay loam, sandy clay loam, silty clay loam
V	Fine texture	Sandy clay, silty clay, clay

Experienced field operatives can determine texture by rubbing the moistened soil between their fingers. This is not feasible for the non-specialist unless he has been trained in this technique. If in doubt, a sample should be sent to the laboratory for analysis (see A4). Textures are not necessarily homogenous down the profile and in many soils a gradual increase in clay content results in a sequence such as L, M and H texture units. Alluvial soils are particularly variable. For Checklist purposes it is the average texture of the 0-100 cm layer which is most critical. When estimating average textures thin layers less than 10 cm thick can be ignored.

Stone lines may occur below the topsoil. Thin layers (less than 10 cm thick) cause few problems but thicker ones (e.g. 30-50 cm thick) reduce water holding capacity and may prevent water moving downwards. Seek specialist advice if stone lines are common. Seepage losses from the irrigation system may be considerable if excavated in soils containing stone lines.

A4 Collection of Soil Samples

Soil samples for laboratory analysis are only required from the top 100 cm. Four samples per pit are sufficient. In homogenous soils where horizons are not recognisable collect samples at depths 0-25 cm, 25-50 cm, 50-75 cm, and 75-100cm. Otherwise collect the samples from recognisable horizons, rejecting stones, roots or concretionary material. Place about 500g in a plastic bag, insert a label giving village or project name, number of the pit and depth of soil sample e.g. Kudu village, pit P1. 20-40 cm.

A5 Request for Laboratory Analyses

The question of what soil analyses are needed should be discussed with the regional Laboratory chief. Many laboratories have a routine set of analytical procedures. However, these may be geared to agronomic requirements and may not be suitable for determination of properties relating to irrigation development, especially in terms of salinity and alkali problems.

For Checklist purposes, the following analyses are required to assess suitability for irrigation:

Soil texture - sand, silt and clay content (if necessary - see A3.2 above)

pH (preferably in a 1:2.5 soil:water suspension)

Electrical Conductivity (EC) Conventionally, agricultural soil salinity is categorised according to the electrical conductivity measured in deciSiemens/metre (dS/m) of the pore water, referred to as the saturation extract, taken from a saturated sample (ECe) . In the first instance, however, it is simpler to screen soils for salinity status by measuring the conductivity of a 1:5 by volume soil water extract ($EC_{1:5}$):

Conductivity $EC_{1:5}$ (dS/m)	Designation	Crop Reaction
<0.4	Salt free	Negligible except for most sensitive crops
0.4 - 0.8	Slightly saline	Yields of many crops restricted
0.8 - 1.6	Moderately saline	Only tolerant crops yield satisfactorily
> 1.6	Strongly saline	Only v. tolerant crops yield satisfactorily

Salinity is often associated with poor drainage. However, where the soils are free draining, slight/moderate salinity levels encountered may be due to lack of sufficient rainfall to leach the salts into the sub-soil and application of reasonable quality irrigation water (1.5 dS/m maximum) will reduce topsoil salinity levels. Any soils with an EC1:5 greater than 0.4 dS/m should be thoroughly examined and additional technical advice sought.

An approximate figure for ECe may be derived by multiplying the EC1:5 figure by a factor (F)

appropriate to the textural classification of the soil as defined in Section A3.2. Thus ECe = F x $EC_{1:5}$ dS/m. The factors given below are based on an average saturation percentage for each textural group, and may be changed if there is sufficient local information to warrant modification:

Soil Type	**Q**	**L**	**M**	**H**	**V**
Multiplication Factor (F)	25	16	12	10	7.5

Exchangeable Sodium Percentage (ESP). Additionally, if the pH of any horizon is greater than 8.5 the ESP of that soil should be measured in accordance with the methods recommended In USDA Handbook 60 on Diagnosis and Improvement of Saline and Alkali Soils. Soil permeability to water generally decreases with increasing ESP. Soils with ESP greater than 15 usually require treatment with a material such as gypsum. However, some soils show permeability decrease below 15. Conversely, many of the cracking clay soils (Vertisols) have a natural low permeability when wet and in some instances ESPs of up to 25 have had little significant effect. As a general rule, however, an ESP of 15 should be taken as a cutoff unless local experience indicates otherwise.

A6 Soil and Site Description Sheet

It is useful to pull all soil and site information together on a separate proforma from which data can be entered into the checklist. It is good practice to make out such a data sheet for all pits described and sampled. A suggested proforma with data appended is attached as Table A2.

