

# Guidelines for Water Management and Irrigation Development

**SPECIAL PROGRAMME FOR FOOD SECURITY**

1996  
**FAO Water Resources,  
Development and Management Service**



**Food and Agriculture Organization  
of the United Nations**

# Table of Contents

<b>Guidelines for water management and irrigation development</b>	<b>1</b>
<i>Philosophy and Objectives of the Special Programme</i>	<i>1</i>
<i>Principles of the Water Development Component</i>	<i>2</i>
<i>Preparation Phase</i>	<i>5</i>
<i>Definition of the framework for irrigation development (objective 1)</i>	<i>5</i>
<i>Development of the institutional framework for implementation (objective 2)</i>	<i>7</i>
<i>Formulation of the demonstration/pilot phase (objective 3)</i>	<i>9</i>
<i>Demonstration Phase</i>	<i>11</i>
<i>Principles and Process</i>	<i>11</i>
<i>Increase of agricultural production on irrigated land</i>	<i>14</i>
<i>Improvement of performance of existing schemes through improved on-farm irrigation technology</i>	<i>15</i>
<i>Demonstration and development of suitable technologies for irrigation expansion</i>	<i>16</i>
<i>Improvement of performance of existing schemes through capacity building of staff and local community and the development of the institutional base for self-management</i>	<i>17</i>
<i>Expansion Phase</i>	<i>18</i>

<b>Annex 1: Irrigation development model categories</b>	<b>19</b>
<i>Fully Commercial Venture</i>	<i>19</i>
<i>Central or Core Unit Scheme</i>	<i>20</i>
<i>Settlement Schemes</i>	<i>20</i>
<i>Farmer Support Scheme</i>	<i>22</i>
<i>Community Support Scheme</i>	<i>23</i>
<b>Annex 2: Techniques for water supply and distribution</b>	<b>24</b>
<i>Introduction</i>	<i>24</i>
<i>Surface water resources</i>	<i>24</i>
<i>Direct abstraction from rivers</i>	<i>24</i>
<i>Storage reservoirs</i>	<i>25</i>
<i>Spate irrigation</i>	<i>26</i>
<i>Water harvesting</i>	<i>26</i>
<i>Ground water</i>	<i>27</i>
<i>Shallow groundwater</i>	<i>27</i>
<i>Deep Groundwater</i>	<i>28</i>
<i>Canals and Pipes</i>	<i>29</i>
<i>Open channels</i>	<i>30</i>
<i>Pipelines</i>	<i>30</i>

<i>Canal control systems</i>	<b>31</b>
<i>Types of hydraulic structure</i>	<b>31</b>
<i>Canal and Farm Water Management</i>	<b>32</b>
<i>Pumping</i>	<b>33</b>
<i>Power Units</i>	<b>34</b>
<i>General comments</i>	<b>35</b>
<b>Annex 3: Techniques for water application</b>	<b>36</b>
<i>Introduction</i>	<b>36</b>
<i>Surface irrigation</i>	<b>36</b>
<i>Basin irrigation</i>	<b>37</b>
<i>Border irrigation</i>	<b>38</b>
<i>Furrow irrigation</i>	<b>38</b>
<i>Selection of method</i>	<b>38</b>
<i>Sprinkler irrigation</i>	<b>40</b>
<i>Trickle irrigation</i>	<b>41</b>
<i>Micro irrigation</i>	<b>42</b>
<i>Selection criteria for irrigation method</i>	<b>42</b>
<i>References</i>	<b>43</b>

<b>Annex 4: Evaluating and classifying land for irrigated agriculture</b>	<b>44</b>
<i>Basic principles</i>	<b>44</b>
<i>A Step-by-step Guide to the Procedures</i>	<b>46</b>
<i>List of main steps</i>	<b>46</b>
<i>References</i>	<b>48</b>
<b>Annex 5: Water resources assessment</b>	<b>49</b>
<i>Introduction</i>	<b>49</b>
<i>Water availability</i>	<b>49</b>
<i>Data gathering</i>	<b>49</b>
<i>Data analysis</i>	<b>49</b>
<i>Objective</i>	50
<i>Irrigation from wells</i>	<b>50</b>
<i>Information required</i>	50
<i>Irrigation from small dams</i>	<b>51</b>
<i>Information required</i>	51
<i>Irrigation from river diversion</i>	<b>52</b>
<i>Information required</i>	52
<i>Assessment of floods</i>	<b>52</b>
<i>Further readings</i>	<b>53</b>

<b>Annex 6: Crop water use irrigation requirements</b>	<b>54</b>
<i>Introduction</i>	<i>54</i>
<i>Introduction to CROPWAT and CLIMWAT</i>	<i>55</i>
<i>Establishment Climatic Database</i>	<i>55</i>
<i>Cropping Season - Rainfed and Irrigated Crops</i>	<i>56</i>
<i>Cropwater Requirements</i>	<i>56</i>
<i>Irrigation Scheduling</i>	<i>56</i>
<i>Scheme Irrigation Supply</i>	<i>57</i>
<i>Monitoring and Evaluation</i>	<i>58</i>
<i>Evaluation of Rainfed Production</i>	<i>59</i>
<i>Evaluation of Farmers Irrigation Practices</i>	<i>59</i>
<i>Water Supply Efficiency</i>	<i>60</i>
<b>Annex 7: Participatory methods</b>	<b>75</b>
<i>Introduction</i>	<i>75</i>
<i>Participation, Rapid Rural Appraisal, Participatory Rural Appraisal, Participatory Evaluation Methods</i>	<i>76</i>
<i>Contract participation</i>	<i>77</i>
<i>Consultative participation</i>	<i>77</i>
<i>Collaborative participation</i>	<i>77</i>
<i>Collegiate participation</i>	<i>78</i>
<i>The Main Issues to be Addressed</i>	<i>79</i>
<i>Key Performance Areas</i>	<i>80</i>

<b><i>Core Principles of RRA/PRA/PEM</i></b>	<b>81</b>
<b><i>Systems</i></b>	<b>81</b>
<b><i>Exploratory and highly iterative</i></b>	<b>81</b>
<b><i>Rapid and progressive learning</i></b>	<b>81</b>
<b><i>Highly Participative</i></b>	<b>81</b>
<b><i>Interdisciplinary approach and team work</i></b>	<b>81</b>
<b><i>Flexibility and use of conscious judgement</i></b>	<b>82</b>
<b><i>Cost effectiveness: fairly-quick-and-fairly-clean</i></b>	<b>82</b>
<b><i>Methodology</i></b>	<b>83</b>
<b><i>Main features</i></b>	<b>83</b>
<b><i>Tool-box</i></b>	<b>83</b>
<b><i>Activating the RRA/PRA/PEM process</i></b>	<b>85</b>
<b><i>Data</i></b>	<b>86</b>
<b><i>Sequence development</i></b>	<b>87</b>
<b><i>Application of RRA//PRA/PEM</i></b>	<b>88</b>
<b><i>Analysis and Appraisal</i></b>	<b>89</b>
<b><i>Plan of Action</i></b>	<b>89</b>

<b>Annex 8: Training and extension</b>	<b>104</b>
<i>Introduction</i>	<i>104</i>
<i>Objectives</i>	<i>105</i>
<i>The Training Programme:</i>	<i>105</i>
<i>Institutional Support</i>	<i>106</i>
<i>Institutional Structure</i>	<i>106</i>
<i>Support Functions</i>	<i>107</i>
<i>Coordination</i>	<i>109</i>
<i>Training Plan,</i>	<i>109</i>
<i>Staff Training</i>	<i>111</i>
<i>Technical Staff Training</i>	<i>111</i>
<i>Extension Staff Training</i>	<i>112</i>
<i>Farmers Training</i>	<i>114</i>
<i>Participatory Approach</i>	<i>116</i>
<i>Farmers Training Schedule.</i>	<i>116</i>
<i>Farmers Training Schedule</i>	<i>117</i>
<i>Monitoring and Evaluation</i>	<i>117</i>
<i>Reporting</i>	<i>117</i>
<i>Technical Backstopping</i>	<i>118</i>
<i>National Workshop</i>	<i>118</i>



<b>Annex 9: Financing Irrigation Development with Special Reference to Sub-Saharan Africa</b>	<b>119</b>
<i>Background: Investments in Irrigation in LDCs</i>	<i>119</i>
<i>Irrigation and FAO's Programme to Increase Food Production</i>	<i>121</i>
<i>Towards Farmer-financed, Farmer-managed Irrigation</i>	<i>121</i>
<i>Main Cost Categories in Irrigation Investments</i>	<i>124</i>
<i>Assessing the Viability of Investment</i>	<i>125</i>
<i>Methods of Financing Direct Irrigation Costs</i>	<i>127</i>
<i>Financial Services for Small-scale Irrigators</i>	<i>129</i>
<i>Informal Savings Groups and Linkage Schemes</i>	<i>130</i>
<i>Cooperative Savings and Credit Arrangements</i>	<i>131</i>
<i>NGOs and Irrigation Finance</i>	<i>132</i>
<i>Commercial Banking Sector</i>	<i>134</i>
<i>Credit to Irrigation Schemes</i>	<i>135</i>
<i>Project-Managed Credit Schemes</i>	<i>136</i>
<i>Moneylenders and Traders</i>	<i>136</i>
<i>Conclusions and Recommendations</i>	<i>137</i>
<i>Bibliography</i>	<i>139</i>

<b>Annex 10: Approach to economic analysis of water management and irrigation development under SPFP</b>	<b>140</b>
<i>Scope of Economic Analysis</i>	141
<i>Valuation Perspectives</i>	141
<i>“with” Versus “without” Comparisons</i>	142
<i>Time Horizon</i>	142
<i>Valuing Benefits and Costs</i>	142
<i>Decision Criteria</i>	144
<i>Comparing Programmes</i>	145
<i><u>Format for Economic Analysis</u></i>	<u>146</u>
<i>Programme Environment</i>	146
<i>Farm Model Analysis</i>	146
<i><u>References and Further Detailed Reading</u></i>	<u>148</u>
<b>Annex 11: Monitoring and evaluation</b>	<b>149</b>
<i><u>Introduction</u></i>	<u>149</u>
<i><u>A Revision of the Terminology</u></i>	<u>149</u>
<i><u>Conditions for Successful Monitoring and Evaluation</u></i>	<u>150</u>
<i><u>Defining the M&amp;E Components</u></i>	<u>151</u>

<b><i>M&amp;E of the Preparation Phase</i></b>	<b>152</b>
<b><i>Monitoring of the implementation of the preparation phase</i></b>	<b>153</b>
<i>Human resources allocated:</i>	153
<i>Financial costs:</i>	153
<i>Time control:</i>	153
<b><i>M&amp;E in the Demonstration Phase</i></b>	<b>153</b>
<b><i>M&amp;E in the Expansion Phase</i></b>	<b>155</b>
<b>Appendix 1: Sample check list for the preparation phase</b>	<b>156</b>
<b><i>In relation to the objective No.1: “Definition of the framework for irrigation development”</i></b>	<b>156</b>
<b><i>Was the collection of available information about the irrigation sector?:</i></b>	<b>156</b>
<b><i>Was the assessment of the potential contribution of irrigated agriculture to food security carried out?</i></b>	<b>156</b>
<b><i>Are government policies in the water sector satisfactory for the development of the irrigation component?</i></b>	<b>156</b>
<b><i>The rate of expansion of irrigation development in the last 3 years was:</i></b>	<b>157</b>
<b><i>Indicate level of investment by External Support Agencies (ESAs) in irrigated agriculture and main donor countries</i></b>	<b>157</b>
<b><i>How do you evaluate the role of the private sector in the development of irrigation.</i></b>	<b>157</b>
<b><i>The report covering the above aspects is :</i></b>	<b>157</b>

<b><i>In relation to Objective No. 2: “Development of the institutional framework for implementation”</i></b>	<b>157</b>
<b><i>Has the national team been formally established and responsibilities for implementation identified?</i></b>	<b>157</b>
<b><i>Has the government formally committed to carry out the demonstration phase?</i></b>	<b>158</b>
<b><i>Were the national consultants identified?:</i></b>	<b>158</b>
<b><i>Will the national team require external technical assistance?</i></b>	<b>158</b>
<b><i>In relation to Objective No. 3: “Formulation of the Demonstration/Pilot phase”</i></b>	<b>158</b>
<b><i>Were the locations for the pilot programmes identify?</i></b>	<b>158</b>
<b><i>Were farmers informed and their potential interest in participate assessed?</i></b>	<b>158</b>
<b><i>Were the technological options to be demonstrated identified?</i></b>	<b>159</b>
<b><i>Was the Plan of Work for the demonstration phase completed for the envisaged period (3/4 years)</i></b>	<b>159</b>
<b>Appendix 2: Outline for the description of the present state of the pilot demonstration area</b>	<b>160</b>
<b><i>Geographical description of the area</i></b>	<b>160</b>
<b><i>Meteorological characterization</i></b>	<b>160</b>
<b><i>Soils description</i></b>	<b>160</b>
<b><i>Population</i></b>	<b>160</b>
<b><i>Crop production</i></b>	<b>161</b>
<b><i>Marketing and Prices</i></b>	<b>161</b>
<b><i>Irrigation infrastructure and technology</i></b>	<b>161</b>

<i>Land ownership</i>	161
<i>Institutional set up</i>	162
<i>Farmers organizations</i>	162
<i>Farmers income and welfare</i>	162

### **Appendix 3: Proposed monitoring system for the demonstration phase** 163

#### *In relation to Objective No. 1: To intensify and increase agricultural production on irrigated land* 163

*1st Indicator: Increase over average production* 163

*2nd Indicator: Cropping intensity* 164

*3rd Indicator: Increase in Planted area* 164

#### *In relation to Objective No. 2: To improve the performance of irrigation systems* 164

*4th Indicator: Overall irrigation efficiency* 164

*5th Indicator: Operation and Maintenance costs* 165

#### *In relation to Objective No.3: Adoption of Irrigation technologies* 166

*6th Indicator: Percentage of farmers that adopted the irrigation technology.* 166

*7th Indicator: Water use at farm level* 166

*8th Indicator: Farm irrigation efficiency* 167

<b><i>In relation to Objective No.4: To improve capacity of staff and local community for self-management</i></b>	<b>168</b>
<hr/>	
<b><i>9th Indicator: Training activities carried out</i></b>	<b>168</b>
<b><i>10th Indicator: Self management</i></b>	<b>168</b>
<i>Frequency</i>	168
<i>Ranking systems</i>	169

# Guidelines for water management and irrigation development

## ***PHILOSOPHY AND OBJECTIVES OF THE SPECIAL PROGRAMME***

- 1 The main objective of the Special Programme is to help LIFDCs improve their food security through increased food production and productivity as well as through stability in year-to-year production, on an economically and environmentally sustainable basis. Its goals are to maximize national food self-reliance, increase employment and income creating opportunities, and reduce the risk of disruptive variations in food supply. It addresses the problem of access to food mainly through the benefits obtained by participating households and the stimulus provided by increased production to the local and national economies.
- 2 The Programme aims at achieving sustainable increase in food production and productivity in LIFDCs through dissemination of existing and proven agricultural technology. It uses on-farm and small-scale demonstrations as an entry point for identifying the actions necessary to remove constraints, and thus creates a socio-economic environment conducive to the success and widespread adoption of improved production technologies. It follows a participatory and integrated approach in order to enhance sustainability and equity.
- 3 In each country, the Programme follows a phased approach. It starts with the Formulation of a National Programme through a participatory process of identification of staple foods, areas and improved technologies which would be the focus of Programme activities. A national Task Force acts as a bridge between FAO, government, farmers, other private sector agents and external partners in developing and implementing the details of the Special Programme activities in the context of the specific country situation.
- 4 Programme Implementation commences with a Pilot Phase which is an action-oriented, participatory process of consultation, problem identification and planning. The Pilot Phase features: on-farm demonstrations of improved, sustainable farming and water management technologies and practices; assessment of the potential for low-cost irrigation development; and analysis of constraints and opportunities at both local and national levels.

The demonstrations serve as a vehicle for initiating a process of continuing dialogue between farmers, private sector agents and government officials on the:

- potential benefits of the improved technologies and agricultural practices being demonstrated;
- constraints to their more widespread adoption; and
- action needed to overcome these constraints.

A successful Pilot Phase is followed by a wide-ranging Expansion Phase covering technical solutions, policy measures, investments and capacity-building programmes which will address problems impeding sustained increases in food production. A National Plan of Action for the Expansion Phase is formulated and the mobilization of resources necessary to implement the Plan of Action is initiated during the Pilot Phase.

- 5 The Special Programme for Food Security (SPFS) combines a number of features, the synergy of which is critical to its implementation and success. These features which are described in the main document (SPFS/DOC/4): Rationale, Objectives and approach and include:

- focus on high potential areas
- use of demonstrations as the point of entry
- promotion of water development and irrigation
- conservation of the natural resource base
- participatory approach in planning, implementation and constraint analysis
- integration of policy measures, capacity building and investment to remove constraints
- national ownership and partnership philosophy

The function of FAO is to mobilize experience and expertise and to act as a catalyst. FAO may provide seed money but is not the main funding agency.

## ***PRINCIPLES OF THE WATER DEVELOPMENT COMPONENT***

---

- 6 The water development component of the SPFS, more specifically addressed in these guidelines, recognizes the following features:
- water development is essential for food security
  - focus on low-cost solutions and development models which stimulate self-reliance and management responsibility at local level
  - economic viability, internal resource mobilization and private sector involvement



- holistic approach addressing constraints at technical, institutional and economic levels
- 7 Water development and irrigation are essential to increase food security and to reduce the variability of food production in most food deficit countries. It is said that most of the production increase required to feed the world population in the next 30 years, has to come from irrigated agriculture. Three critical preconditions are required to bring this about and to close the threatened gap between food production and consumption: investment in water development, good government policies, and an educated labour force with high quality technical support.
- 8 These three conditions are linked. Water shortage is becoming a critical constraint in many countries. Water resources, which until quite recently were considered cheap and plentiful, are now fully recognized to be scarce and valuable. In the first place, rainfall must be better managed and used more efficiently where it falls through on site moisture conservation, because higher productivity of rainfed agriculture is urgently needed. However, extreme seasonal variations and erratic dry periods represent high risks for farmers even in humid areas and make investment in expensive fertilizer and other agricultural inputs often unattractive. In these cases a wide range of water management techniques, including full-scale irrigation, are required to unleash the potential of modern agronomy.
- 9 Good government, including transparent and enforceable property laws, the maintenance of local and regional security, as well as sound management of the macro-economy, is necessary to promote agricultural investment and its profitability. Water resources development requires a range of production inputs and profitable markets. Governments can create or ruin the enabling environment. Productive agriculture also requires a wide range of technical skills, including water management skills and specialist support, either in the public or the private domain.
- 10 Irrigated agriculture can be remarkably productive and financially rewarding if these three preconditions exist. Yield levels of up to six tons of rice per ha per crop are now being regularly obtained in African irrigation schemes which only a few years ago were close to collapse. Constraining factors such as price distortions, shortage of energy and agricultural inputs, weak transportation system and limited access to markets are being gradually removed. It is time to launch a second generation of irrigation development which is more responsive to the needs and expectations of the local population and still physically and economically sustainable.

- 11 Statistics show that global irrigation expansion has declined in recent years and now stands at about 0.7 % per year as against 2.5 % in the 70s, however, with large regional variations. Among the reasons for the decline in irrigation expansion are the exhaustion of suitable sites in major irrigation countries in Asia and the increasing costs of new developments. In Africa irrigation development has been, for a variety of reasons, very expensive. There is, however, scope for a substantial reduction of irrigation investment costs brought about by a readjustment of currencies, more reliance on the private sector, changes of the design concept with the government providing only the basic infrastructure, more competition among construction companies, and better and more professional project management. Recognizing these conditions the SPFS focuses initially on small-scale, low-cost irrigation development with intermediate, water saving technologies in decentralized schemes, without being dogmatic on the type of irrigation and of technology used.
- 12 It has now been established that small-scale irrigation developments which allow for more participation and decision-making of farmers are generally most successful. Whilst large schemes have economics of scale, the larger the scheme the more anonymous the decision making process, the higher the overhead and administration costs, and the greater the chances of conflicts between farmers and management.
- 13 While the SPFS favours a holistic approach and gives equal weight to physical, agronomic, institutional, economic and environmental aspects, economic criteria are probably decisive for the implementation of the expansion phase and the sustainability of irrigated agriculture. When applying criteria it should be kept in mind that irrigation projects generate intangible benefits such as reduced infant mortality and improved nutritional balance. They may also reduce pressure on surrounding marginal land and create employment through multiple linkages. Drought relief operations costs may cost much more than timely investment in water development. Therefore, in addition to standard economic criteria such as the net present value or the internal rate of return it is also important to assess, from a qualitative point of view, other development objectives.
- 14 The water management and irrigation development component follows a phased approach comprising of a preparation phase, demonstration phase and extension phase. The result of the preparation phase is a framework for irrigation development and a plan of action for the demonstration phase. The demonstration phase is designed to demonstrate, verify and adapt suitable technologies for improving water management in existing irrigation schemes and new approaches to irrigation development. The results of the demonstration phase will be used in the formulation of an irrigation expansion programme.

National workshops will be organized to promote ownership and involvement of all stakeholders, to fine-tune the programme, and to attract external support. Details of the immediate objectives and activities of the three phases are presented in the following chapters and in the related annexes.

## **PREPARATION PHASE**

---

15 The objectives of the preparation phase are threefold:

1. to define framework of irrigation development
2. to develop the institutional framework for implementation
3. to formulate the pilot/demonstration phase

Preconditions for starting the preparation phase are: evidence of a chronic food deficit problem, physical potential and need for irrigation development, and commitment of the government. The preparation phase is the joint effort of a national team and an FAO mission. The output or result of the preparation phase is a national plan comprising of a framework for irrigation development and a plan of action for the subsequent demonstration phase.

### **Definition of the framework for irrigation development (objective 1)**

16 Activities for the attainment of objective 1 include the following. The activities are not necessarily in sequential order:

- collection and review of available information on the irrigation sector
- assessment of potential contribution of irrigated agriculture to food security
- assessment of relevant government policies, priorities and programmes
- identification of recent trends in irrigation development
- analysis of the institutional framework
- assessment of the interest and current activities of external support agencies
- assessment of the capacity of the service sector in the country
- review of the performance of irrigated agriculture and identify main constraints at macro level
- writing of a report containing a framework for irrigation development

17 **Collection and review of all available information** on irrigation in the specific country is the first step in the process. A range of relevant studies such as agricultural sector reports, irrigation sub-sector studies,

river basin master plans, hydrological assessment reports, water policy documents, projects reports etc. exists in most countries. Many external support agencies have made substantial investment in these studies, which are nowadays readily available. A notable example are the hydrological assessment reports of the World Bank, which provide a wealth of information on water resources in African countries. The FAO library, the documentation center of the Investment Center (TCI) and the AQUASTAT database are also prime sources of information.

- 18 **National agricultural statistics are analyzed** to assess potential contribution of irrigated agriculture to food security. The relative percentage of irrigated and rainfed agriculture in the production of staple and specialized export crops will be determined. Prevailing market prices, import policy and production costs influence the economic feasibility of producing staple crops under irrigation. In many cases the analysis will show that irrigated agriculture must attain high yield levels for growing food crops, or must be restricted to specialized crops for economic feasibility. Variations of rainfed production due to climatic variability should also be analyzed and the potential effect of irrigation on reducing these variations should be assessed.
- 19 **Government policies and priorities** determine and in many cases seriously limit the scope for private irrigation development. Policy documents related to water and land rights, allocation of water to the sector, subsidies for investment in irrigation and pricing principles must be analyzed. The review of current development budgets reveals important information on sectorial priorities. Many countries have already formulated national irrigation development programmes which in most cases redefine the functions of government agencies and contain elements which promote decentralization and self-management by user groups and increased reliance on the private sector.
- 20 **Analysis of recent trends in irrigation development** such as the rate of expansion, the technology used, preferred types of irrigation, reveals important information. Equally important is the analysis of the performance of the irrigation sector in recent years. Trends in the level of production and the cropping pattern should be analyzed. These information assist in the preliminary identification of major constraints for irrigation development at macro level. A more complete constraint analysis will be required during the demonstration phase.
- 21 Another important aspect to be analyzed at this stage are the **interests and current activities of major ESAs**. Many of these agencies have explicit strategies for irrigation development or support major programmes in the country. The SPFS should be linked wherever possible to these activities, without however compromising the specific character of the programme. Local representatives of the agencies

should be kept informed and involved as much as practical. Roundtable meetings and special presentations are suitable means to stimulate their interest. Establishing contacts with representatives of ESA's and obtaining information on the respective cycle of project identification, appraisal and decision making is important in order to secure financing for the demonstration and expansion phase.

- 22 The presence of a vigorous private sector either for direct investment in irrigated agriculture or for the supply of irrigation equipment, spare parts, agricultural inputs is essential for irrigation development. It is thus important that even in the preparation phase a rough **assessment of the private sector** is done which covers suppliers of irrigation equipment, repair facilities, availability of private consultants and engineers for irrigation design and supervision of construction, and of local construction companies. Equally important is an overview over sources of supply of agricultural inputs, marketing of different crops, processing facilities, and means of transport. These information will strongly influence the direction of irrigation development and the type of demonstrations proposed.
- 23 Some of the analytical work of the preparation phase can be done at the FAO headquarters, resulting in a desk study which serves as a basis for discussion with the national team and an FAO mission. The study will be updated and amended in the course of the process. National consultants will provide further details or will be contracted to analyze in more detail specific aspects. In other cases the national team might take the initiative and produce a framework for irrigation development which will be reviewed by FAO either in the Regional Office or Headquarters.

### *Development of the institutional framework for implementation (objective 2)*

- 24 Activities for the attainment of objective 2 include the following:
  - creating or strengthening of the national team and linkage with on-going operations, if any;
  - analysis of the institutional framework and assignment of responsibilities for the implementation of the pilot programme;
  - identification of national consultants, local research institutions and NGOs, capable of implementing special tasks or providing backstopping during the course of the demonstration project;
  - verification of government commitment;
  - assessment of the technical and managerial capacity of the staff of the irrigation agency and leaders of the farming community and development of suitable training programmes;



- integration of human resources development measures and technical assistance in the plan of action.
- 25 Successful irrigation development requires simultaneous introduction of suitable agronomic packages and improved irrigation management. Hence, it is most desirable that one and the same national team for SPFS should be responsible for the on-going agronomic demonstrations and for the irrigation demonstrations. Split responsibility for agriculture and water development in the government often represents an obstacle to coordinated action preventing an integrated approach to irrigation development and introduction of improved agricultural practices. It is thus important that representatives of all concerned agencies are included in the national team (including adequate capacity for water development). Clear responsibilities should be assigned to the concerned agencies. Allocation of sufficient resources and high quality staff to the national team are the best indication of the commitment of government to the SPFS.
- 26 Involvement of FAO staff from HQ or Regional Offices for standard technical backstopping must be limited because of cost considerations. Typical technical assistance components such as design, implementation and training should be arranged through suitable TCDC arrangements and use of retired experts. National consultants should be used wherever possible for special task such as analysis statistical data, planning and design, training or monitoring. Some international consultants will be required to insert the necessary innovations and for quality control. It is advisable to conclude umbrella or retainer agreements with individual consultants or qualified institutions to provide specific services over a range of time. Under these agreements consultants would be available at short notice without the need of concluding a separate contract for each assignment. Retired experts are particularly useful in this context because of their flexibility. FAO technical staff should be involved, together with national consultants in programme design, monitoring and evaluation.
- 27 Training of professional staff of government agencies involved in the programme and (participatory training) of farmers and in particular their representatives is an important task which must be implemented parallel to the demonstrations in order to increase the capacity of farmers for decision making, self management, resource mobilization and conflict resolution. Relevant training programmes need to be developed at an early stage and should be included in the plan of action.

### **Formulation of the demonstration/pilot phase (objective 3)**

- 28 Activities for the attainment of objective 3 include the following. The activities are not necessarily in sequential order nor is it required to complete the whole list in order to achieve the objective:
- develop hypothesis on what should be demonstrated, taking into account: trends in irrigation development; past performance of irrigation; major constraints and natural resources endowment;
  - identify suitable regions and, if possible, locations for pilot programmes;
  - confirm through field visits, present farmers' practices, initiatives and interest in irrigation development;
  - identify most promising technological options suitable to prevailing farming systems;
  - propose appropriate approaches and methodologies to introduce suitable technological options in farmers' fields;
  - formulate pilot/demonstration phase with schedule of activities and cost estimate over 3 to 4 years period.
- 29 The analysis of trends in irrigation development, possible contribution to food security, past performance of the sector, resources endowment and major constraints as outlined above leads to the **development of orientations for future irrigation development**. At this stage a consensus should emerge in the national team on the benefits expected from irrigation development. These could include:
- unlocking of untapped high potential agricultural resources;
  - promoting technical transformation in agriculture, including efficiency of production;
  - creating entrepreneurial and job opportunities for farmers and the service sector;
  - increased and more stable production, generating various linkages and multipliers in the economy and stimulating income and employment e.g. agro-industry, processing etc.;
  - providing a lead sector in the rural development process;
  - improving food security and nutritional balance at village and household levels through garden type irrigation farming.
- 30 **Identification of target regions and sites** will be done in a multistage process. The analytical studies should have already resulted in the identification of regions with potential for irrigation development. Additional criteria to be applied in the selection process include:
- sites should be typical of the regions which have potential for irrigation expansion;
  - accessibility to land and water, appropriate climatic conditions, existence of basic infrastructure and suitable locality;

- actual demand for irrigation by communities and individuals, market orientation;
  - existing local supportive institutional capacity e.g. active farmers association, extension service and provincial irrigation agency;
  - nature and proximity of markets either end-consumers or agro-industries;
  - favourable socio-economic climate.
- 31 Brief field visits to the target region are required at this stage in order to **ascertain and verify information** from written documents. These visits should also be used to identify potential sites for demonstrations, to establish first contacts to farmer groups and ascertain their interest. The above criteria for selection should be used as a checklist. It is important that sites selected for demonstrations be typical for the area. Ideally a selected demonstration site would have already some irrigation which could be improved and upgraded while also offering scope for irrigation extension.
- 32 Selection of sites and technology are interrelated. Selection of a site determines to a large extent already the orientation of development and the **range of feasible technological options**. Selection of sites and technologies is thus an iterative process. The difficulty is that contacts to farmers groups and officials need to be established without raising undue expectations and creating commitments at this stage. Criteria for the selection of technological options include:
- low and medium cost development options, taking into account the specific economic conditions of the country;
  - Irrigation technology. Preference is given to techniques which increase water use efficiency or reduce operational costs;
  - Support of service sector. Preference is given to technologies which can be supported by the local service sector or which have the potential of being supported;
  - Economic advantage. Preference is given to technologies which have a clear economic advantages for the farmers through higher yields, improved quality and water saving. Pay-back period should be in the order of 3 years;
  - Social preference. The strategy is to build on what already exists or what is being tried by progressive farmers, with potential for improvement.
- 33 A **selection of technological options**, conditions of applicability and operational characteristics are presented in Annex 1 to 3, to be used as a guideline. Options include: techniques for increasing water use efficiency at farm level, water harvesting, wetland development, lift irrigation through manual pumps or motorized pumps, river diversions, development of shallow aquifers, restructuring of large schemes etc.



The final selection of technology should be done by farmers who should be fully aware of the implications in terms of investment, operation and maintenance. Organization of farmers participation will be discussed in more detail in subsequent chapters and in Annex 7. Participation in decision making, resource mobilization and labour supply for construction work are essential for sustainability and ownership.

- 34 **Investment cost** should be kept as low as possible during the demonstration phase. At this stage it is not important to develop large areas but to demonstrate the potential of better technologies. Investment should be covered as much as possible from local resources but some external support will be required to cover the risk of demonstrations and to provide incentives for innovations. Cost recovery is not the prime objective during the demonstration phase but beneficiaries should participate in the investment through provision of manual labour and material if appropriate. In some cases it might be a stated objective of the demonstrations to test the viability of revolving funds for the replacement of mechanical material or further expansion.
- 35 The **concept for demonstrations** as it emerges at this stage should clearly define: what should be demonstrated; why should there be a demonstration; what are expected results, what is the methodology used to introduce improved technology or better practices in farmers' fields. These information will be used in the formulation of a plan of action for the demonstration phase over a period of 3 to 4 years. The plan of action will include a cost estimate of the demonstration phase and clear description of the tasks to different partners.

## ***DEMONSTRATION PHASE***

---

### ***Principles and Process***

- 36 During the preparation phase the strategic orientation of irrigation development have emerged and a region with scope for irrigation expansion has been selected. Also a tentative site for demonstrations may be already be identified. The first step in the demonstration phase is to verify the selection. Using the criteria outlined in para 30, a more detailed analysis will be done to ascertain the suitability of the tentative sites. The sites must be representative for the area and have scope for irrigation expansion.
- 37 The most important point is to assess the motivation of farmers to work together in irrigation development. FAO recognizes that any technological innovation must be adopted by the users to be sustainable. However, not everything can be left to the discretion of

farmers who might lack the insight and the knowledge of the potential of new technologies. The best way to overcome the problem is through indirect methods of intervention. Early in the process a RRA or PEM (Rapid Rural Appraisal or Participatory Evaluation Method) should be conducted by the National Team with the objective to assess jointly with local farmers and irrigation officials the current irrigation practices, the main problems and the potential for improvement at selected sites. Annex 7 presents details of the methodology. The process will result in a consensus on the objectives and orientations of the demonstrations.

- 38 Before any demonstration is started it is essential that an agreement on the selected solution and on the required material contributions of the different partners has been reached. The features of any technological options should be clearly explained to farmers including benefits, operational characteristic, maintenance requirements, operation and investment costs. Every effort should be made to reach a consensus decision, with the farmers having the deciding vote if they accept the consequences.
- 39 Contributions of farmers could be in kind through the provision of labour and/or material. Indirect assistance (credit, technical expertise) will be offered to help solving problems that the farmers are unable to solve on their own, but without compromising their responsibility. Government services should abstain from providing direct support, i.e. they should whenever possible not directly implement works. It is important to kept track of the supply of inputs of all kinds in order to have a basis for the calculation of the total costs of the project.
- 40 It follows from the above that the decision on the choice of technology will be done essentially by the farmers, while the technical design of structures, distribution system or small dams requires special expertise. Nothing undermines the confidence of farmers in irrigation more than a failed diversion structure after the first rains. It is therefore important that adequate safety margins are incorporated into the design and that the risk of failure is minimized. The design should be done, wherever possible, by private local engineers with backstopping by TCDC experts and occasionally by HQ staff. Government services too, could provide the design as a indirect contribution to the users. The design process has to be transparent and the farmers should formally accept the design, before it is implemented. Several FAO Irrigation and Drainage Paper and Training Manuals provide practical information on design and maintenance.
- 41 Construction should be done as much as possible with the direct participation of farmers and local labour. Active involvement in construction is probably the single most important factor in ownership. Adequate technical supervision and respect of construction norms is

required, especially for work which is critically for the safety and performance of the structure. Food-for-work may be used with care, because it could create the risk that the work is not considered the property of the users but that of an outside agency which pays for the construction. There may be cases where food-for-work is essential because of largely de-capitalized rural households. Works that can not be done in a cost effective manner or acceptable quality by manual labour should be contracted to private enterprises. Ideally it would be the farmer's associations who would let the contract, supported with technical and legal assistance of the project.

- 42 Specification of equipment and supplies is part of the design process. Farmers should be fully involved in decision making. Pros and cons of various types of equipment such as problems of maintenance, need for spare parts and consumable should be explained. Equipment should preferably be purchased from local sources of supply. Adequate assurance should be obtained that spare parts are available or could be ordered at short notice. Non-conventional sources of supply should be investigated. Irrigation material is now available from India, Brazil, Rumania and South Africa at a fraction of the traditional costs. However, quality control is not always assured and supply of spares might be a problem. Suppliers should be encouraged to establish agents in the country. Contracts for the supply of equipment should preferably be passed by the farmers.
- 43 Financing of irrigation development beyond the demonstration phase has to come essentially from local resources. External finance will never be sufficient to provide the bulk of the investment. Annex 9 presents some reflections on how to mobilize local resources. It is essential that already early in the demonstration phase efforts are made to mobilize resources for any expansion.
- 44 Irrigation development should be viewed within an integrated economic context. This will avoid the introduction of "islands of development in a sea of poverty" where antagonism is generated and benefit to a wider region is restricted. It should always be remembered that the economic benefit accruing to the society and to the individual farmer from such projects should clearly surpass the economic costs. Without meeting this single most important criterion irrigation development will not be sustainable and not contribute to food security and economic development. Economic and financial analysis, especially at farm level must be part of the demonstration phase. Annex 10 provides a guide on the methodology.
- 45 Monitoring and analysis of constraints have been describe in another guide but irrigation development requires a somewhat different approach. No irrigation demonstration would be complete without

continuous monitoring and final evaluation. Irrigation projects can be divided into four interrelated levels for monitoring and evaluation purposes. The first covers planning, design and construction of physical facilities. The second incorporates operation and maintenance. The third focuses on agricultural production and the fourth deals with the development process and the achievements of the socio-economic objectives. Annex 11 presents an outline of a monitoring system.

46 The objectives of the demonstration phase will vary from site to site, depending on the results of the RRA and on the strategic orientation of irrigation development. However, in most cases the demonstration phase will focus on one or more of the following objectives:

1. increase of agricultural production on irrigated land through appropriate agronomic packages and improved irrigation scheduling;
2. improvement of performance of existing schemes through improved on-farm irrigation technology;
3. improvement of performance of existing schemes through capacity building of staff and local community and the development of the institutional base for self-management;
4. demonstration and development of suitable approaches for irrigation expansion.

Solutions to address the identified problems will be developed, preferably by national consultants. External support will be provided as required to insert innovative thinking and outside experience. Key considerations for the different cases are presented in the following.

### *Increase of agricultural production on irrigated land*

47 Demonstrations of improved packages to increase agricultural production will be similar on irrigated and non-irrigated land. Agronomic packages will comprise improved fertilization, pest and weed control, improved varieties, and better timing of operations. These agronomic packages are described in another guide and are thus not repeated here. Moisture control, however, is basically different on irrigated and non-irrigated land. Whereas on rainfed land the emphasis is on moisture conservation and reduction of drought risk through staging and selection of drought resistant varieties, moisture control on irrigated land requires proper scheduling of irrigations.

48 Improved irrigation scheduling is thus an important element of the demonstration phase. The issue is especially important when the irrigation potential is already largely exhausted or when there is evidence of the increase of salinity. Farmers in most countries have little understanding of soil-water-plant interrelationship. They like to see

water on the ground and almost always tend to over-irrigate, if they have access to water. The results are wastage of precious water, increase of water logging and salinity, and depression of yield.

- 49 Improvements in irrigation scheduling require reliable and flexible water supply systems. Private wells or unrestricted access to surface water sources are ideal. In large canal system water is usually supplied on rotation with little concern for crop water requirements. Changes in the mode of operation from supply to demand driven operation, but also provision of interim and on-farm storage, could vastly improve the scope for improved scheduling. The most important precondition however is reliability in water supply. If the water supply is unreliable any farmer will over-water his field on the hope that the extra water applied will bridge him over to time he may get water again.
- 50 There are many methods to measure the moisture content of the soil and to schedule irrigation, ranging from simple penetration sticks to tensiometers and more sophisticated computerized methods of water balancing (CROPWAT). Further information on the subject is presented in Annex 6. It may be noted that the proceedings of the FAO/ICID Consultation on Irrigation Scheduling, Rome 1995, contain the most up-to-date information on the subject.
- 51 Rational irrigation scheduling can also optimize agricultural production under conditions of drought. Depending on the specific water demand of the crop, the length of the growing cycle, yield response and the value of the crop decisions have to be made which crop to irrigate how much in order to minimize crop losses. User friendly computer models are nowadays available (Annex 6).

### ***Improvement of performance of existing schemes through improved on-farm irrigation technology***

- 52 Improving the performance of existing irrigation schemes will be in most cases the point of entry for irrigation development. Unsuitable or badly designed and maintained on-farm irrigation technology is often the cause for low performance. If water distribution is not reasonable uniform, water use efficiency will be very low and improved irrigation scheduling will be useless. Some irrigation methods might cause soil erosion on sloping land or might not be compatible with the water supply system.
- 53 When selecting the most suitable irrigation method it is important not only to consider the technical suitability for prevailing crop-soil-water conditions but also the ability of farmers to use and maintain the equipment. Presence of local manufactures are a precondition for the use of mechanical irrigation equipment.