TABLE A1 - Relationship of soil texture units to physical properties

Soil Type	Soil Texture Unit	Stored Water mm/m	Drainable Porosity %	Infiltration Rate[1] mm/hour	Critical Water Table Depth[2] mm
Sand, loamy sand	Q	50	15	50+	500
Sandy loam, fine sandy loam	L	100	12	40	1000
V.fine sandy loam, loam, silt loam, silt	M	150	10	20	1800
Clay loam, sandy clay loam, silty clay loam	H	180	8	2	1600
Sandy clay,silty clay, clay	V	200	7	1	1400

1: *Surface infiltration is terminal rate*
2: *Watertable depth corresponding to upward flux of 1mm/day (Talsma 1963)*

TABLE A2 Soil and site description sheet

Village/Scheme Name	Kudu
Irrigation Block No	2
Physiographic Position	Valley slope
Vegetation	Grassland
Slope %	2
Slope Characteristics	Hummocky
Land Smoothing m3/ha	240
Stone Removal m3/ha	None
Erosion	None
Area of Block ha	60
Area of Soil P1 ha	12
Percentage Soil P1 in Block	20
External Drainage (Flood Hazard)	None
Internal Drainage	Imperfect
Depth to Drainage Barrier cm	40
Depth to Groundwater Table cm	> 120
Profile Reference	P1

Soil Description:

Depth cm	Sample No	Colour	Texture	Texture Unit	pH	Salinity $EC_{1:5}$ dS/m	Alkali Hazard ESP
0 - 20	P1.1	Black	Loam	M	6.5	0.1	-
20 - 40	P1.2	Grey	Sandy loam	L	6.2	0.1	-
40 - 42	Not sampled. Layer of iron concretions, some mottles						
42 - 70	P1.3	Dark brown	Clay	V	8.8	l.0	12
70 -120	P1.4	Yel. brown	Clay loam	H	8.8	0.8	10
120+	Friable weathered rock						

PART 4:
Check list summary

GUIDELINES

Introduction

The Checklist Summary is intended to set out in concise form the existence or otherwise of possible constraints to the proposed development. Where appropriate, the tabulation provides guidance as to whether particular aspects as determined from the Preparatory and Field Data Sheets fall within acceptable limits. It must be emphasised, however, that contravention of a particular limit does not necessarily mean that a scheme is infeasible. Account must be taken of local circumstances, and it is fully anticipated that the Checklist will evolve to accommodate these. Where no guide figures are given, a qualitative judgement must be made on the basis of the Data Sheet findings. Where there is insufficient information available on which to reach a conclusion regarding a particular aspect, the item should be categorised as "Not Known". While in principle such items will require further investigation, this will however only be justified if no other major constraints likely to adversely effect the viability of the proposed development have been identified.

In Section C2 Topography and Soils, the criteria given are those applicable to dry-foot crops. Where paddy rice is contemplated, because of the emphasis on water retention, different criteria will apply to some texture and drainage aspects. Where this is the case, figures relating to paddy rice are shown in brackets.

The findings in the Checklist Summary should be agreed with the participants prior to departure of the field team. Where major constraints have been revealed, discussion may suggest modifications to the proposed scheme allowing these to be overcome or circumvented. Where there is uncertainty as to whether the available resources are sufficient for project needs, development in the first instance should be limited to that for which resources can be assured. The opportunity, however, remains for further development should operational experience show the additional resources to be available.

Following return of the completed Checklist to district/provincial headquarters and entry of results from any laboratory analyses, the findings (unless further investigation is considered necessary) should be confirmed and the farmers formally notified as to whether the scheme will be taken further or not.

Compilation of information on different schemes in the standardised form of the summary will facilitate ranking should this be required.

Part 4.1 - SUMMARY SHEETS

Ref.	Item	Source	Unit	Constraint: None	Constraint: Minor	Constraint: Major	Not Known
✓ relevant Constraint/Not Known column in accordance with findings on Preparatory and Field Data Sheets							
C1	**Environmental Aspects**						
	Wildlife • Fauna	F2.1					
	• Forest, Flora	F2.2					
	Sites of value						
	• Archaeological	F2.3					
	• Other	F2.4					
	Water related disease	F1.4.1					
C2	**Topography and Soil**						
	General Land Features						
	Vegetation	F3.1.3		Cultivated, grassland, swamp	<Savannah>	Forest, thick bush, swamp (mangrove)	
	Land Surface						
	Slope	F3.2.1	%	0-2	2-5	>5	
	Land smoothing	F3.2.1	m3/ha	<250	250-500	>500	
	Rock outcrop	F3.2.2	%	<5	5-10	>10	
	Stone removal	F3.2.2	m3/ha	<250	250-500	>500	
	Salt crust	F3.2.2	%	<5	5-10	>10	
	Erosion	F3.2.3		Sheet	Rill	Gully	
	Soil Properties (Dominant Soil)						
	Proportion of block	F3.3.1	%	<80	50-60	>50	
	Field observation	F3.3.2					
	• total soil depth		m	>1.5 (>0.5)	1.0-1.5 (--)	<1.0 (<0.5)	
	• texture			M, H (V)	L,V(M,H)	Q (Q,L)	
	• internal drainage			F (P)	I (I)	P (F)	
	• calcium carbonate (reaction to acid)			< Vigorous	Vigorous	-----	
	Laboratory test results	F3.3.3					
	• acidity/alkalinity		pH	4.5 - 8.5	8.5 - 9	<4.5 - 9.0	
	• salinity (EC1:5)		dS/m	<0.4	0.4 - 0.8	>0.8	
	• alkali hazard		ESP	<10	10 - 15	>15	
	Drainage						
	Depth to limiting layer						
	Water table depht-pre rains	F3.4.1	m	>1.5 (--)	1.5 - 1.0 (--)	<1.0 (--)	
	Surface flooding	F3.4.2	m	>2.0 (--)	1.0 - 2.0 (--)	< 1.0 (--)	
	• river	F3.4.3		V. rare, rare	Infrequent	Frequent	
	• rainfall			V. rare, rare	Infrequent	Frequent	