- 54 Technical considerations include soil type (infiltration rate and water holding capacity), crops, climate, costs (capital and operating), water supply (quantity, quality), labour requirements (number and skills). It is also important to consider the method of water supply in relation to the method of irrigation. A discussion of the key issues which are important for selection is given in Annex 2.
- 55 The Annex 2 is not a design handbook. It needs to be stressed that design of any on-farm irrigation system, even of small scale, requires professional knowledge and experience in similar work. Any construction work or installation of mechanical equipment must be supervised by qualified technicians. The risk is great that faulty design, selection of unsuitable or defective equipment will ruin the effect of the demonstrations and undermine the confidence of farmers.
- 56 It is conventional wisdom that the cost of mechanical or localized irrigation equipment are unacceptably high for smallholders. This must no longer be the case. Experience in India and China has shown that suitable irrigation material can be produced by local manufacturers at a fraction of the costs of imported equipment, if there is sufficient local demand. Intermediate technological solutions, based on locally available material and manufacturing skills, are sometimes available. A manual on low-cost, localized irrigation method is being prepared by FAO and will be available shortly.

### ***Demonstration and development of suitable technologies for irrigation expansion***

- 57 Development of new irrigation schemes will be the exception rather than the rule in the demonstration phase. However, farmers might want to expand their irrigated area once they have seen the effects of improved irrigation scheduling and on-farm irrigation technology. In other cases there might be scope to test improved construction methods such as low-cost drilling methods for tubewells or construction methods for small dams. The SPFS should be able to respond to these opportunities which will provide valuable information for the expansion phase.
- 58 Development of new irrigation or expansion of existing schemes requires adequate knowledge of land and water resources. Technical studies on soil suitability and water availability may be needed. These studies require specialized know-how. In order to reduce the scope for these studies it is advisable to select sites with ample and secured water supply and suitable soils as demonstrated by successful irrigation in the vicinity. However, even in areas with apparently homogenous soil some samples should be analyzed to ascertain the physical and chemical

properties of the soil. Annexes 4 and 5 contain information on the procedure and on issues to be considered.

- 59 Selection of technological options for water acquisition and conveyance requires professional expertise. The characteristics of the site will largely determine the range of options. Any feasible option should be developed to a point which allows decision making by farmers and provincial irrigation staff. This means that the benefits, the costs, operational characteristics and maintenance requirements should be known with some precision. Annex 2 provides an overview over the existing options for water captation and conveyance.
- 60 Expansion of existing schemes or development of new schemes is an opportunity to develop and test innovative methods of resource mobilization and construction. Experience in Guinea and elsewhere shows that the costs of construction can be substantially reduced if the farmer groups are made responsible for contract management. Faced with the real costs of construction they readily contribute their own labour force and supervise paid construction work closely. However, enthusiasm cannot replace professional knowledge in all circumstances and quality of construction remains essential.

### ***Improvement of performance of existing schemes through capacity building of staff and local community and the development of the institutional base for self-management***

- 61 A weak institutional structure is in many cases the reason for neglect, deterioration and poor performance of irrigation. Irrigation requires in almost all cases group action, respect of rules and regulations, mutual trust and leadership. Most Asian countries have long traditions in irrigation and have developed the corresponding social culture. Irrigation is relatively new in Africa and relevant experience may be lacking. However, Africans have a tradition of group activities and management of common property which could be mobilized for irrigation development.
- 62 Capacity building and institutional development is more successful if done in conjunction with physical improvements. Capacity building will always be required and should accompany the three cases described above. The difficulty is that farmers need to make decisions at a stage when their institutional structure and confidence is not adequately developed. It is very important that a group of trained irrigation extension workers is available to act as facilitators and catalysts. In most cases these persons have to be trained at the beginning of the programme, therefore, it may be required that the first part of the demonstration phase will focus exclusively on training of irrigation extension staff.

- 63 FAO has developed an approach to training of irrigation staff and farmers which has proved successful in Nepal and Laos. The method alternates training courses for staff and farmers. While the irrigation staff provide the training to farmers, they receive feedback and upgrading at regular intervals. During the process the irrigation staff acts as facilitators in any emerging situation which is related to irrigation development. The approach is based on “learning by doing” under close supervision. A brief description of the approach is presented in Annex 8.

## EXPANSION PHASE

---

- 64 The objective of the expansion phase is to develop realistic irrigation expansion programme in order to maximize contribution of irrigated agriculture to food security and to establish an economically viable irrigation sector. The expansion phase will most likely encompass most of the following activities:

- Review and evaluate results of demonstration;
- Review water availability taking into account internationally shared water resources and allocations to competing sector. River basin studies may be required;
- Evaluation of land capability for low cost irrigation development;
- Development of draft programmes to address major institutional constraints (land tenure, water rights, legal capacity of farmer groups, function of government agencies);
- Development of draft programme to establish effective support services (extension service, credit, marketing, transport, storage, input supply);
- Consultation with external donors;
- National workshop to discuss and amend draft strategy documents;
- Government adoption of an irrigation expansion plan;
- Mobilization of external donors support;
- Mobilization of internal resources;
- Implement of programmes.

Detailed guidelines for the planning and implementation of these activities will be developed as experience is accumulated and the SPFS progresses.



# ANNEX 1: Irrigation development model categories

In the context of Africa, five irrigation development models may be recognised.

- **Fully commercial venture**
- **Central or core unit scheme**
- **Settlement scheme**
- **Farmer support scheme**
- **Community support scheme**

The models are described below, in summary form, according to their character and objectives, and are analyzed briefly as to their probable advantages and limitations.

## ***FULLY COMMERCIAL VENTURE***

---

**Character:** Vary greatly in size, but are often large-scale (estate, group farm, etc), and run as a business in the form of a self-contained commercial unit. Can be individually owned and run, or operated by a corporation, co-operative etc. Professional managers are usually employed on a profit sharing basis.

**Objective:** Maximisation of profits through efficient utilisation of agricultural resources, technology, etc.

**Advantages:** Can be very efficient, depending on external interference and internal motivation and discipline. Economies of scale should increase profitability. Well run operations can be made available to extension services for demonstration purposes and research, etc.

**Drawbacks:** Minimal linkages to farmers outside the scheme. Limited value as a base for rural development, ie., can be an island in a development area. May compete unfairly with small scale farmers for limited markets.

**Comments:** Private sector should undertake these operations with venture capital taking full commercial risk. Of limited value within the strategy for developing agriculture. The most successful and capable farmers from other small scale developments may aspire to and graduate to such larger and intrinsically more demanding farming units.

Should infrastructure such as telephones or linking roads be required, Government should supply these through normal activities.

### ***CENTRAL OR CORE UNIT SCHEME***

---

**Character:** Primarily estate farming but incorporating peripheral settlements of smaller participating farming units. Settlement farmers depend for many inputs on the core unit.

**Objective:** Provision of a stable, commercially orientated farming environment with a high level of support and extension available, which will enable participant farmers to develop agricultural skills whilst operating viable units.

**Advantages:** Provision of in-house, readily available and relevant extension, and other services. Can provide expensive agro-industrial infrastructure, etc., where necessary. Increased possibility of vertical integration of production, thereby increasing returns to farmers and or the scheme. Can be a source of supply of well-trained farmers for other fully commercial schemes.

**Drawbacks:** Overall viability of such schemes by be compromised by conflicting interests between core and satellite units, reduced performance incentives and distortion of economic factors through the subsidising effect of the core unit. Freedom of choice and adaptability of core units can be hampered by the required support role of such schemes.

**Comment:** Ideally symbiotic but often parasitic in nature. Can take over role of Government agencies in the area, eg. extension services, where these are limited or inadequate. May evolve into a settlement type scheme where the core unit gradually disappears as it is subdivided into a number of smaller viable units.

### ***SETTLEMENT SCHEMES***

---

**Character:** Normally comprise small but potentially viable farming units, with varying degrees of security of tenure, consolidated as close-settlement units within a macro-scheme structure. Support service is provided by Government agencies or co-operatives. Project management in the initial development/consolidation phase is limited to support services and not production in its own right.

**Objective:** Establishment of entrepreneurs on usually small but viable individual farming units with cohesive macro structure, with adequate extension and support services provided.

Income generated to be sufficiently attractive so as to adequately compensate for commercial risks, and to encourage performance.

**Advantages:** Closely approaches 'real-life' situation, where buffering is minimal and rewards are performance-related. Selection of successful individuals is therefore accelerated.

**Drawbacks:** The absence of intensive support and training may result in inefficiencies leading to the failure of potentially successful farmers. Units can be too small, especially when gross margins are squeezed through changes in the market or rising input costs. Capital costs of infrastructure are often disproportionately high with small operating units. A portion of this may have to be imposed upon farmers in order to ensure project viability.

**Comment:** Selection of candidates can be a problem, as can the removal of unsuccessful farmers. Tenure is important and security of tenure is often directly related to a farmers' production efforts. Freedom to sell or buy land should be incorporated into the design of the scheme. Landowners may prefer to nominate a person to work the land, or hire a 'manager'. Some contractual arrangement should then be formally entered into.

Owing to the complex nature of irrigation farming and the shortage of trained farmers, phasing of the settlement may be necessary. The phasing must take cognisance of the availability and selection of farmers, their training and acquiring of practical experience.

Phasing may also accommodate the gradual transfer of responsibility and decision making to the farmer. Full risk taking may be delayed by an appropriate period, which would coincide with the training programme.

When irrigation involves a complete restructuring of the agricultural environment, a phasing-in period of several production seasons should be considered if annual crops are to be grown, and an even longer timespan in the case of perennial horticultural crops and dairy farming.

The phasing-in period should be limited to the shortest time possible within practical limitations. However, the danger of setting targets that are too high or of expecting too much too soon is real. It may be more appropriate to phase-in technology or production, from a "low" to a "high" level rather than to attempt to phase-in farmer per se.

During the phased implementation, a certain degree of management support will be necessary.

## **FARMER SUPPORT SCHEME**

---

**Character:** Frequently concerned with existing farmers of a particular region, where support services, extension etc is introduced as a comprehensive programme in order to upgrade agricultural performance. In other situations it can be the vehicle to initiate and sustain new irrigation projects. Farming units often vary in size, are sometimes widely scattered and may comprise diverse enterprises. Farmer support schemes are more supportive than prescriptive and the development impetus is sustained through active farmer participation. The initiative is left largely with the farming community. Irrigation may be the principal activity, or be of a supplementary nature. Farmer support programmes (FSP) can also include the upgrading of existing intensive irrigation or close settlement schemes.

**Objective:** The provision of comprehensive supporting services to promote and enhance farming endeavours and promote project development in a non-prescriptive manner.

**Advantages:** Provision of support to rural communities can revitalise an area. Inputs such as training, marketing services, finance facilities, research, etc., increases the potential viability and regional/national returns to this investment can be high. Private sector involvement is promoted, eg mechanisation contractors. The rate of development is in accordance with and appropriate to the requirements of the participants.

**Drawbacks:** Recurrent cost to Government can be high, depending on existing infrastructural and personnel resources. There is no guarantee that results will be concomitant with the inputs. In this regard, there is minimal leverage on individuals whose performance is not equivalent to the resources committed or expended, pro rata, in that area. Development impetus may be inadequate to justify initial investment required for large schemes.

**Comment:** Farmer support may be needed to upgrade irrigation schemes which have failed due to deficiencies in institutional or technical factors. In other cases, existing farmers with access to water rights may wish to increase their productivity and so gain meaningful entrance to commercial markets. Those who do not have access to sufficient agricultural land for commercial production may also qualify for farmer support on a group basis.

Support programmes need to ensure that production inputs; comprehensive mechanisation services catering for all aspects of land preparation, cultivation and transport; farmer credit; marketing; training; extension and research programmes; management support; subsidisation; user charges and water tariffs; etc., are delivered in an effective and efficient manner.

Off-farm infrastructure also warrants attention in a Support Programme, the off-farm infrastructure comprising those elements seldom paid for directly by the farmer, c.f. on-farm fixed improvements. These include feeder roads and bridges, certain boundary fences and road fences, conservation works and other services such as surveying, legal aspects, etc.

The Farmer Support Programme should, in addition, assist farmers in gaining access to commercial markets. Within an FSP project, co-operation between farmers will vary, but emphasis should always be on the individual as a decision maker.

Finally, planning must take cognisance of the complimentary nature of the component support factors of the programme in order to promote efficiency and optimum returns.

### ***COMMUNITY SUPPORT SCHEME***

---

**Comment:** Essentially a small-scale irrigation development (garden plots or allotments) based on villages or communities. Participants are largely women (part time farming is the norm) and the produce is household orientated. Often an extension of a regional Farmer Support Programme.

**Objectives:** The provision of a support programme specifically catering for small-scale subsistence requirements.

**Advantages:** Can stabilise food provision and provide limited income in village settlements, thus improving rural quality of life. Minimal inputs required to achieve good results.

**Drawbacks:** May divert scarce resources from commercially orientated ventures. May not be financially viable, and may require significant ongoing subsidies.

**Comment:** Such programmes are frequently undertaken in conjunction with other developments, eg. settlement schemes, core unit schemes, etc.

## ANNEX 2: Techniques for water supply and distribution

### *INTRODUCTION*

---

Developing irrigated agriculture can be a complex issue involving not just the technologies of irrigation but a wide variety of issues including soils, agriculture, economics, sociology and marketing. There are many examples of poor irrigation practice from which important lessons can be learnt for the future. There are also some very good examples which show what can be achieved with careful planning and design. The problems of successful irrigation development are many but the choice of technology can play a part in ensuring the success of irrigation. Annexes 2 and 3 set out the technical options available and the circumstances under which each might be appropriate.

### *SURFACE WATER RESOURCES*

---

#### *Direct abstraction from rivers*

Direct abstraction of irrigation water from natural rivers offers a relatively inexpensive supply of water in contrast to man-made reservoirs which require costly embankments and spillway arrangements. The main problem is to determine what the river discharge will be at some point in the future so that a match can be made with the maximum irrigation requirement and the downstream commitments for water. Thus, although this provides one of the cheapest surface water supplies it is unfortunately the least reliable.

Abstraction can either be by gravity or by pumping. A control structure may be needed on the river to maintain command levels at low flows. This type of control can be expensive to construct and maintain as the structure must be capable of passing the flood flows in the river. An alternative is to build some simple structure which will need replacing each year. This represents often an economically viable alternative but requires a good level of organization of the benefitting farmers.



## Storage reservoirs

Water storage is important when rivers flows are not available or run low, which is the time when irrigation water is most needed. The longer the dry period the larger the capacity of the reservoir to compensate for the dry spell. One of their advantage over direct abstraction is that the amount of water stored is known at the beginning of the cropping season and farmers can make sound judgements about the extent and intensity of their cropping.

Larger rivers with major dam storage offer a similar advantage in that the extent of the supply is known and releases from the dam can be controlled so that they match irrigation water demands along the river. However multipurpose dams have often operational rules which are the source of conflict among different users. This usually requires strong legislation and law enforcement to control and maintain flows, particularly for users who are far downstream.

**On stream** (or impounding) reservoirs. The site for the dam and the reservoir must be known as fully as possible in terms of the topography and geology. Sufficient hydrological information should also be available to be able to completely design the spillway works to deal with flood conditions. Factors to consider include:

- Characteristics of the dam site and catchment area e.g. water quality after storage, reservoir life, effective storage volumes, water abstraction works and reservoir operation;
- Availability of suitable construction materials for the construction of the body of the dam;
- Cost of the spillway which is independent of the irrigated area and dependent only on the hydrology of the river;
- Catchment protection against soil erosion in order to reduce reservoir sedimentation;
- The safety and well being of people and the environment adjacent to the reservoir.

**Off stream** storage can be much less expensive than on stream. Much smaller spillway capacity is needed and sedimentation can be avoided by suitably designed intake works. Storage located some distance from the river may need pumping stations, intake works and pipelines which will add to the cost.

**Health.** All reservoirs in the tropics are potential health hazards, in particular for the main diseases associated with irrigation, malaria and schistosomiasis. Engineering and operational precautions to reduce these problems will be needed. This may result in additional cost but this must be offset against the improvements in community health.

Few cost benefit analyses take into account the improved health of the community but this is no reason for omitting sensible engineering measures which ensure such improvements.

## **SPATE IRRIGATION**

---

Spate irrigation is a unique form of irrigation, predominantly found in arid and semi arid regions where use is made of occasional heavy floods of short duration. The floods (or spates) diverted from the wadis by control structures into the fields can provide one, exceptionally two, watering of 400 to 800 mm which is sufficient to sustain a deep rooting crop. Agricultural yields are generally low and may vary greatly from year to year depending on the size and frequency of the spates. Devastating floods can damage and frequently destroy irrigation structures and agricultural lands and yearly repair and maintenance are essential elements of the system. Spate water infiltrates into the bed of wadis and irrigated fields feeding the wadi aquifers which are subsequently tapped using wells for drinking water, stock watering as well as irrigation.

The most important constraint when planning for spate irrigation is usually the lack of sufficient data on spate hydrology to predict floods and sediment loads in the wadi and to design of the weirs and diversion works. Such works must cope with the sudden rise in spate discharge and the large concentration of sediment and be able to control the discharges into the offtaking canals and exclude sediment from them. Consideration will also need to be given to wadi characteristics, traditional water rights along the wadi, subsequent operation and maintenance procedures and the regulation of groundwater resources in the wadi.

The development of spate irrigation is thus a very specialised area and demands special expertise for its proper assessment.

## **WATER HARVESTING**

---

Water harvesting is usually practised in areas of low rainfall e.g. 100 to 200mm a year. Typical systems include:

**Micro catchments** - small catchments surrounding a tree or a small plot. Can be up to 30m long with a catchment to cropped area of 3:1. Water storage is in the soil profile.

**External catchments** - larger catchments 30 to 300m long used to channel water into a smaller cropped area. Overflow facilities are needed for excess water and land levelling may be needed to avoid uneven crop growth.



There are many other systems but the principles are similar. All methods require a thorough analysis of rainfall and runoff relationships of the area to establish the size of catchment required to meet the water requirements of the cropped area.

This is a low cost solution to increasing crop yield in low and erratic rainfall areas for trees, cereals such as sorghum, millet and maize. It is also used for rangeland and fodder crops. It is not suited to higher value crops which rely on the regular and reliable application of water for yield.

## **GROUND WATER**

---

### ***Shallow groundwater***

Shallow groundwater, 1 to 2m below ground, is a very useful supply of water for farms located away from a surface water supply. This source may be less reliable than surface water because there is no easy way of assessing whether there is enough water there to ensure adequate irrigation except through pumping experience. However, the farmer is saved the cost of an expensive canal or pipe system to bring water from a more distant surface source. Types of well used include:

- **hand dug wells** - simplest of wells dug up to a few metres in depth and may be lined with concrete pipes, bricks, or wood. Output is usually limited to 1 or 2 l/s with hand pumps;
- **hand dug horizontal galleries** dug into hillsides which intercept the groundwater and from which water flows out under gravity (qanats). Local experience in digging the underground galleries is almost a necessary condition for their implementation
- **well points** - small diameter tubes jetted into the ground to collect groundwater from a wider area to increase the available discharge. Output depends on the extent of the well field and the hydraulic characteristics of the aquifer
- **ranney wells** - infiltration galleries drilled or excavated horizontally from a caisson. Much greater yields depending on the extent of the galleries. (Up to 40l/s and more reported).

The choice depends on site conditions and the expertise and equipment available locally. Well depth depends on the depth to the groundwater and the well linings must be matched to the water bearing strata.

A thorough understanding of the recharge mechanism is essential for any substantial development of this source. An example of this is in NE Nigeria where small farmers depend on recharge of the shallow groundwater for extensive small scale irrigation along a seasonal river corridor. For many

years recharge was thought to occur during floods when the river overtopped its banks causing extensive flooding and infiltration. Detailed studies have now shown that recharge comes primarily from the river channel itself which means that recharge can take place any time there is water in the channel and not just in the flood season. This understanding is now completely changing the policy for the development of small scale irrigation adjacent to the river and has helped to determine the optimum potential for the development of the water source.

As yields from shallow groundwater are usually low this source is generally only suited to small farms. This is often in line with the popular development of small sustainable farms which can operate well with little or no government support. However, too many small farms can create large scale problems. The groundwater may be over-exploited and require farmers to change pumping to submersible units (this will involve a significant increase in cost). Regional licensing of groundwater abstraction may be needed to control and sustain abstraction.

The skills for small hand dug wells and small petrol driven centrifugal pumps are widely available in many areas and so are popular options for shallow groundwater exploitation. The more sophisticated wells produce higher discharges but will require more sophisticated pumping and construction technology.

### ***Deep Groundwater***

This may be water which has permeated through the ground from a surface source many kilometres away (rechargeable) or water which has been trapped by impermeable soils for many thousands of years (fossil water). The former is useful irrigation but the latter is irreplaceable and so it is highly questionable if this should be used for irrigation.

The development of deep groundwater is complex and requires knowledge of the storage and flow characteristics of the aquifer. Tubewells which may be 20 - 100m or more below ground level can be expensive to construct and require specialised drilling methods depending on the strata. Much reliance is placed on local knowledge for aquifer development together with more modern techniques. Tubewell development is fraught with difficulty and often unexpected conditions below ground level can make drilling an art as well as a science.

Tubewells will require submersible pumps and these should be considered as an integral part of the well design and construction. Issues to consider include:

- water storage costs are low but it is difficult to determine just how much water is available;
- over-exploitation of coastal aquifers may cause irreversible saline intrusion;
- water must be pumped and so farmers must rely on an external source of energy;
- maintenance of wells and pumping equipment require heavy investments and technical capabilities that are often beyond farmers organizations. Government support is often provided.

Farmers who rely on tubewells can experience many difficulties depending on the local circumstances. In Bangladesh, for example, several farmers share water from the same tubewell which may not be directly owned by the farmers. The well operator or owner may give preference to some farmers despite contract agreements and together with fuel shortages and pump breakdowns this usually means that some farmers do not get the water they need. This situation can be exacerbated by poor layout design around the well and excessive canal seepage which affects mainly those farmers furthest away from the well. Farmers in such circumstances are often unable to take advantage of high yielding varieties which can enhance their farm income.

## **CANALS AND PIPES**

---

The distribution system conveys water from the source of supply to the fields and may comprise pipes, open channels or a combination of both.

Channel distribution and surface irrigation is usually the least capital cost option when planning a new scheme. However, it will only be the best option if it works as planned. Field experience in many countries has shown that this combination is very difficult to manage properly. Canal systems are very slow to respond to changes in demand and because of this farmers are restricted in the timing and amount of water they can have which in turn puts restrictions on the crops they can grow. In contrast pipe systems are much easier to manage because they respond faster to changes in demand and they can be turned off when water is no longer needed. This is ideal for farmers who wish to choose their irrigation times and their cropping pattern to suit their needs rather than those of the irrigation system management.

A combination of canals and pipes for distribution has been used in Sri Lanka and Egypt to good effect. The main and secondary distribution was in canals but the tertiary distribution to farms was in pipes.

## **Open channels**

The most common method of water distribution for irrigation is with open channels. Although unlined canals are the most common the choice should be based on: economics of both capital and running costs, expected water seepage, and expectations for suitable maintenance. Lined canals do not just reduce seepage losses in highly permeable ground they can also reduce the need for maintenance later in the life of a scheme. Thus, capital investments made at the beginning of the scheme may reduce costs later. This is particularly important when it is known that maintenance is likely to be under-resourced.

Large water losses can easily occur in open channels. This may be seepage but it is more likely to be through mismanagement of the canal system. Therefore it is most important to ensure a suitable operation as this may save more water than lining of canals.

## **Pipelines**

Pipelines are essential for sprinkle and trickle irrigation but are often considered too expensive for surface irrigation when compared with canals. However, expensive is a relative word and when both capital and operating costs are considered low pressure concrete or plastic pipes can be an attractive option and are well suited to tertiary distribution. Low pressure pipes have several advantages:

- very low distribution losses - can be less than lined channels. It is much easier to close off the flow in a pipe than in an open channel and so avoid wastage
- reduced distribution losses means that a larger area of land can be irrigated whose returns may offset the additional capital cost of the pipes
- less land area is taken up by buried pipes again increasing the cropped area within the scheme. Channels can take up 0.5 to 2% of the command area.
- pipes can often be installed at lower cost than lined canals
- pipe systems can provide a more flexible, responsive and reliable system of supply
- because of the improved flexibility irrigation efficiency is likely to improve
- reduced contact with water has potential health benefits

## CANAL CONTROL SYSTEMS

---

Hydraulic control structures are used in canal systems to distribute water and to maintain canal command levels. The choice of structures should include the ease of management of the canal system as well as the hydraulic needs of the system. The main choice is between automatic control, flexible control and fixed control.

**Automatic control** normally involves the Neyrpic (French) gates which automatically control water levels and/or discharges in canals to pre-set values. These gates were used extensively in N. Africa to manage scarce water resources require very little skill from both the canal operators and the farmers. All the management decisions about command level and discharge can be built into the gate settings during design.

Such systems are expensive. Although the gates are very reliable maintenance may be a problem as spares will be specialist parts.

**Flexible control** systems use gates which can be adjusted to suit the changing water demands of the crops. However, this can only be done from a supply point of view and does imply that there are experienced staff who know how to set the gates and can make the right adjustments at the right time. Without experienced operators this system can be very difficult to operate effectively and efficiently particularly on a large scale.

**Fixed control** comprises fixed weirs along each canal to divert the flows into the farms. It is quite inflexible and may lead to wastage but it can be managed easily both by system managers and by farmers. The water runs through the system and any excess goes into the drainage system. A system similar to this has recently been constructed in N. Nigeria on a scheme covering 2000 ha and is working well. Remember that the relatively poor efficiency of this type of system may not be important. 'Losses' go back into the river or recharge the groundwater and so will be available elsewhere for someone to use.

### *Types of hydraulic structure*

There are two types of hydraulic structure for water level and discharge control along canals; the orifice structure (underflow) and the weir structure (overflow). A weir structure makes a very good cross regulator because the head is insensitive to changes in discharge. Conversely, an orifice structure is a good head regulator because the discharge is relatively insensitive to changes in canal water levels. However, the combination of weir cross regulators and orifice head regulators along a canal can result in poor distribution of water along a canal particularly when it is operating below its design discharge.



The farmers at the head of the system get most of the water while those at the tail get very little. Thus the choice of irrigation structures along a canal can exacerbate the common top ender tail ender problem. One way of avoiding this problem is to ensure that the type of structure used is the same for both the cross regulator and head regulator. This was done in the example quoted above for N. Nigeria although it is not necessary for the structures to be fixed.

## **CANAL AND FARM WATER MANAGEMENT**

---

Canal and farm water management practices can have a significant influence on the design of the canal system. Too many canal systems are designed with hydraulic convenience and low cost in mind rather than ease of canal management and farmer preferences. Many irrigation schemes in the past have been designed on a continuous flow (24 hour irrigation) or rotational basis with little thought given to how this will be managed in practice. The theme in irrigation for the past 10 years has been design for management and this is still very relevant today. The need to introduce flexibility in the design is more widely accepted as a necessary condition of adapting to future cropping patterns.

**Continuous flow** this can be the cheapest to construct and operate from a canal management point of view. However, it requires farmers to irrigate day and night with very low discharges which usually leads to very poor irrigation efficiency.

**Rotational flow** costs more in construction but can improve efficiency. Flexibility is reduced among farmers who must follow the same cropping patterns, irrigate in sequence and cooperate with each other. Irrigation again may be on a 24 hour basis. Both continuous and rotational flows are supply oriented systems in which farmers have little choice once the system has been constructed. It is very difficult to adapt rotational systems to modern irrigation systems like micro sprinkler and localized irrigation because the high frequency of application required is incompatible with the established rotations. On farm storage is solution that can solve or reduce this problem but represents an important additional cost.

**Demand oriented** systems give farmers more choice e.g. farmers may wish to irrigate only during the day or during certain days of the week. Such systems tend to be more difficult to design and operate and cost more but the increase in operational benefits may mean that output is also greatly increased with a greater area irrigated. Systems which can provide on-demand irrigation include:



**Canal storage or night storage** - storage in canals or at strategic points along the canal system allows demand for water to be met more easily and reduce night irrigation. This system has been very successful in the Sudan for storing water overnight but there have been problems of sedimentation and weeds in the canals and the increased risk of malaria and schistosomiasis. Canal construction costs will be higher than for continuous flow schemes as the design capacity must be larger.

**Downstream control** is a method of canal control which is not widely used but is much more responsive to farmer demand than all the above canal operating methods which use the principle of upstream control. The method requires special automatic gates to control water levels and is more expensive to construct than upstream control. However, its advantage of meeting farmer demands in a flexible way means that this approach requires much more consideration from irrigation engineers than it has received in the past.

**Pipe systems** are ideal for on demand irrigation. They respond rapidly to changes in demand. (See pipelines section for details).

Most of the examples of irrigation schemes that do not work well have a history of supply orientation and a little consideration for farmer preferences. These past errors need not be repeated. This means avoiding continuous flow (24 hour irrigation) and rotational flow schemes unless they have simple control systems and have the full backing of the farmers.

## **PUMPING**

---

The most common types used are axial flow; centrifugal and mixed flow pumps.

**Axial flow pumps**, efficient for lifting large volumes of water at low pressure, are ideal for lifting water from a river or lake into open channel distribution systems. However, axial flow pumps are normally only available for the larger discharges and hence only for the larger irrigation schemes. However, such pumps would be well suited to small scale irrigation also but unfortunately small axial flow pumps are not easily obtained.

**Centrifugal pumps** are well suited to sprinkle and trickle irrigation in terms of discharge and pressure and are the most common type of pump used in irrigation. Although not well suited to low head surface irrigation schemes it is often the only type of pump available in many countries and so is widely used for this purpose despite its poor efficiency in such situations. They are much cheaper to buy and maintain than axial flow pumps and small pump sets are often readily available and maintainable in most developing countries for use by small farmers.

**Mixed flow pumps** are a mixture of axial flow and centrifugal pumps and combine the best features of both pump types.

Table 2.1 gives some general orientations for the pump selection but price considerations and local availability may have overriding impact in the selection.

**TABLE 2.1 - Pump Selection for Irrigation Schemes**

Irrigation System	Pressure (bar)	Discharge	Pump Type
<i>Surface Irrigation</i> <ul style="list-style-type: none"> <li>• open channel distribution</li> <li>• pipe distribution</li> <li>• deep tube well</li> </ul>	0.5 1.0 >2.0	high discharge high discharge low discharge	axial <sup>1</sup> /mixed axial <sup>1</sup> /mixed mixed/centrifugal
<i>Sprinkle System</i>	2-5	medium discharge	centrifugal
<i>Trickle System</i>	1-2	low discharge	centrifugal

## Power Units

Pumps can be driven by a diesel or petrol engine or an electric motor. In some special cases solar or wind power or even hand or animal power may be used but they are not so common and are generally limited to very small irrigated plots.

**Internal combustion engines** have a good weight to power output ratio, and are compact in size and relatively cheap due to mass production techniques. Petrol engines tend to be the cheaper overall for small schemes (1 to 2 ha) but diesels become more cost effective on schemes over 4 ha.

Diesel engines are more efficient to run and if operated and maintained properly they have a longer working life (10 years) and are more reliable than petrol (4 years). In some countries petrol driven pumps have needed replacing after only 2 or 3 years operation. Diesel pumps operating in similar conditions could be expected to last at least 6 years. However, the useful life of an engine is best measured in hours of operation and this depends on how well it is operated and serviced. There are cases in developing countries where diesel pumps have been in continual use for 30 years and more.

The annual maintenance of petrol engines can be as much as 10% of capital cost whereas diesel maintenance is only 5%.

<sup>1</sup>: Ideal pump type but not usually available.

**Electric motors** are very efficient in energy use and can be used to drive all sizes and types of pumps. They can also last much longer than other power units (up to 10 years) with low maintenance costs (approx. 1% of capital costs). The main draw back is the reliance on a power supply which is beyond the control of the farmer and in many places it is unreliable.

Electrically driven pumps are much cheaper to operate than diesel pumps. For larger schemes the energy costs become a much more significant part of the overall cost of the scheme and so any savings in energy could result in significant cost savings. For large schemes a stand by generator will be essential to cover power failures.

**Animal powered water wheels** have been extensively used in countries with long tradition in irrigation but they are gradually disappearing from the irrigation scene. Small centrifugal pump units are very competitive in price and easy to operate. It will be difficult to justify the introduction of such pumping devices nowadays but in some remote places they could be justified.

When dealing with small farms pumping costs are not important. It is the capital cost of the system, equipment availability and its useful life expectancy which dominates the decision making.

### *General comments*

To conclude it is local conditions such as the availability of equipment and spares, together with good maintenance facilities which ultimately decide on the type of technology to choose and not just the most desirable from a financial and technical point of view.

For the simplest of shallow wells, small centrifugal pumps located at ground level (or hand lifting devices in some areas) are used to lift the water into the distribution system.

Deeper water will require submersible pumps. Diesel driven submersibles can be very expensive and so are far more expensive to buy and maintain than surface pumps. Electric submersible pumps are a much cheaper option but are at the mercy of the local power supply.

## ANNEX 3: Techniques for water application

### INTRODUCTION

---

There are several ways of applying water to crops. The principal methods are:

- **Surface irrigation**
- **Sprinkler irrigation**
- **Trickle irrigation**

The objectives in selecting any of these methods is to apply an adequate amount of water to meet crop needs; apply water uniformly; avoid unnecessary wastage of water and ensure there are no long term problems on the farm (e.g. soil erosion, salinity).

When selecting the best method it is important to consider not just its technical suitability for the crop-soil-water conditions but also the ability of the farmers to use and maintain the method. If the above objectives are to be achieved it will depend as much, if not more, on the skills of the farmers as on the method itself.

Technical considerations include; soils (infiltration rate and water holding capacity), crops, climate, cost (capital and operating), water supply (quantity and quality) and labour requirements (both skills and number, note that increasing numbers is no substitute for lack of skill).

### SURFACE IRRIGATION

---

This is the most common method of irrigation and accounts for 95% of irrigation in the world. It still accounts for up to 70% of irrigation in the USA and it is a method that is not only well established but will be here for a long time to come. Surface irrigation is well suited for use on both small and large schemes. Basin, border and furrow are all surface irrigation methods. The choice between them depends on the crop, cultivation practices, soils, topography and farmer preferences (Table 3.1).

Surface irrigation methods are often selected because they are considered to be simple methods well suited to farmers with little or no knowledge of irrigation. This can be an over simplistic assumption (Table 3.4).

Surface irrigation should never be described as **simple** if at the same time there is a need to use water efficiently. The method places too much responsibility for achieving good results in the hands of the farmer and the technology provides little in the way of support. Good control over the highly variable nature of the movement of water across a soil surface and its infiltration into the soil over a season is extremely difficult to achieve and this makes surface irrigation one of the most complex methods of applying water to soil ever devised. It is thus hardly surprising that the efficiency of surface irrigation in the hands of farmers who have no control over farm discharges and the timing of applications, is poor.

In contrast to its management the design of surface irrigation layouts for basins, borders and furrows and their construction is relatively simple and no special materials are needed. Maintenance too produces few problems and can be done locally by farmers themselves. Larger schemes may require laser controlled grading.

Potentially surface irrigation can be very efficient if all the factors involved are under the careful control of a skilled and experienced farmers. More often, however, the water management skills on the farm are lacking and, in the case of large schemes, water supplies may be uncertain (see canal management in Annex 2), and so efficiency tends to be low. For this reason a realistic application efficiency for surface irrigation design is usually assumed to be 60%. This is the potential efficiency but in practice it could be well below this. However, it would be unwise to design for a lower value; 60% is realistic and is a figure for the farmers to aim for as their irrigation skills develop.

### ***Basin irrigation***

Basin irrigation is the simplest and most widely used of all surface irrigation methods because of its simplicity. Basins can be adapted to suit many crops, soils and farming practices. They are ideal for the small farm where a wide range of crops can be grown in small basins. Larger basins are well suited to large mechanised farms. Row crops can be accommodated by ridging or constructing beds in the basins. (note this is not furrow irrigation).

Basins constructed primarily for flooded rice are now increasingly being used for diversified cropping. Modifications to allow for upland crops need to be allowed for in design.

### Border irrigation

Border irrigation is less popular than basin. They are usually rectangular in shape and are well suited to larger farms. Border lengths range from 100m to 800m and 3m to 30m wide. As a general rule borders should be as long as possible to reduce the cost of irrigation and drainage systems and to ease the problems of mechanisation.

### Furrow irrigation

Furrow irrigation is the most widely used method for row crops and is the most misunderstood of all the surface methods. It is usually practised on gently sloping land up to 2% in arid climates but restricted to 0.3% in humid areas because of the risk of erosion during intensive rainfall. From a farming point of view furrows should be as long as possible as this reduces the cost of irrigation and drainage and makes it easier to mechanise. The technique is well suited to larger farms and should not be confused with furrowed-basins which are best suited to small farms.

Furrow length depends on soil type, steam size, irrigation depth and land slope and ranges from 60m to 300m or more but farm (or field) size and shape put practical limits on furrow length.

Efficient furrow irrigation always involves runoff and so a surface drainage system will be needed.

### Selection of method

The choice between the methods of surface irrigation depends on land slope, soil type (infiltration rate) field shape, crops and labour requirements. The following (Table 3.1) summarises these key characteristics.

TABLE 3.1 - Selecting Surface Irrigation Methods

Irrigation method	Land slope (%)				Soil infiltration rate (mm/h)	Field shape	Crops				Labour h/ha per irrigation
	Humid regions		Arid regions				Row crops	Sown, drilled crops	Flooded rice	Orchards	
	Bare soil	Crop cover	Bare soils	Crop cover							
basin	level or <0.1% (steep slopes need terracing)				up to 30	any shape	yes	yes	yes	yes	0.5 - 1.5
border	0.5	2.0	2.0	5.0	up to 30	rectangular	yes	yes	no	yes	1 - 3
furrow	0.3	-	2.0	-	up to 30	rows of equal length	yes	no	yes	yes	2 - 4



## **SPRINKLER IRRIGATION**

---

Sprinkler irrigation is used on approximately 5% of irrigated land throughout the world. It will never seriously replace surface irrigation but it has one distinct advantage; good water management practices are built into the technology thus providing the flexibility and simplicity required for successful operation, independent of the variable soil and topographic conditions. Pumps, pipes and on farm equipment can all be carefully selected to produce a uniform irrigation at a controlled water application rate and, provided simple operating procedures are followed, the irrigation skills required of the operator are minimal. This puts more of the responsibility for successful irrigation more in the hands of the designer rather than leaving it entirely to the farmer. Thus sprinkle can be much simpler to operate and requires fewer water management skills. However, it requires much more sophisticated design skills and on farm support in terms of maintenance and the supply of spare parts (Table 3.4).

Sprinkle is potentially more efficient and uses less labour than surface irrigation and can be adapted more easily to sandy and erodible soils on undulating ground which may be costly to regrade for surface methods. There are many types of sprinkle system available to suit a wide variety of operating conditions but the most common is a system using portable pipes (aluminium or plastic) supplying small rotary impact sprinklers. Because of the portability of sprinkle systems they are ideal for supplementary irrigation.

The efficiency of sprinkle irrigation depends as much on the farmer as on the system. For design purposes a figure of 75% is generally used.

Sprinkle irrigation is better suited to large farms rather than the small farms found in many developing countries. Typical spacing for sprinklers is 18m x 18m and this is not very flexible and adaptable to the multitude of small plots usually found on small farms. One option which may fit more closely to the small farm are the smaller sprinklers connected to a main line by flexible hoses - the hose pull system. The sprinklers can then be more easily located around the farm with great flexibility.

Larger schemes can accommodate the requirements of traditional sprinkle irrigation and also take advantage of the recent developments in systems which reduce labour and energy costs through the use of automation. At the forefront of all these developments is the centre pivot machine which can irrigate up to 100ha from a single machine. These machines are also very adaptable. In UK they have been used on small and irregular shaped fields and they cross field boundaries to irrigate several fields growing different crops at the same time. One machine can also irrigate several farms if the farmers are able to cooperate. Their role in irrigating large areas with minimal inputs should not be underestimated.

In Libya they were used to irrigate large desert areas and as far as the farmers under the pivots were concerned it rained once a week as the pivot rotated. Thus, from a management point of view it provided a relatively simple system to operate and left the farmers to do the farming. However, considerable skills are needed to operate these machines and to maintain them. But these skills are no more than those required to keep motor cars running and in most developing countries they do this very successfully from within their private sectors.

Another mobile irrigator is the large raingun sprinkler which operates between 5 and 10 bar pressure and can irrigate up to 4ha at one setting of the machine. These are ideal for large farms and estates where soil infiltration rates are high and labour costs are significant. Guns are well suited to supplementary irrigation on modern farms such as those found in Europe.