Project Name ____________________

Proposal Date d/m/y ____________________

Proposed irrig. area ha ____________________

Ref.	Item	Source	Unit	Constraint: None	Minor	Major	Not Known
C3	**Agriculture**						
	Land Ownership						
	Willingness to relinquish Land for irrigation	F4.1.2					
	Proposed Cropping Pattern						
	Crops						
	• climate	F4.5.4					
	• labour	F4.5.4					
	• disease/pests	F4.3					
	• inputs	F4.3					
	• agricultural services	F4.3					
	Livestock						
	• climate	F4.5.6					
	• labour	F4.5.6					
	• disease/pests	F4.3					
	• veterinary services	F4.3					
	Markets						
	Access	F4.4.1					
	Demand						
	• cereals	F4.4.2					
	• vegetables/fruit	F4.4.2					
	• livestock	F4.4.2					
	• livestock products	F4.4.2					
C4	**Water Resource**						
	Water Quality						
	Sediment risk	F6.1	w.mean	<0.1	0.1 - 0.3	>0.3	
	Field measurement - EC	F6.1	dS/m	<1	1 - 3	>3	
	Laboratory test results	(F6.1)					
	• Sodium		adj.SAR	<3	3 - 9	>9	
	• Chloride		me/l	<4	4 - 10	>10	
	• Boron		me/l	<0.7	0.7 - 2.0	>2.0	
	Adequacy of Supply (no storage)	F8.1.1 - F8.2.1					
	Adequacy of Supply (with seasonal storage)	F8.1.2					
	Right to abstract water	P10.3					

Ref.	Item	Source	Unit	Constraint			
				None	Minor	Major	Not Known
C5	**Irrigation Infrastructure**						
	Abstraction Site (Surface Supply)						
	Bed material	F9.1		Rock Clay	Sandy Clay / Silty Clay	Silt, Sand, Gravel, Cobbles	
	Bank material	F9.1		Rock Clay	Sandy Clay / Silty Clay	Silt, Sand, Gravel	
	Bank erosion	F9.1					
	Alignement	F9.1		Outside	Straight	Inside	
	Gravity Diversion Structure (Surface Supply)						
	Weir height	F9.2	m	<1.0	1.0 - 1.5	>1.5	
	Weir length	F9.2	m	<5	5 - 10	>10	
	Propn. mean annual flood over weir within banks	F9.2	%	<20	20 - 10	>10	
	Well (Groundwater Supply)						
	Depth	F9.3	m	<10	10 - 20	>20	
	Spacing	F9.3	m				
	Pump						
	Depth of entry channel (surface supply)	F9.4	m	<1.5	1.5 - 2	>2	
	Static lift	F9.4	m	<6	6 - 20	>20	
	Length of rising main	F9.4	m	<15	15 - 30	>30	
	Availability of spare/support	F9.4		Y	-----	N	
	Availability of fuel	F9.4		Y	-----	N	
	Storage Provision						
	Catchment	F9.5	Km2	<5	-----	>5	
	Need						
	• seasonal	F9.5		N	-----	Y	
	• night	F9.5		N	Y	-----	
	• groundwater	F9.5		N	Y	-----	
	Head Canal						
	Length	F9.6	m	<1000	1000 - 3000	>3000	
	Mean gradient	F9.6	m/Km	1 - 3	3 - 5	>5, >1	
	Proportion of route	F9.6					
	• dissected terrain		%	<10	10 - 30	>30	
	• cross fall>1 in 5		%	<20	20 -50	>50	
	• permeable horizons		%	<10	10 - 20	>20	
	Drainage crossings	F9.6	No/Km	0 - 3	4 - 6	>6	
	Major structures	F9.6		N	-----	Y	
	Availability of land	F9.6					
C6	**Economic Indicators**						
	Net Benefit/Hectare	F10.3		*	*	*	

*: Enter Authority criteria

Part 4.1 - SUMMARY SHEETS (cont'd)

Ref.	Item Source	Unit	Constraint: None	Minor	Major	Not Known
C7	**Development and Operation**					
	Establishment of WUA	F11.1				
	Provision of Construction Inputs					
	• finance	F11.2				
	• labour	F11.2				
	Operation and Maintenaince					
	• water control	F11.3				
	• mainetnaince	F11.3				
	Establishment of WUA					
	• short term	F11.4				
	• medium term	F11.4				
	Establishment of WUA					
	• agricultural	F11.5				
	• water management	F11.5				
	• businness/marketing	F11.5				