**TABLE 3.2 - Summary of Sprinkler Irrigation Systems**

System			Use
Conventional systems	portable	hand move roll move tow line	Uses small rotary impact sprinklers Widely used on all field and orchard crops Labour intensive
	semi permanent	sprinkler hop pipe grid hose pull	Similar to portable. Lower labour input but higher capital cost
Mobile gun systems	hose pull hose drag		Large gun sprinklers but can be replaced by boom. Good for supplementary irrigation
Mobile lateral systems	centre pivot linear move		Large automatic systems. Ideal for large farms with low labour availability
Spray lines	stationary oscillating rotating		Fixed spray nozzles. Suitable for small gardens and orchards

### **TRICKLE IRRIGATION**

Trickle irrigation is the least used system on a world scale and involves less than 0.1% of irrigated land. Even in Israel where much of the early research and development was done and water is very scarce, trickle has not flourished as much as might be thought. Sprinkle irrigation still provides more than 70% of Israel's irrigation because this is still considered to be a most efficient method of irrigation and one which is financially viable. Trickle is not without its technical problems and high cost and on a large scale emitter blockage can cause serious crop losses if the systems are not carefully managed.

But in some areas with the right characteristics it can be a very useful method.

Many claims are made about this method, including increased crop yields, greater efficiency of water use, possible use of saline water, reduced labour requirements and its adaptability to poor soils. An important advantage is the ease with which nutrients can be applied with the irrigation water.

Claims made about water saving need to be judged with care. Crops respond primarily to water and not to the method of application. If the right amount of water is being applied to the crop at the right time it will flourish. It will not depend on whether the water comes from a sprinkler or a trickle emitter. Thus the saving is only in the potential efficiency of the method when compared to other methods.

There are also misunderstandings about the efficiency of trickle irrigation. Its potential is 90%. However, actual efficiency, like in surface and sprinkler irrigation will depend to a large extent on the farmer and how the equipment is used in practice.

A distinct advantage of trickle is that it is well suited to small and varied plots on small farms. This is how trickle is being used in India where farmers have gone from surface irrigation to trickle and have missed out sprinkle as being an inflexible system for small plots. Simple local manufacture of trickle parts has also encouraged Indian farmers to take up the method and they are assured of spare parts.

A major technical problem with trickle irrigation is emitter and lateral blockage from sand and silt, chemical precipitation from groundwater and algae from surface water. Each of the problems takes the use of trickle into a level of technology and support which is difficult to sustain in a developing country. On a small scale of these problems can simply be overcome by the farmer going around and cleaning the system regularly. However, on a large scale this would not be practicable.

Trickle really comes into its own when water is scarce, when it is expensive, when the quality is marginal, when the land is marginal, when labour is expensive or not available and it is being used on high value crops. In such cases there may be no option but to use trickle. It can be an easy system to operate. It is a pipe system and so can be switched on and off easily by the farmer and so there is the potential for high levels of efficiency. But there may be problems in realising that potential.

## MICRO IRRIGATION

This is a method of irrigation part way between sprinkle and trickle. It uses small sprinklers (mini sprinklers or spitters 30 to 60 l/hr) to spray water over a limited area of a few metres and is ideally suited to orchards or small plots. Another technique is the bubbler which allows water to bubble from a pipeline at a much faster rate than a trickle emitter and so avoids the problem of blocking.

Many farmers now prefer micro irrigation methods to trickle because they will not only do same the job as trickle but are less susceptible to blockage by silt and chemical precipitates. It is also easy to see when an irrigator is partially blocked because the spray pattern is distorted. With a trickle system a partly blocked emitter only comes to light when it is tested or the crop nearby shows sign of stress. At this point it may be too late to take any corrective action.

## SELECTION CRITERIA FOR IRRIGATION METHOD

The following summarises the selection criteria:

**TABLE 3.3 - Technical Factors Affecting Selection of Irrigation Method**

Irrigation Method	Crops	Soils	Labour (h/ha/irrigat.)	Energy Demand	Potential Efficiency (%)	Capital Cost
Surface					60	low
• Basin	all crops	clay, loam	0.5 - 1.5	low		
• Border	all crops except rice	clay, loam	1.0 - 3.0	low		
• Furrow	all crops except rice and sown/drilled	clay, loam	2.0 - 4.0	low		
Sprinkle	all crops except rice	loam, sand	1.5 - 3.0	high	75	medium
Trickle	row crops, orchards	all soils	0.2 - 0.5	medium	90	high

Note that it is difficult to give general indication of the cost of each systems because this depends on the site conditions and the availability of locally manufactured equipment. However, in broad terms an indication of the relative capital cost is given.

**TABLE 3.4 - Scheme Development Factors Affecting Selection of Irrigation Method**

Irrigation method	Design	Construction	Operation	Maintenance
Surface	simple	simple	complex	simple
Sprinkle	complex	complex	simple	complex
Trickle	complex	complex	simple	complex

## **REFERENCES**

---

*Critchley W, Siegert K.*

1991. Water harvesting. FAO Rome.

*Kay MG*

1983. Sprinkler Irrigation - Equipment and Practice. BT Batsford UK.

1986. Surface Irrigation - Systems and Practice. Cranfield Press UK.

*Van Bentum R, Smout IK*

1994. Buried Pipelines for Surface Irrigation.

Intermediate Technology Publications UK.

*UNDP/FAO*

1987. Spate Irrigation. Proceedings of the Subregional Expert Consultation on Wadi Development for Agriculture in the Natural Yemen.

*Waterhouse J.*

1982. Water Engineering for Agriculture. BT Batsford UK.

## ANNEX 4: Evaluating and classifying land for irrigated agriculture

### *BASIC PRINCIPLES*

---

Certain concepts and principles are fundamental to successful land evaluation for irrigated agriculture. The basic principles advocated by the Framework for Land Evaluation (FAO, 1976), on which the methods described here are based, are complementary to the principles of the US Bureau of Reclamation, which are specifically for irrigation. The following is a summary of the introduction to the “Guidelines - Land Evaluation for Irrigated Agriculture” (FAO, 1985). The reader is referred to this publication for more detailed information.

- 1 The FAO Framework indicates that it is necessary to evaluate land and not just soils. The suitability of soils for irrigated crops is useful information, but it is inadequate for making decisions about land use development. Therefore, all relevant land characteristics, including soils, climate, topography, water resources, vegetation, etc. and also socio-economic conditions and infrastructure need to be considered.
- 2 The main objective of land evaluation for irrigated agriculture is to predict future conditions after development has taken place. It is necessary to forecast the benefits to farmers and the national economy and whether these will be sustained without damage to the environment. Essentially, a classification of potential suitability is required which takes account of future interactions between soils, water, crops and economic, social and political conditions.
- 3 Some factors that affect land suitability are permanent and others are changeable at a cost. The costs of necessary improvements may be determined, so that economic and environmental consequences of development can be predicted. Typical examples of permanent features are temperature, soil texture, depth to bedrock and macro-topography. Changeable characteristics, which may be altered deliberately or inadvertently, may typically include vegetation, salinity, depth to groundwater, microrelief, and some social and economic conditions (e.g. land tenure, accessibility).
- 4 Land suitability must therefore be assessed and classified with respect to specified kinds of land use, i.e. cropping, irrigation and management systems. It is obvious that the requirements of crops and irrigation and management methods differ, so the suitability of any land unit may be



classed differently for various uses. It can be useless or misleading to indicate suitability for irrigated agriculture in general if the land developer needs to know about its potential for a specific irrigated crop or irrigation method.

- 5 Land evaluation requires a comparison of the outputs obtained with the inputs needed to generate these outputs, on different kinds of land. In other words, land suitability evaluation is essentially an economic concept, although formal economic analysis may not be necessary for simple surveys. Assessment of physical factors alone does not permit prediction of the results of irrigation; they must be translated into economic terms. It is most important to achieve a land classification that reflects differences in the long-term productivity and profitability of the land under irrigation rather than one that focuses only on physical differences without regard to their economic implications.
- 6 The evaluation must take account of the local physical, political, economic and social conditions. The success of irrigation, when it is introduced, may depend as much on factors such as pricing policies for crops, labour supply, markets, accessibility, land tenure, etc. as on climate and soils. To avoid any misunderstanding all the factors, which are relevant in the local situation, should be explicitly stated rather than assumed. However, not all conditions need to be considered: only those that can usefully be taken into account in classifying land.
- 7 The land suitability must be for sustained use, that is, permanently productive under the anticipated irrigation regime. Either there should be no land degradation anticipated or the cost of prevention or remedial action to control erosion, waterlogging, salinization etc. should be included in the comparison of outputs and inputs.
- 8 The evaluation, where more than one apparently viable alternative exists, should compare more than one kind of use. Comparison may be, for example, between the present use and proposed uses, or between different crops and irrigation methods. The reliability of the evaluation is enhanced by comparing inputs and outputs for several alternatives to ensure that the land use selected is not only suitable but the best of suitable alternatives.
- 9 It is evident that an interdisciplinary approach is required, because one discipline alone cannot cover all aspects of land suitability evaluation. Land evaluation can be carried out using general economic considerations to establish a context for selecting appropriate crops and management, and to establish the criteria for boundaries between suitable and unsuitable land. A quantitative evaluation at project or farm level, however, requires formal analysis in financial and economic terms.

## ***A STEP-BY-STEP GUIDE TO THE PROCEDURES***

---

A progression from a “provisionally-irrigable” to an “irrigable” classification is assumed in the following steps. The steps can be readily modified if an alternative approach is used. The appropriate type of classification and the measure of suitability to be used (i.e. land productivity index, net farm income or net incremental irrigation benefit) must be decided prior to each evaluation.

### ***List of main steps***

#### **1 Deciding the land utilization types (LUTs) to evaluate**

- Step 1** Land is evaluated with respect to its suitability for a given land use. Discuss with farmers and at local government level the alternative land uses (i.e. LUTs or farming systems) of interest and prepare to evaluate each of these separately.
- Step 2** Describe the LUTs. For each LUT, a complete description is required.

#### **2 Developing the land suitability class specification**

- Step 3** From the agronomic, management, land development, conservation, environmental and socio-economic factors, select the relevant “class-determining” factors that can be expected to influence the suitability of land for the given LUT and that may vary from land unit to land unit.
- Step 4** For each selected “class-determining” factor, enter the appropriate land use requirement or limitation.
- Step 5** Quantify “critical limits” corresponding to levels of suitability for individual land use requirements and limitations. These are the specifications for each factor in terms of the requirements and limitations of the LUT. These specifications may be represented by appropriate land qualities, or their representative land characteristics, together with the inputs and land improvements that influence productivity index, net farm income. Enter the “critical limits”, separating the suitability levels for each individual factor.

### **3 Field survey and mapping of “provisionally-irrigable” classes and subclasses**

**Step 6** Survey, delineate and describe the land units. Prepare a map of the land units, with a legend numbering the land units which can also accommodate the symbols for the land suitability classes.

**Step 7** For each land unit, decide which land qualities and land characteristics are “class-determining” with respect to the requirements and limitations of the LUT(s). For each land unit, enter the appropriate values of the land qualities and land characteristics.

**Step 8** Match “critical limits” of each land use requirement or limitation with the conditions found in the land unit to obtain a factor rating of s1, s2, s3, n1 or n2 for each combination of LUT and land unit. Enter the factor rating on Format 3. Assumptions about inputs, land improvements and their benefits and costs should also be indicated.

**Step 9** Decide the relative “significance” of each “class-determining” factor (or a group of interacting factors) by entering Very Important, Moderately Important, Less Important or Not Important, as appropriate.

**Step 10** Combine individual “class-determining” factor ratings to obtain a tentative land suitability classification for each LUT on each land unit. Interactions between factors and “Significance” must be taken into account in this step. Estimates of crop yield and economic benefit/costs, according to the guidelines, may be needed to assign the classes and subclasses. Enter the tentative land suitability class and subclass (S1, S2, S3, N1 or N2, etc.) on the map.

**Step 11** Where necessary, adjust the LUT description, or introduce inputs or land improvements, and repeat steps 1-10 until the most practicable cropping, irrigation and management farming system is obtained.

### **4 Presentation of the results of the “provisionally-irrigable” classification**

**Step 12** Take the final set of “provisionally-irrigable” classes and subclasses in Step 11 and present them for all the combinations of LUTs with land units:

- describe each LUT in terms of cropping, irrigation and management systems using descriptors;

- provide maps of “provisionally-irrigable” land with legends;
- indicate land development, inputs and management recommendations for each combination of LUT-land unit;
- present the results from basic surveys, including maps and descriptions of land units;
- write a summary of the recommendations.

## 5 Determination and mapping of “irrigable” land

**Step 13** Revise the cropping, irrigation and management in an updated description of the LUT for specific land units. Revise the specifications and critical limits in the light of new information on water supply and economic data. Proceed to revise the classification to determine which areas of the “provisionally-irrigable” land can actually be irrigated under an economically and financially viable project plan.

**Step 14** Repeat mapping as in Step 6, with additional field survey as necessary, changing land unit boundaries and earlier mapped symbols as necessary.

**Step 15** Complete the mapping, tabulations and present the results of the classification of “irrigable” land.

**Step 16** Based on the recommendations in Step 15, participate with other technicians in the project investigation to establish patterns of land use for the project reflecting the likely situation with the project at full development. With land use options thus reduced to a recommended and likely single LUT on each land unit for the “with” project situation, prepare maps and tabulations of the “irrigable” land classification for the project. The predicted economic results of each LUT can be incorporated in the overall economic analysis for the project.

A diagram with the place of the land evaluation exercise within the overall land use planning strategy is indicated in Figure 1.

## REFERENCES

---

### FAO

1976. A Framework for Land Evaluation. Soils Bulletin no. 32, Rome.  
1985. Guidelines - Land Evaluation for Irrigated Agriculture. Soils Bulletin no. 55, Rome,

## **ANNEX 5: Water resources assessment**

### ***INTRODUCTION***

---

Setting up an irrigation system requires the knowledge of the water availability, together with the information on floods which could have an impact on water management or on construction design of the irrigation scheme.

### ***WATER AVAILABILITY***

---

Assessment of water resources for irrigation purpose consists of obtaining information on the distribution of water availability along the year to be compared with irrigation water requirement.

#### ***Data gathering***

Assessment of water resources or floods requires the analysis of all available information about the hydrology of the site. In the most fortunate cases, data will be available for the site itself. It will consist in series of information on runoff, precipitation, well logs, or in elaborated information on low flow probabilities, flood recurrence or abstraction rates. In most cases, however, data will be rare or absent and the information will have to be obtained through indirect ways (comparison with neighbouring sites, use of regional formulae etc.). In any case, a field visit and discussion with local people will be very useful in gathering general information about the hydrology of the region.

#### ***Data analysis***

Analysis of information and assessment of water resources are the competence of a specialised institution or consulting firm. Usually, the Ministry in charge of water affairs or the Water resources authority has a section dealing with data collection and water resources assessment. This institution should be contacted to provide the necessary information for the development of the irrigation scheme.

Although most of the procedures for water resources assessment are similar and rely on the same kind of information, one can differentiate between three situations:

- irrigation from wells
- irrigation from a small dam
- irrigation by river diversion

For each of these situations, the tasks to be performed are developed below and presented in the form of terms of reference for the specialised institution in charge of water resources assessment.

For all cases, the objectives are the same and can be summarised as follows:

*Objective*

The objective of the assessment is to insure the reliability of the water supply to the planned irrigated scheme located in .....

The expected size of the scheme is ..... hectares and the corresponding water requirement will be as follows:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1 ha													
Whole scheme =... ha													

*Irrigation from wells*

The groundwater resources assessment is required to determine (i) the reliability of the supply to a planned irrigated scheme and (ii) the number of wells to be dug or drilled.

*Information required*

The following information is required from the (Ministry, Consultant ...):

- 1 Physical characteristics of the aquifer:**  
Extension (illustrated with a map), depth to water level, saturated thickness ...
- 2 Hydraulic characteristics:**  
Results of pumping tests performed in the vicinity of the planned scheme: transmissivity, storage coefficient, porosity, well performance....



**3 Water balance:**

Recharge area of the aquifer, average amount of recharge, recharge during drought periods, discharge area, seasonal fluctuations, present abstraction from existing wells tapping the same aquifer, estimated reserve that could be used in drought period....

**4 Proposed well field lay-out:**

Type (dug or drilled), number and design of the proposed wells and related characteristics (total depth, expected discharge, expected salinity...). Calculated drawdown induced by the well field and expected interference to and from nearby well fields.

**5 Recommendations related to the maximum possible extension of the irrigated scheme:**

The recommendations will also include suggestions concerning limitations to be applied to water abstractions in case of extended drought periods.

### *Irrigation from small dams*

The way to assess water available from a small basin will depend on the availability and duration of measurements of water level in the dam.

#### *Information required*

The following information is required from the (Ministry, Consultant ...):

- 1 Collect existing information on monthly runoff in the river and water level in the reservoir and establish the monthly distribution of inflow for several exceedence probability levels (50%, 80%);
- 2 Establish the level/area/volume relationship for the reservoir;
- 3 Assess average monthly evaporation and infiltration losses from the reservoir on the basis of existing records or, if not available, on the basis of regional values of evaporation and geological characteristics of the reservoir;
- 4 Assess water requirements for other users at the dam and downstream, including cattle, fish production, and base flow requirements;
- 5 Build a simple monthly water balance model to assess water availability for the two exceedence probability levels (50%, 80%) and for the irrigation requirements proposed above and indicate possible shortages or competition with other users

### ***Irrigation from river diversion***

Assessment of water availability from river diversion does not differ substantially from dam assessment. It will also depend on the availability of information on runoff.

#### ***Information required***

The following information is required:

- 1 Collect existing information on monthly runoff in the river and establish the monthly distribution of inflow for several exceedence probability levels (50%, 80%);
- 2 Give or establish the rating curve (level vs. runoff) of the river at the intake site;
- 3 Compare with irrigation water requirements, assess the hydrological feasibility of the proposed diversion, and check the results against downstream users, including base flow requirements for environmental purposes;
- 4 Draw the monthly runoff and level distribution curves in the river for the two exceedence probability levels (50%, 80%) and compare with the irrigation requirements proposed. Indicate possible shortages or competition with other users.

### ***ASSESSMENT OF FLOODS***

---

Assessment of flood is important to design structures like dams, levees or drainage canals, or, in the case of wetland development, to assess the frequency and duration of floods in the project area. Several techniques are available and empirical methods have been worked out to assess flood on the basis of information on rainfall and basin characteristics. Generally, the flood having a return period of 10 years is computed. Additional methods exist to extrapolate this result to longer return periods. The choice of the return period depends on the purpose of the computation. Construction of a small dam's spillway, for instance, could be designed on the basis of the 100 years flood.

Like in the case of water resources assessment, the study should be carried out by the institution in charge of water resources or a competent consulting firm. The study should perform the following tasks:

- 1 Collect all available information on flow regime, stage and discharge in the river at project site;

- 2 Compute or assess the 10-year and 100 year flood for the purpose of construction design;
- 3 Develop tables of monthly values of water level for an average year and for levels reached 1 out of 5 years (20% exceedence probability);
- 4 Infer from the available data the average and 20% exceedence value of maximum level rise during the cropping season and compute the maximum level exceeded during a period of more than 5 days.

### ***FURTHER READINGS***

---

*Linsley, R., M. Kohler and L. Paulhus*

1982. Hydrology for engineers. McGraw-Hill, 508 p.

*Miquel, J.*

1984. Guide pratique d'estimation des probabilités de crues. Eyrolles, Paris, 160 p.

*WMO*

1981. Guide to hydrological practices. 2 volumes, No 168.

*Lovell, C.J., Batchelor, C.H., Semple, A.J.*

1992. Development of small scale irrigation using limited groundwater resources, Institute of Hydrology/ODA

*Kergreis, A., Claude, J.*

1991. Utilisation rationnelle de l'eau des petits bassins versants en zone aride, Aupelf, John Libbey Eurotext, Paris

*Fletcher, G. Driscoll*

1987. Groundwater development and wells, Second edition; Johnson Division, St Paul, Minnesota

*Detay, M.*

1993. Le forage d'eau, Masson, Paris

*Brassington, R.*

1988. Field hydrogeology, Geological Society of London Professional Handbook, Open University Press, London; John Wiley and Sons, New York

*Clark, L.*

1988. Water wells and boreholes, Geological Society of London Professional Handbook, Open University Press, London; John Wiley and Sons, New York

# ANNEX 6: Crop water use irrigation requirements

## INTRODUCTION

---

An important element in the introduction of effective water use technologies will be the timely supply of water in the right quantities to farmers. An adequate knowledge of crop water use and irrigation requirements for the various crops in the given climatic conditions will be essential in the planning, implementation and monitoring of the irrigation demonstrations. Standardized procedures with FAO software and an extensive climatic and crop database will allow routine calculations and ready information on crop water climate conditions in the SPFP pilot areas.

The guidelines provide information on the following topics:

- 1 Introduction to the use of computer software (CROPWAT and CLIMWAT)  
for the preparatory and planning phase:
- 2 Establishment climatic data base
- 3 Crop water requirements of main crops  
for the implementation phase:
- 4 Development of practical irrigation scheduling
- 5 Estimates of irrigation water supply  
for monitoring and evaluation:
- 6 Collection of basic information during the growing season
- 7 Evaluation of rainfed production
- 8 Evaluation farmers irrigation practices
- 9 Efficiency irrigation water supply

## ***INTRODUCTION TO CROPWAT AND CLIMWAT***

---

Based on substantial amount of research carried out on this field, FAO has developed standard procedures for a range of practical applications in both irrigated and rainfed agriculture. Procedures and applications are included in the CROPWAT software package.

The main functions of CROPWAT are:

- To calculate:
- Reference evapotranspiration
  - Crop water requirements
  - Effective rainfall
  - Crop irrigation requirements
  - Rice irrigation requirements

Its main application are:

- To develop:
- Irrigation schedules under various management conditions
  - Scheme irrigation supply for various cropping patterns
  - Rainfed production and drought effects

CLIMWAT is a climatic database to be used in combination with CROPWAT. It allows the ready calculations of crop water requirements, irrigation supply and irrigation scheduling for various crops for a range of climatological stations worldwide.

The CLIMWAT database has been compiled by the FAO Agro-meteorological Unit and includes data from a total of 3262 meteorological stations from 144 countries divided into five continents and is contained on five 3 ½" diskettes (1.44 Mb) arranged according to continent and country:

Procedures and concepts are presented in the Irrigation & Drainage Papers No. 24, 25, 27, 33, 46 and 49.

## ***ESTABLISHMENT CLIMATIC DATABASE***

---

In order to assess the climatic conditions as basic indicator for crop production for rainfed and irrigated agriculture, relevant climatic need to be collected to assess evapotranspiration, rainfall and the variability of rainfall.

The initial information and data to be collected during the preparatory phase are:

- information on available meteorological station representative for the selected SPFP pilot and demonstration areas;

- average monthly rainfall, temperature and, if available, evapotranspiration data;
- time series (at least 10 years) of monthly or daily rainfall.

The CLIMWAT database contains for most countries sufficient data to determine average monthly  $ET_0$  and rain for the nearby climatic stations. Table 1 shows the list of CLIMWAT stations for Zambia and the selected four stations for the 4 SPFP demonstration areas. Table 2 and 3 show an outprint of the climatic and rainfall data from CLIMWAT.

### ***Cropping Season - Rainfed and Irrigated Crops***

Plotting graphically the rainfall and  $ET_0$  provides immediate information on the main cropping seasons for rainfed and irrigated crops as shown in Fig. 1.

## **CROPWATER REQUIREMENTS**

Calculation of crop water requirements and crop irrigation requirements can be carried out from basic information from the crops selected and should include:

- 1 average planting date
- 2 average harvesting date

Standard information on crop coefficient, rooting depth, depletion level and yield response factors are included for most crops in the CROPWAT program. Length of the individual growth stages need, however, to be adapted to fit planting and harvest dates.

Table 5 gives an example of the standard outprint of the water and irrigation requirements of maize and rice.

By adjusting rainfall for respectively a dry (80% probability) and a wet (20%) year (see table 4), an idea can be obtained on the variability of irrigation requirements under varying climatic conditions.

## **IRRIGATION SCHEDULING**

To provide practical guidelines on the frequency and application of irrigation to the various crops grown in the demonstrations, the irrigation scheduling of CROPWAT should be used for which additional information need to be collected on the irrigation method and the average application depth.



Table 6 gives indicative values for application gifts of the various irrigation methods:

<b>Irrigation Method</b>	<b>Application Depth</b>
Small basins (<200 m <sup>2</sup> )	40 - 80 mm
Large basins (>500 m <sup>2</sup> )	80 -150 mm
Furrows	30 - 60 mm
Borders	40 - 80 mm
Sprinkler	30 - 60 mm
Drip	10 - 20 mm

In addition, information on the waterholding capacity of the prevalent soil type needs to be obtained or estimated. Indicative values for:

- light sandy soils: 80 - 100 mm
- average medium textured soil: 140 mm
- heavy textured soil: 200 mm

Standard information on the various soil types is included in the CROPWAT.

Similarly, standardized crop information concerning rooting depth, allowable depletion and yield response factor is included in the selected crop file.

Development of a practical schedule is done by selecting the appropriate timing and application options. Several runs should be carried out before a satisfactory solution is found which allows as much as possible easy operational rules understandable and practical for farmers assuring minimal waterlosses and avoiding waterstress.

Table 7 and 8 show the typical steps in developing a practical irrigation schedule. In table 7 the irrigation schedule is adapted to a fixed irrigation gift of wheat of 40 mm. In table 8 this is further simplified by a schedule of 3 irrigations with a 3-week interval (21 days) with the first irrigation to be given within 6 weeks (42 days).

## ***SCHEME IRRIGATION SUPPLY***

The irrigation supply for a given irrigation scheme can be determined by selecting an appropriate cropping pattern with information on:

- 1 type of crops irrigated

- 2 planting date of each crop
- 3 area covered by each crop

Table 9 indicates how the information is entered in CROPWAT.

Table 10 shows the outprint of the calculations with monthly netto scheme water supply in mm/day and l/s/ha. To obtain the gross irrigation requirement (l/s) for the irrigation scheme the values need to be multiplied by:

- 1 area of the irrigation scheme in ha
- 2 estimated scheme irrigation efficiency

## **MONITORING AND EVALUATION**

---

To assess performance of irrigated and rainfed agriculture during the demonstration phase, basic information needs to be collected to more accurately evaluate crop growth for given climatic and ecological conditions.

Collection of basic data include:

- 1 **Climatic data** from a suitable and reliable meteorological station nearby. Minimum data to be collected include:
  - daily rainfall values
  - 10 daily maximum and minimum temperature data

If no suitable weather stations is available, rain gauge and maximum/minimum thermometer should be installed according to WMO standard procedures. A reliable observer should be instructed on correct measurement procedures.

- 2 **Crop data**

Information on crop data should include minimally:

- planting date or range of planting dates if a large area is to be evaluated;
- timing of critical growth stages: emergence, 10% leaf cover, 70% leaf cover,
- flowering, grainset harvest;
- occurrence and extent of pests and diseases
- fertilizers applied and fertilization condition

### 3 Soil-Yield data

Some basic soil characteristics should be collected and analyzed concerning texture, soil water retention characteristics, infiltration rates, soil depth, land slope.

### 4 Field Irrigation data

For selected crops and fields:

- dates of each irrigation applied including pre-irrigation over the total irrigation season;
- description of irrigation method and field lay-out (length and size, levelling conditions);
- estimation of average application depth by discharge measurements (estimates) and irrigation timing;
- farmers assessment on adequacy of supply.

### 5 Scheme Irrigation data

- accurate estimate of area planted and irrigated and cropping pattern;
- estimate of irrigation supply (l/s) over the irrigation season (intake discharge, pump operation time, fuel consumption, etc.);
- evaluation of water distribution by assessment of supply criteria to the different canal units and regulation (measurement discharge/timing) of water supply to the various units and responsibilities in water distribution;
- farmers assessment on adequacy, equity and efficiency of supply.

## ***EVALUATION OF RAINFED PRODUCTION***

---

An assessment of the adequacy of rainfall and effect of rainfall deficits on crop production can be made from actual rainfall data. Tables 11, 12, 13, 14 and fig. 3 and 4 show for Choma, Zambia the rainfall values for an average year (table 11) and for the drought year of 1993-94 (table 12). The effect of rainfall on waterstress and yield is shown in fig. 3 and table 13 for an average year and for fig. 4 and table 14 for the drought of 1993-94.

## ***EVALUATION OF FARMERS IRRIGATION PRACTICES***

---

An important step introducing more efficient water use practices is the evaluation of actual farmers irrigation practices.

Based on simple climatic, crop and soil data and basic information compiled on the frequency of irrigation and the average irrigation application depth an assessment can be made on the efficiency of water application and the effect of possible stress.

Fig. 5 and table 15 show an example from Buner, Pakistan, where farmers grow tomatoes in small basins irrigated every two weeks in the initial period and every week during flowering and harvesting period. Evaluation of the schedule shows a distinct over irrigation and a low irrigation efficiency of only 67%.

By changing from basins to furrow irrigation, less water per irrigation can be supplied considerably improving irrigation efficiency.

### ***WATER SUPPLY EFFICIENCY***

---

An assessment of the efficiency of water supply of a given irrigation system can be made by comparing actual supply with estimated requirements.

An example of such evaluation is given in tables 16, 17 and 18 and fig. 6 for an irrigation system in India. Table 16 shows the cropping pattern of the concerned system with 2 irrigation seasons and 5 different crops grown in different periods. Table 17 shows the calculated irrigation requirements of the given irrigation system. In table 18 the measured water supply data are compared with the estimated gross irrigation requirement with an assumed irrigation efficiency of 50%. Fig. 6 shows well that only in the peak period a satisfactory efficiency is achieved.

**TABLE 1 - CLIMWAT - List of Climatic Stations**

Country: Zambia		Country Code: Zam		
no.	Station Name	Altitude	Latitude	Longitude
1	Mbala	1673 m.	8.51 S.L	31.20 E.L
2	Kawambwa	1324 m.	9.48 S.L	29.05 E.L
3	Kasama	1384 m.	10.13 S.L	31.08 E.L
4	Mansa	1259 m.	11.06 S.L	28.51 E.L
5	Samfya	1172 m.	11.21 S.L	29.32 E.L
6	Mwinilunga	1363 m.	11.45 S.L	24.26 E.L
7	Mpika	1402 m.	11.54 S.L	31.36 E.L
8	Solwezi	1386 m.	12.11 S.L	26.23 E.L
9	Lundazi	1143 m.	12.17 S.L	33.12 E.L
10	Ndola	1270 m.	13.00 S.L	28.39 E.L
11	Serentje	1384 m.	13.14 S.L	30.13 E.L
12	Kasempa	1234 m.	13.32 S.L	25.51 E.L
13	Zambezi	1078 m.	13.32 S.L	23.07 E.L
14	Chipata	1032 m.	13.33 S.L	32.35 E.L
15	Kabompo	1075 m.	13.36 S.L	24.12 E.L
16	Petauke	1036 m.	14.15 S.L	31.17 E.L
17	Kabwe	1207 m.	14.27 S.L	28.28 E.L
18	Kaoma	1213 m.	14.48 S.L	24.48 E.L
19	Mongu	1053 m.	15.15 S.L	23.09 E.L
20	Lusaka C.A.	1280 m.	15.25 S.L	28.19 E.L
21	Kafue Polder	987 m.	15.46 S.L	27.55 E.L
22	Choma	1210 m.	16.51 S.L	27.04 E.L
23	Sesheke	951 m.	17.28 S.L	24.18 E.L
24	Livingstone A.P.	986 m.	17.49 S.L	24.49 E.L

**TABLE 2 - Cropwat and climwat outprint climatic data**

Monthly Reference Evapotranspiration Penman Monteith							
Meteostation: Choma		Country: Zambia					
Altitude: 1210 m.		Coordinates: - 16.51 South 27.04 East					
Month	Mintemp °C	Maxtemp °C	Humid. %	Wind Km/day	Sunshine hours	Radiation Mj/m2/day	Eto-PenMon mm/day
January	16.2	26.5	80	69	9.1	24.8	4.7
February	16.2	26.5	80	69	9.9	25.8	4.8
March	14.2	26.6	82	69	9.7	24.0	4.3
April	11.6	26.7	81	52	9.2	21.0	3.6
May	6.6	24.8	71	60	6.2	14.8	2.7
June	3.7	22.6	75	60	5.4	12.9	2.2
July	3.2	22.7	72	86	5.8	13.8	2.5
August	5.0	25.2	63	78	5.7	15.3	2.9
September	9.1	29.0	56	86	7.5	19.9	3.9
October	12.7	31.1	52	86	8.7	23.2	4.8
November	15.7	29.0	72	78	9.2	24.8	4.9
December	16.5	27.5	73	78	9.1	24.7	4.8
Year	10.9	26.5	71	73	8.0	20.4	3.8

Cropwat 7.0 (06/12/95)

TABLE 3 - Outprint Rainfall Data

Monthly Rainfall Data		
Climate Station: Choma	Eff. rain method: USDA S.C. Method	
	Rainfall Effective (mm/month)	Rainfall (mm/month)
January	200.0	136.0
February	185.0	130.2
March	80.0	69.8
April	23.0	22.2
May	6.0	5.9
June	6.0	5.9
July	0.0	0.0
August	0.0	0.0
September	1.0	1.0
October	22.0	21.2
November	93.0	79.2
December	209.0	139.1
Total	825.0	610.5

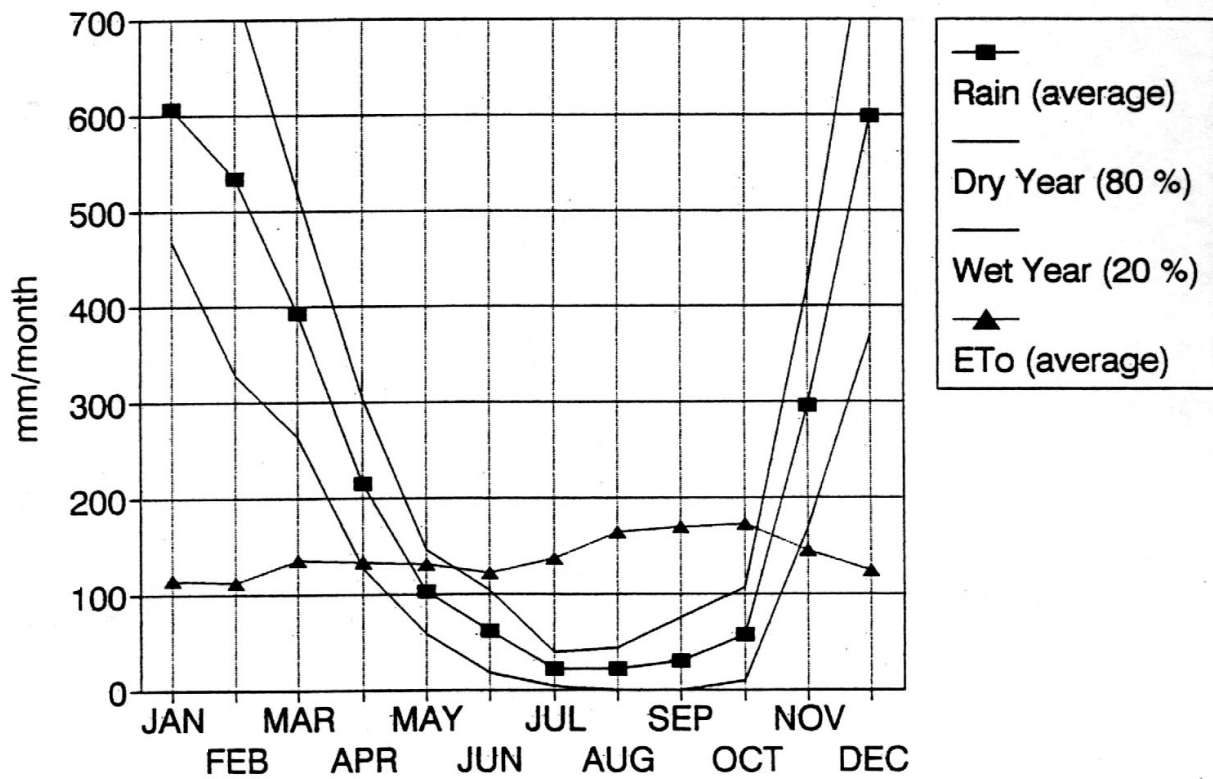
Cropwat 7.0 (06/12/95)

TABLE 4

PROVIN: SOUTH SULAWESI Station Ujang Pandang													
Rain	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1980	654	555	357	227	94	19	0	76	0	17	217	820	3036
1981	559	509	309	140	152	49	17	2	23	48	326	681	2815
1982	727	429	544	163	73	6	0	0	1	0	47	453	2443
1983	293	152	118	119	68	175	4	0	5	187	515	544	2180
1984	679	673	511	246	192	53	55	35	167	28	309	687	3635
1985	532	295	517	248	151	71	17	9	6	33	497	335	2711
1986	468	500	558	209	47	109	29	15	1	91	317	176	2520
1987	873	474	412	111	54	18	0	0	0	0	114	1151	3207
1988	526	1056	410	210	141	27	38	49	74	102	387	663	3683
1989	744	696	183	477	51	78	50	30	18	66	220	464	3077
Average	605	534	392	215	102	61	21	22	30	57	295	597	2931
Maximum	873	1056	558	477	192	175	55	76	167	187	515	1151	3683
Minimum	293	152	118	111	47	6	0	0	0	0	47	176	2180
Stand Var	165	244	152	105	52	51	21	26	53	58	151	271	495
80%	467	329	264	127	58	17	3	0	0	9	168	369	2515
20%	744	739	520	303	146	104	39	43	74	106	422	825	3346



Figure 1 - ETo-RAIN DISTRIBUTION (Ujang Pandang, Indonesia)



**TABLE 5 - Crop Water Requirements and Irrigation Schedules Wheat**

**Cropwat: 24 September 1995**

**Reference Evapotranspiration Eto according Penman-Monteith**

Country: Nepal                                      Meteo Station: Butwal      (20 yr)  
 Altitude: 205 meter                                  Coordinates: 27.42      N.L.      83.28 E.L

Month	MaxTemp °C	MinTemp °C	Humid. %	Wind Km/day	Sunshine hours	Sol. Radia Mj/m2/day	ETo-PenMon mm/day
January	22.4	12.5	60	86	8.0	14.2	2.3
February	24.7	13.4	58	104	8.8	17.4	3.1
March	30.8	18.3	45	121	9.3	20.9	4.6
April	35.6	23.9	35	147	9.9	23.9	6.3
May	36.0	25.8	46	147	9.5	24.2	6.6
June	34.0	26.1	71	130	6.1	19.2	5.0
July	31.6	25.4	82	121	6.0	18.9	4.4
August	31.8	25.4	80	104	5.4	17.5	4.1
September	30.9	24.2	81	95	5.4	16.0	3.6
October	30.3	22.2	63	86	7.5	16.6	3.6
November	27.3	17.5	58	78	8.3	13.8	2.2
Year	29.9	20.7	62	108	7.7	18.2	1483

Climatic data compiled by FAO Agro-meteorological unit

**Cropwat: 24 September 1995**

Climate file: butwalClimate Station: butwal

	ETO (mm/day)	Rainfall (mm/month)	Eff. Rain (mm/month)
January	2.3	33.0	31.0
February	3.1	11.0	11.0
March	4.6	24.0	23.0
April	6.3	27.0	26.0
May	6.6	79.0	69.0
June	5.0	436.0	169.0
July	4.4	764.0	201.0
August	4.1	713.0	196.0
September	3.6	429.0	168.0
October	3.6	131.0	104.0
November	2.9	10.0	10.0
December	2.2	5.0	5.0
Year total	1482.6	2662.0	1013.0 mm

Effective Rainfall with USBR method

**TABLE 6 a - Crop Water Requirements Maize**

Crop Evapotranspiration and Irrigation Requirements								
Rain Climate Station:		Choma-avg		Crop:		Maize		
Eto climate station:		Choma		Planting date:		20/11		
Month	Dec	Stage	Coeff Kc	Etcrop mm/day	Etcrop mm/dec	Eff.Rain mm/dec	IrReq. mm/day	IrReq. mm/dec
Nov	2	Init	0.45	2.20	2.2	2.6	0.00	0.0
Nov	3	Init	0.45	2.19	21.9	33.0	0.00	0.0
Dec	1	Init	0.45	2.17	21.7	41.7	0.00	0.0
Dec	2	In/De	0.51	2.43	24.3	49.3	0.00	0.0
Dec	3	Deve	0.66	3.15	34.7	48.0	0.00	0.0
Jan	1	Deve	0.86	4.04	40.4	45.7	0.00	0.0
Jan	2	De/Mi	1.03	4.78	47.8	45.4	0.24	2.4
Jan	3	Mid	1.10	5.18	57.0	44.8	1.11	12.2
Feb	1	Mid	1.10	5.23	52.3	45.8	0.65	6.5
Feb	2	Mid	1.10	5.28	52.8	46.0	0.68	6.8
Feb	3	Mi/Lt	1.09	5.05	40.4	38.4	0.26	2.0
Mar	1	Late	0.99	4.42	44.2	29.6	1.46	14.6
Mar	2	Late	0.81	3.47	34.7	22.7	1.20	12.0
Mar	3	Late	0.61	2.50	20.0	12.8	0.90	7.2
Total					494.5	505.8	63.8	

Cropwat 7.0 (06/12/95)

**TABLE 6 b - Crop Water Requirements Rice**

Rice Evapotranspiration and Irrigation Requirements											
Rain Climate Station:		Choma		Crop:		Rice					
Eto Climate Station:		Choma		Transplanting date:		01/12					
Month	Dec	Stage	Area %	Coef Kc	Etcrop mm/day	Perc	Lprep mm/day	RiceRq mm/day	EffR mm/dec	IrReq mm/day	IrReq mm/dec
Nov	1	Nurs	10	1.20	0.58	0.2	1.8	2.5	2.3	2.30	23.0
Nov	2	Land	33	1.15	1.83	0.5	8.1	10.4	9.7	9.47	94.7
Nov	3	Land	78	1.05	3.96	1.2	8.1	13.2	24.7	10.77	107.7
Dec	1	Init	100	1.00	4.83	1.5	-	6.3	34.1	2.93	29.3
Dec	2	Init	100	1.00	4.80	1.5	-	6.3	37.1	2.59	25.9
Dec	3	Deve	100	1.01	4.80	1.5	-	6.3	41.6	2.86	31.5
Jan	1	Deve	100	1.03	4.83	1.5	-	6.3	39.0	2.43	24.3
Jan	2	De/Mi	100	1.04	4.86	1.5	-	6.4	40.4	2.32	23.2
Jan	3	Mid	100	1.05	4.94	1.5	-	6.4	41.7	3.00	33.0
Feb	1	Mid	100	1.05	4.99	1.5	-	6.5	37.0	2.79	27.9
Feb	2	Mid	100	1.05	5.04	1.5	-	6.5	36.0	2.94	29.4
Feb	3	Mi/Lt	100	1.05	4.87	1.5	-	6.4	20.4	3.18	25.4
Mar	1	Late	100	1.01	4.50	1.2	-	5.8	11.7	4.59	45.9
Mar	2	Late	100	0.93	3.98	0.9	-	4.9	1.1	4.74	47.4
Mar	3	Late	100	0.84	3.41	0.4	-	3.8	0.8	3.74	33.6
Total					619	178	180	977	378		602.2

Cropwat 7.0 (06/12/95)

**TABLE 7**

**Crowat: 24 September 1995**

**Irrigation Scheduling**

**Wheat 15 November**

Climate Station: Butwal  
 Crop : Wheat  
 Soil : medium

Climate File: butwal  
 Planting date: 15 November  
 Available Soilmoist: 140 mm/m.

Irrigation Options Selected:  
 Timing: Fixed Depletion of 40 mm  
 Application: Fixed Irrigation gift of 40 mm  
 Filed Application Efficiency 70 %

No. Irr.	Int days	Date	Stage -	Deplet %	TX %	ETA %	NetGift mm	Deficit mm	Loss mm	Gr.Gift mm	Flow L/s/ha
1	40	25 Dec	B	30	100	100	40.0	0.7	0.0	57.1	0.17
2	28	22 Jan	C	24	100	100	40.0	0.5	0.0	57.1	0.24
3	18	11 Feb	D	26	100	100	40.0	2.9	0.0	57.1	0.37
4	16	27 Feb	D	25	100	100	40.0	1.9	0.0	57.1	0.41
END	9	6 Mar	D	7	100	100					

Total Gross Irrigation	228.6 mm	Total Rainfall	56.1 mm
Total Net Irrigation	160.0 mm	Effective Rain	51.3 mm
Total Irrigation Losses	0.0 mm	Total Rain Loss	4.8 mm
Moist Deficit at Harvest	12.4 mm		
Net Supply + Soilretention	172.4 mm		
Actual Wateruse by Crop	223.7 mm	Actual Irr. Req	172.4 mm
Potential Wateruse by Crop	223.7 mm		
Efficiency Irr. Schedule	100.0 %	Efficiency Rain	91.4%
Deficiency Irr. Schedule	0.0 %		

No Yield Reductions due to water shortage.

**TABLE 8**

**Irrigation Scheduling**

**Wheat 15 November**

Climate Station: Butwal  
 Crop: Wheat  
 Soil: Medium

Climate File: Butwal  
 Planting date: 15 November  
 Available Soilmoist: 140 mm/m.  
 Initial Soilmoist: 140 mm/m.

Irrigation Options Selected:  
 Timing: Dates Defined by user: / 40 / 60 / 80  
 Application: Fixed Irrigation gift of 40 mm  
 Field Application Efficiency 70%

No. Irr.	Int days	Date	Stage -	Deplet %	TX %	ETA %	NetGift mm	Deficit mm	Loss mm	Gr.Gift mm	Flow L/s/ha
1	40	25 Dec	B	30	100	100	40.0	0.7	0.0	57.1	0.17
2	20	15 Jan	C	15	100	100	40.0	0.0	14.1	57.1	0.33
3	20	5 Feb	C	23	100	100	40.0	0.0	1.5	57.1	0.33
END	31	6 Mar	D	39	100	100					

Total Gross Irrigation	171.4 mm	Total Rainfall	56.1 mm
Total Net Irrigation	120.0 mm	Effective Rain	54.7 mm
Total Irrigation Losses	15.7 mm	Total Rain Loss	1.4 mm
Moist Deficit at hHarvest	64.7 mm		
Net Supply + Soilretention	184.7 mm		
Actual Wateruse by Crop	223.7 mm	Actual Irr. Req	169.1 mm
Potential Wateruse by Crop	223.7 mm		
Efficiency Irr. Schedule	86.9 %	Efficiency Rain	97.4%
Deficiency Irr. Scedule	0.0 %		

No Yield Reductions due to water shortage.

**TABLE 9 - Cropwat Cropping Pattern**

Cropping Pattern					
Name:					
Nr.	Crop file	Crop name dd/mm	Planting date dd/mm	Harvest Date %	Area
1	Rice	Rice	01/12	31/03	20
2	Maize	Maize	20/11	30/03	55
3	Beans	Beans	20/12	20/03	20
4	Tomato	Tomato	10/05	22/09	20
5	Cabbage	Cabbage	10/04	09/07	20
6	Citrus	Citrus	01/01	27/12	5

Cropwat 7.0 (06/12/95)

**TABLE 10 - Scheme supply**

Scheme Irrigation Requirements												
Rain Station: Choma						Cropping Pattern:						
Eto Station: Choma												
Crop Nr	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Crop IrReq (mm/day)												
1	2.6	3.0	4.4	-	-	-	-	-	-	-	7.5	2.8
2	0.9	1.7	3.0	-	-	-	-	-	-	-	0.0	0.0
3	0.1	1.8	2.5	-	-	-	-	-	-	-	-	0.0
4	-	-	-	-	1.9	2.0	2.7	3.0	2.5	-	-	-
5	-	-	-	2.4	2.3	2.3	0.7	-	-	-	-	-
6	0.0	0.1	2.7	2.4	1.8	1.5	1.6	1.7	2.4	2.3	0.7	0.1
SQ1	1.0	1.9	3.2	0.6	0.9	0.9	0.8	0.7	0.6	0.1	1.5	0.6
SQ2	32	53	98	18	29	28	24	21	19	4	46	17
SQ3	0.12	0.22	0.37	0.07	0.11	0.11	0.09	0.08	0.07	0.01	0.18	0.07
AR	100.0	100.0	93.3	25.0	45.0	45.0	31.7	25.0	25.0	5.0	61.7	93.3
Aq	0.12	0.22	0.39	0.28	0.24	0.24	0.28	0.28	0.32	0.29	0.29	0.07

SQ1,SQ2,SQ3 = Net Scheme Irr. Requirements in mm/day, mm/month and Ls/h  
 AR = Irrigated area as percentage of total scheme area  
 AQ = Irrigation requirements in L/s for actually irrigated area

Cropwat 7.0 (06/12/95)

**TABLE 11 - Choma, Zambia Rainfall data 1994-95**

Monthly Rainfall Data		
Climate Station: Choma		Eff. rain method: USDA S.C. Method
	Rainfall (mm/month)	Effective Rainfall (mm/month)
January	49.6	45.7
February	127.8	101.7
March	42.0	39.2
April	0.0	0.0
May	0.0	0.0
June	0.0	0.0
July	0.0	0.0
August	0.0	0.0
September	0.0	0.0
October	20.6	19.9
November	99.4	83.6
December	66.4	59.3
Total	405.8	349.4

Cropwat 7.0 (06/12/95)

**TABLE 12 - Rainfall data 1993-94**

Monthly Rainfall Data		
Climate Station: Choma		Eff. rain method: USDA S.C. Method
	Rainfall (mm/month)	Effective Rainfall (mm/month)
January	156.7	117.4
February	122.8	98.7
March	13.9	13.6
April	1.7	1.7
May	0.0	0.0
June	0.0	0.0
July	0.1	0.1
August	5.9	5.8
September	4.6	4.6
October	32.8	31.1
November	99.9	83.9
December	140.8	109.1
Total	579.2	466.0

Cropwat 7.0 (06/12/95)



### CROPWAT Rainfed Production Maize – Average Rainfall

Figure 2 - CROPWAT (Irrigation Scheduling Graphics Output)

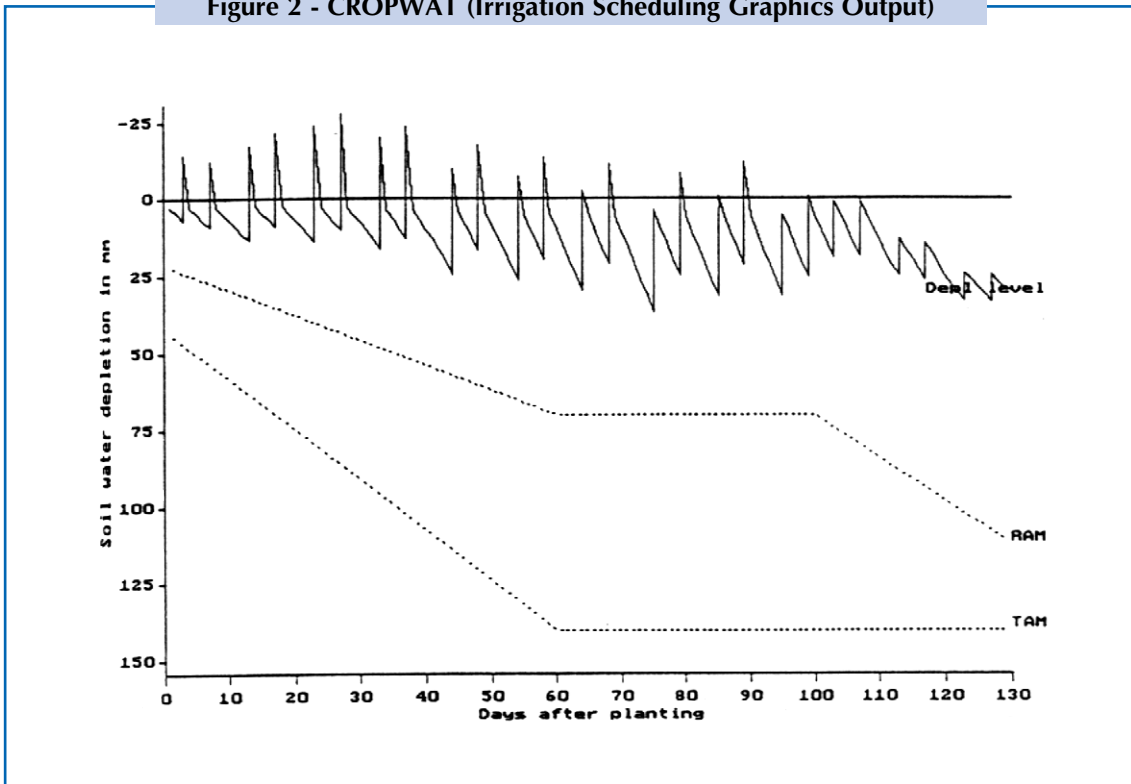


TABLE 13 - Cropwat Rainfed Production Maize - Average Rainfall

Irrigation Scheduling													
Rain Station: Choma Eto Station: Choma				Crop: Maize Soil: Medium				Plant date: 20/11					
Timing: No Irrigation, only rainfall Application:								Field Efficiency: 70 %					
No. Irr.	Int days	Date	Stage	Deplet %	TX %	Eta %	NetGift mm	Deficit mm	Loss mm	Gr.Gift mm	Flow L/s/ha		
End	131	30 Mar	D	23	100	100							
Total Gross Irrigation				0.0 mm				Total Rainfall				716.3 mm	
Total Net Irrigation				0.0 mm				Effective Rain				465.3 mm	
Total Irrigation losses				0.0 mm				Total Rain loss				250.9 mm	
Moist Deficit at Harvest				31.6 mm									
Actual Water Use by Crop				497.0 mm				Actual Irrig. Req.				31.6 mm	
Potential Water Use by Crop				497.0 mm									
Efficiency Irr. Schedule				- %				Efficiency Rain				65.0 %	
Deficiency Irr. Schedule				0.0 %									
No Yield Reductions													

### CROPWAT Rainfed Production Maize – Rainfall 1994 - 1995

Figure 3 - CROPWAT (Irrigation Scheduling Graphics Output)

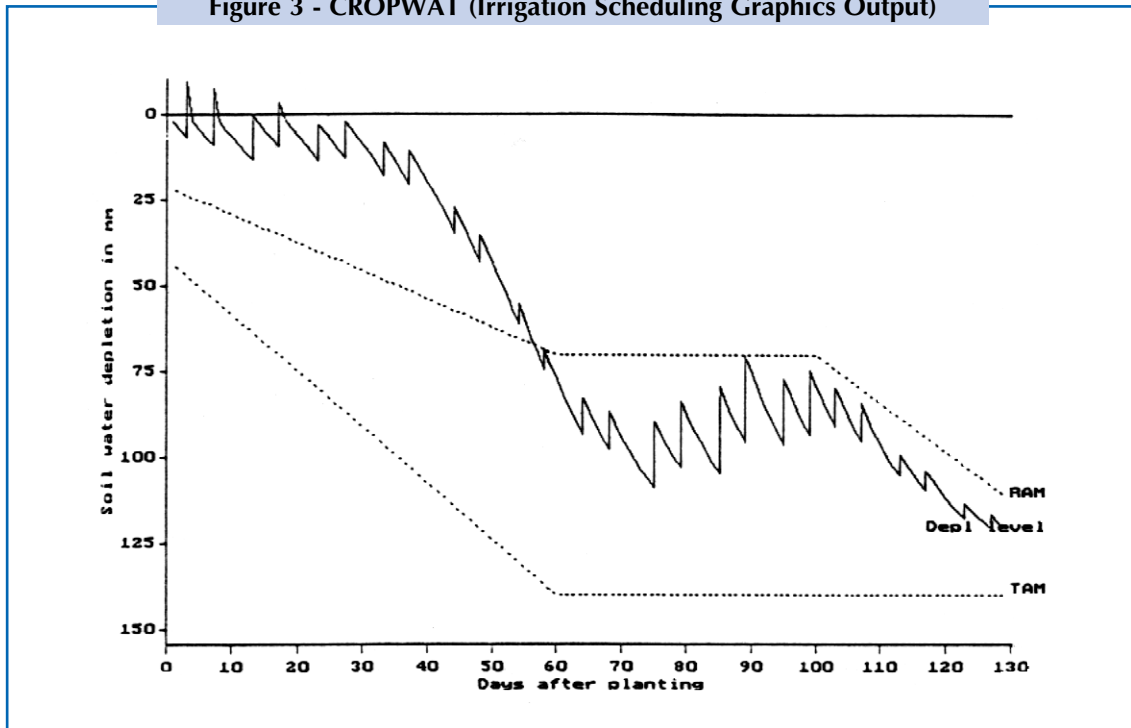


TABLE 14

#### Irrigation Scheduling

Rain Station: Choma - 95  
Eto Station: Choma

Crop: Maize  
Soil: Medium

Plant date: 20/11

Timing: No Irrigation, only rainfall  
Application: Field Efficiency: 70 %

No. Irr.	Int days	Date	Stage %	Deplet %	TX %	Eta mm	Netgift mm	Deficit mm	Loss mm	Gr.Gift L/s/ha	Flow
END	131	30 Mar	D	87	71	84					

Total Gross Irrigation	0.0 mm	Total Rainfall	318.8 mm
Total Net Irrigation	0.0 mm	Effective Rain	297.7 mm
Total Irrigation Losses	0.0 mm	Total Rain Loss	21.1 mm
Moist Deficit at Harvest	121.8 mm		

Actual Water Use by Crop 497.0 mm

Efficiency Irr. Schedule	- %	Efficiency Rain	93.4 %
Deficiency Irr. Schedule	15.6 %		

Yield Reductions	Stage	A	B	C	D	Season %
Reductions in Etc	0.0	0.2	26.8	20.3	15.6	%
Yield Response Factor	0.40	0.40	1.30	0.50	1.25	
Reductions in Yield	0.0	0.1	34.9	10.1	19.5	
Cumulative Yield Reduct.	0.0	0.1	35.0	41.6		



**TABLE 16 - Cropping Pattern**

Project:		Rajolibanda Climatic Station:			Kurnool	
No.	Crop:	Area %	Planting dates	Harvest dates		
1	Paddy	13	10 July	10 Nov		
2	Paddy	12	20 July	20 Nov		
3	Paddy	13	1 Aug	1 Dec		
4	Paddy	12	10 Aug	10 Dec		
5	Paddy	7	10 Dec	10 Apr		
6	Paddy	6	20 Dec	20 Apr		
7	Paddy	7	1 Jan	1 May		
8	Cotton	15	1 Aug	1 Feb		
9	Groundnut	6	15 July	5 Nov		
10	Groundnut	7	1 Aug	20 Nov		
11	Groundnut	7	15 Aug	5 Dec		
12	Groundnut	20	15 Dec	5 Apr		
13	Groundnut	20	1 Jan	20 Apr		
14	Groundnut	20	15 Jan	5 May		
15	Sorghum	5	15 July	15 Nov		
16	Sorghum	5	1 Aug	1 Dec		
17	Sugarcane	5	1 Jan	1 Jan		

**TABLE 17 - Scheme Irrigation Requirements**

Project:Climatic Station: Kurnool													
No.	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	
1	-	-	-	-	-	4.5	8.7	5.9	4.8	4.1	0.9	-	
2	-	-	-	-	-	0.9	9.9	6.0	4.8	4.7	2.5	-	
3	-	-	-	-	-	-	8.6	6.0	4.9	4.9	4.3	-	
4	-	-	-	-	-	-	4.2	8.3	4.9	4.9	5.3	1.2	
5	7.2	8.0	8.1	2.0	-	-	-	-	-	-	4.3	8.9	
6	7.2	8.0	8.8	4.5	-	-	-	-	-	-	0.8	10.2	
7	8.0	9.3	10.6	8.7	2.8	-	-	-	-	-	-	9.1	
8	2.8	-	-	-	-	-	-	-	0.1	1.7	3.3	3.5	
9	-	-	-	-	-	-	0.7	1.7	3.0	2.5	0.7	-	
10	-	-	-	-	-	-	-	-	0.9	1.6	1.4	-	
11	-	-	-	-	-	-	-	-	0.2	1.6	2.6	0.7	
12	1.9	4.6	5.3	1.4	-	-	-	-	--	-	-	0.4	
13	0.9	3.9	5.7	3.4	-	-	-	-	-	-	-	-	
14	1.0	3.0	7.1	7.1	1.8	-	-	-	-	-	-	1.5	
15	-	-	-	-	-	-	-	0.4	1.9	1.9	0.9	-	
16	-	-	-	-	-	-	-	-	0.9	2.3	2.3	-	
17	3.7	4.5	5.5	5.9	5.9	4.3	2.6	2.2	1.3	1.5	2.7	3.2	
SQ	2.9	4.2	5.7	3.7	0.8	0.9	4.1	3.5	2.9	3.2	3.1	3.2	mm/d
SQ	86	127	172	111	25	27	123	105	87	97	93	95	mm/m
SQ	0.33	0.49	0.66	0.43	0.10	0.10	0.48	0.41	0.34	0.37	0.36	0.37	ls/h
Ar	100.	85.3	85.3	58.5	13.9	17.5	54.8	64.3	85.3	100.	86.3	80.1	%
AQ	0.33	0.58	0.78	0.73	0.70	0.59	0.87	0.63	0.39	0.37	0.41	0.46	ls/h

**TABLE 18 a**

<b>Kharif</b>							
	Jun	Jul	Aug	Sep	Oct	Nov	Total
Actual Supply	5.8	26.3	35.4	36.2	39.6	38.5	181.8 MCM
Net SWR	27.0	123.0	105.0	87.0	97.0	93.0	532.0 mm
Irr. Eff.	50 %	50 %	50 %	50 %	50 %	50 %	%
Gross SWR	54.0	246.0	210.0	174.0	194.0	186.0	1064.0 mm
Irr. Area	10000	10000	10000	10000	10000	10000	HA
Supply Req.	5.4	24.6	21.0	17.4	19.4	18.6	106.4 MCM
Requir./Supply	93 %	94 %	59 %	48 %	49 %	48 %	59 %

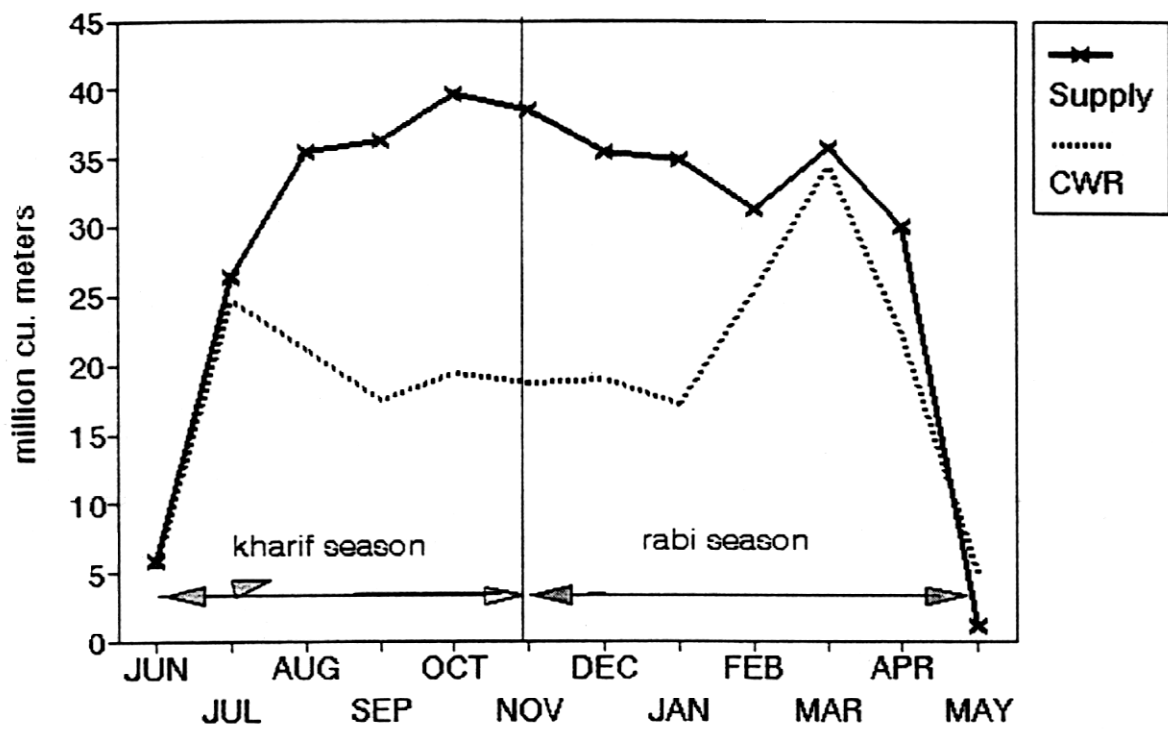
Evaluation scheme water supply Kharif season

**TABLE 18 b**

<b>Rabi</b>							
	Dec	Jan	Feb	Mar	Apr	May	Total
Actual Supply	35.4	34.9	31.2	35.8	30.0	1.1	168.4 MCM
Net SWR	95.0	86.0	127.0	172.0	111.0	25.0	616.0 mm
Irr. Eff.	50 %	50 %	50 %	50 %	50 %	50 %	%
Gross SWR	190.0	172.0	254.0	344.0	222.0	50.0	1232.0 mm
Irr. Area	10000	10000	10000	10000	10000	10000	HA
Supply Req.	19.0	17.2	25.4	34.4	22.2	5.0	123.2 MCM
Requir./Supply	54 %	49 %	81 %	96 %	74 %	455 %	73 %

Evaluation scheme water supply Rabi season

Figure 6 - IRRIGATIONS SYSTEM PERFORMANCE (Rajolibanda Scheme, India)





## ANNEX 7: Participatory methods

### INTRODUCTION

---

The Pilot Phase of the Special Programme for Food Security is an action-oriented, participatory process of consultation, problem identification and planning. The Guidelines for Water Management and Irrigation Development of the SPFS identify in particular the following steps where active participation of the local farmers is important:

- 1 Preliminary confirmation of the hypothesis, on what should be demonstrated and on target areas of the SPFS, which has emerged from the analysis of secondary data and discussions/brainstorming with key informants at the national level during the preparation phase;
- 2 Baseline surveys of the selected demonstration sites using Rapid Rural Appraisal/Participatory Evaluation Methods/Participatory Rural Appraisal;
- 3 Joint assessment of current irrigation practices, of main problems and potential for improvement at selected sites;
- 4 Consensus on the objectives and orientations of the demonstrations;
- 5 Verification of the interest and determination of farmers of the selected sites to participate in the SPFS;
- 6 Final selection of the technology by the farmers who should be fully aware of the implications in terms of investment, operation and maintenance;
- 7 Detailed planning including local resource mobilization for implementation;
- 8 Participation in the investment and also ideally letting of the contracts for construction works by the farmers' associations, and participation in the decision-making at all stages of implementation;
- 9 Participatory training throughout implementation, including capacity building of the local community to develop an institutional base for self-management;
- 10 Constraints analysis and policy dialogue for the preparation of the expansion phase;
- 11 Monitoring and evaluation.

The guidelines for **Conducting, Monitoring and Evaluating Demonstrations** and on the **Participatory Analysis of Constraints and Opportunities** of the SPFS discuss the rationale for using participatory methods in the SPFS and their application. Annex 8 **Training and extension** and Annex 11 **Monitoring and Evaluation** will discuss in details participatory processes throughout the implementation of the pilot phase. The present Annex concentrates on steps c- through g-, from the baseline survey of the demonstration sites to the detailed planning of the pilot phase.

### **PARTICIPATION, RAPID RURAL APPRAISAL, PARTICIPATORY RURAL APPRAISAL, PARTICIPATORY EVALUATION METHODS**

The development of Rapid Rural Appraisal in the 70s and 80s arose from a search for more “appropriate”, relevant, effective and cheaper social analysis methods, acknowledging the value of local people’s knowledge which had previously been overlooked. The RRA system was at first criticised for a low degree of confidence in results, sometimes leading to a low credibility with decision makers. There was also the danger of superficiality. However, the effectiveness and depth of understanding demonstrated by RRA has led to its wide acceptance among donor and national institutions today.

RRA’s predominant mode is to elicit or extract data from local people for learning by outsiders who would then analyze those data, develop solutions or formulate projects. Development field practitioners felt the need to develop methodologies that were more participatory and that aimed at empowering local people to analyze, develop solutions, plan and implement their development projects. In these methodologies, linkages between analysis, planning and action are more immediate, and the outsiders act essentially as facilitators.

Participatory Rural Appraisal (PRA) is one of these numerous methodologies with strong conceptual and methodological similarities, which now form a wide ranging family. These include Participatory Evaluation Methods (PEM), Rapid Assessment Procedures (RAP), Participatory Action Research (PAR), Participatory Learning Methods (PALM), Rapid Rural Systems Analysis (RRSA), **Méthode Accélérée de Recherche Participative** (MARP), Strategic Planning, and many others. These methods are largely based on group dynamics and visual tools and share a common aversion to quantitative data and questionnaires, and a dependence on the local knowledge base and local resources to the evolution of (local) solutions and actions. These features constitute both the advantages and limits of these methodologies.

RRA/PRA/PEM methods certainly have a role to play in appraising and planning irrigation schemes. However, the “bottom line” concerns who is

to participate in what and on what terms, conditions and expectations. This usually involves (or should involve) negotiations with the local authority and various stakeholders' groups, preferably with some built-in participant selection mechanism involving individual interviews.

The choice of a particular appraisal system will, in practice, depend largely on the type of project and the aim of appraisal.

Four major distinct modes of farmer participation can be identified:

### *Contract participation*

**Developers contract with farmers/communities to provide lands or services.**

In this approach the farmers' role is passive and participation is not a clear cut objective.

### *Consultative participation*

**Developers consult with farmers/communities about their problems and then develop solutions.**

This type of participation can be linked to the doctor-patient relationship. Researchers normally use RRA to define the farming system and diagnose priority problems. This type of participation is useful where solutions (technology) to priority problems entail a substantial change in the current farming system e.g. the establishment of horticultural crops. Such a technological change will only be adopted by farmers/communities, where a history of strong leadership, community cohesiveness and established rapport between community and development agent exists.

### *Collaborative participation*

**Developers and farmers/communities collaborate as partners in the planning/implementation process.**

This approach involves more intensive continuous interaction. Developers actively draw on farmers' knowledge in seeking solutions to identified constraints. Regular meetings are held between farmers and developers to understand farming practices, set priorities among development problems, develop solutions, monitor progress and review results. This approach is useful where conflicting needs/demands, a history of development failure, resistance to development and negative attitudes toward development agents exist. The technical solutions seek to address priority production problems within current farming systems through farmer support.

### *Collegiate participation*

#### **Developers work to strengthen farmers'/communities' informal farming systems in rural areas.**

The emphasis here is on making farmers better able to increase farm production on their own, as well as requesting support from formal institutions. This type of participation is useful with established farmers who are commercialised to a large extent.

In general, RRA techniques lean toward Contract and Consultative Participation while RRA/PEM techniques lean toward Collaborative and Collegiate Participation.

RRA/PRA/PEM have proven useful in studying irrigation systems and in planning and implementing irrigation projects. All have been used fairly widely in this regard. Many RRA/PRA/PEM techniques were applied in identifying constraints and opportunities for implementing irrigation opportunities for farmers, and in designing and planning projects. Present experience has led to the development of various guidelines to carry out the societal, institutional and technical studies needed for project planning and implementation. Involvement in these studies has in general increased local participation and improved working relations with project personnel.

The human and community factors can not be viewed in isolation but rather as a sub-system of the larger rural system. At a macro level national institutional systems, local institutional systems and the agri-rural milieu come into effect.

It is generally assumed that participatory methods are only applicable or only work in the case of small-scale schemes. This is in fact a misconception because historically participatory approaches were developed in the context of small-scale irrigation schemes. However recent advances in approaches to the rehabilitation of large-scale schemes rely on participatory approaches, such as in Office du Niger. Indeed, many RRA/PRA/PEM tools can be applied irrespective of the scale of the project.

In essence, the SPFS is clearly not of the Contract Participation type and closer to Collaborative and Collegiate Participation. This will largely depend on the nature of technologies which it is envisaged to demonstrate or to introduce and on the context of the demonstration sites. In practice, the pilot phase of the SPFS cannot be considered as a typical development programme because of its demonstrative nature. It follows that quantitative data sets are required for detailed economic analysis of demonstrated technologies. Results need to be analyzed thoroughly and conditions for replicability must be clearly identified. The SPFS also puts the emphasis on the demonstration of best available technological or organizational practices and the introduction of innovative approaches which may not be

known in the demonstration sites. Technical soundness of proposed solutions and interventions is of utmost importance in the pilot phase. Finally, the pilot phase of the SPFS aims at obtaining visible and significant impact in a rather short time and therefore lengthy and costly technical or socio-economic investigations are not envisaged. However data availability in the demonstration sites will typically be poor.

The national teams of the SPFS will therefore have to design an appraisal and planning system that properly sequences classical questionnaire-based surveys, RRA/PRA/PEM methods and “classical” technical investigations aiming at time-and-cost effectiveness without jeopardizing technical soundness and the participatory nature of the SPFS, according to: (i) the availability of secondary data; (ii) the nature of the proposed demonstrations, and (iii) context analysis.

The purpose of this annex is therefore not to request national teams to adhere to a particular participatory orthodoxy, sect or religion. Rather, the annex aims at establishing a number of key principles and presenting a “tool-box” of participatory methods national teams may use when preparing/designing the pilot phase, including as substitute or complement to “classical” methods presented in other annexes.

## ***THE MAIN ISSUES TO BE ADDRESSED***

---

The purpose of RRA/PRA/PEM is to answer a set of critical questions which precede and underlie sound planning of irrigation development. These are:

- Is there a demand for irrigation and are farmers willing to consider major changes to their farming system?
- Is a lack of water a limiting constraint in the farming system?
- What are present scheme and on-farm water management practices?
- What are the technical organizational constraints and opportunities in the improvement of the irrigation schemes (at on-farm and system level)?
- Who will benefit?
- Will there be losers and winners?
- What are their present farming systems?
- What are the constraints facing farmers and communities?
- Can production be increased?
- What are the perceptions and skills levels?
- What local institutions, including public and private service providers, are in place to support development and are there institutional problems?
- What is the hierarchial “chain” of support in institutions/services and are these in place?
- History of resistance to development intervention?



- History of failure/success in development intervention?
- What is the attitude toward the development agent/service provider?
- Identification of conflicting needs/demands within the community?
- What are the attitudes of non-agricultural interest groups such as youth and full-time wage labourers?
- Identify whether a process of negotiation is needed within the community, and between the community and the development agent?
- What are the basic socio-economic trends such as migration, off-farm wage employment by household members, changes in agricultural production etc?
- What are perceived community priorities?
- Labour availability, daily and yearly peaks and shortages?
- Current living costs and standards?
- Post harvest practices?
- Land tenure and land management structures?
- Present marketing organization?
- Experience with credit?
- Social activities and customary ceremonies?
- Risk factors and how they can be removed?
- Array of technical solutions to identified problems and constraints to lift for their adoption?
- Prioritization of constraints to lift and problems to solve?
- Identification of priority and most favourable actions to implement?
- Investment, organizational and technical capacity to implement preferred activities?
- Identification of complementary infrastructure/investment activities to implement?
- Agro-ecological, climatic, hydrological, soil suitability data?
- Responsibilities and interests of women and children?

## **KEY PERFORMANCE AREAS**

---

RRA/PRA/PEM methodologies aim at:

- gaining meaningful, manageable, up-to-date information in a cost effective manner;
- introducing a participatory approach to information exchange and solving communities (farmers) problems;
- ensuring that the community/farmers can control the planning process;
- optimising the relationship between research, information and decisions by all parties, the most important being the community;
- using local people's knowledge and capacity to analyze and solve problems;
- building sustainable structures for problem solving and development; and
- the "researcher" being also the educator/facilitator as well as the technical expert.

## ***CORE PRINCIPLES OF RRA/PRA/PEM***

---

### ***Systems***

A system can be described as a set of elements that interact with each other to produce some kind of output. The major elements in rural and agricultural development are:

- the human/institutional sub-system;
- the economic sub-system; and
- the natural/technical system.

RRA/PRA/PEM addresses the human/institutional sub-system in relationship to economic and natural/technical factors.

### ***Exploratory and highly iterative***

RRA/PRA/PEM is highly interactive so that inappropriate hypothesis and concepts can be abandoned or reformulated, based on new information. The faster this happens the faster one learns. For example: Semi-structured interviewing is one of the principal methods used because it allows interviewers to rapidly change questions as new information appears.

### ***Rapid and progressive learning***

RRA/PRA/PEM is not designed to provide the last word on resource use or the final solution to a development problem. New questions arise, but they enable researchers/developers/farmers to pinpoint problems and find solutions.

### ***Highly Participative***

Farmers' (communities) perceptions and understanding of resource situations and problems are important to understand. This is because solutions must be viable and acceptable in the local context and because local inhabitants have extensive knowledge about their resource settings.

### ***Interdisciplinary approach and team work***

In RRA/PRA/PEM an interdisciplinary approach is always important. The rural context in which farming is practised is complex. Farmers do not only have to deal with irrigation and crops but with many other variables which



comprise the rural system. The complexity of the situation makes it impossible for a professional specialising in any one discipline to adequately grasp all the problems that farmers must face, let alone find solutions.

### ***Flexibility and use of conscious judgement***

Although careful planning is a prerequisite of any successful study, an important principle of RRA/PRA/PEM is not just to “plan the work” but “work the plan” in a flexible manner, that allows for creativity and modification where appropriate.

To benefit from flexibility the RRA/PRA/PEM team relies on evaluation and conscious judgement to make effective and appropriate decisions. Two of the most important and basic types of decisions to be made at the start and during the course of RRA/PRA/PEM are what type of information is needed and what degree of precision is required or possible.

### ***Cost effectiveness: fairly-quick-and-fairly-clean***

The most common form of quick-and-fairly-dirty appraisal is rural development tourism - the brief rural visit by the urban based professional. This can be very cost effective with the outstanding individual, but more often than not biases arise toward the opinions of the well off, influential individuals in the community. At the other extreme, traditions of professional research have valued investigations which are much longer and more costly, often involving the collection of massive volumes of data. Sometimes the outcomes are academically excellent and make a contribution to understanding. All too often the delays are excessive, resulting in fairly-long-and-fairly-dirty.

The question then is whether there is a middle zone between quick-and-dirty and long-and-dirty: a zone of greater cost effectiveness. Professional values and reward systems undermine improvisation in learning about rural conditions. But cost effectiveness has its own rigor and generates its own values. Two values are suggested:

- knowing only what is worth knowing, this requires courage to implement. i.e. slough off the tendency to make “dead sure” and to elaborate “because you are there anyway”; and
- appropriate imprecision; in surveys much of the data collected has a degree of accuracy which is not needed, often order of magnitude and trends of change are adequate.

## METHODOLOGY

---

### Main features

The most commonly used methodologies pinpoint a few generally accepted departure points.

- A team approach is used where different disciplines are combined;
- The group interview method is mostly used, applying a structured or semi-structured questionnaire or interview format.
- Short but intensive periods are used as opposed to drawn out procedures, preferably with follow-up rapid surveys with short intervals;
- Wandering around and engaging in conversation with people who are actually busy in the field/household, using structured tools;
- Random sampling is not seen as important as opposed to distinguishing interest group;
- Secondary information is always used and seen as very important.

### Tool-box

In practice the national teams of the SPFS may use the following list as a menu of methods or as a “tool-box” to draw from (Appendix 1 illustrates some of these methods):

- **Secondary sources:** such as files, reports, maps, aerial and RS images, articles and books.
- **Do-it-yourself:** asking to be taught to perform village tasks.
- **Key information:** enquiring who are the experts and seeking them out.
- **Semi-structured interviews:** open-ended check-lists, using participatory as well as traditional verbal methods.
- **“Classical” structured questionnaires**
- **Groups of various kinds:** (casual; specialist/focus structures; community/neighbourhood).
- **Sequences or chains of interviews:** from group to group and/or key informants on various stages of process.
- **They do it:** villages and village residents are used as investigators and researchers.
- **Participatory mapping and modelling:** people use either background maps or local materials to make social, demographic, health, natural resources (soils, trees and forests, water resources, etc.) or farm maps, or construct 3-D models of their land; particularly useful for modelling of irrigation schemes, dams, etc.: during the making of the model or map, functioning, problems, failures, constraints, interventions can be identified and discussed.

- **Participatory analysis of aerial photographs or topo-maps:** to identify soil type, land conditions, land tenure and land management systems, hydrological/flooding conditions, analyze and diagnose water distribution and management systems in existing irrigation schemes, etc.
- **Transect walks:** systematically walking with informants through an area: for irrigation schemes; identifying different zones, local technologies, introduced technologies on-farm water management systems, seeking problems, solutions and opportunities, and mapping and diagramming resources and findings.
- **Time lines:** chronologies of events, listing major remembered events in a village.
- **Trend analysis:** people's account of the past, how things have changed, changes in land use and cropping patterns, in customs and practices in population, etc. and causes of changes and trends.
- **Ethno-biographies**
- **Seasonal diagramming:** by season, month or day, of rainfall, soil moisture crops, labour, non-agricultural labour, income and spending, etc. Data should be desegregated by gender/age group.
- **Livelihood analysis:** stability, crises and coping, relative income, expenditure, credit and debt, etc.
- **Participatory diagramming:** of flows, causality, trends, ranking, scoring: people make their own diagrams, system diagrams, bar diagrams, pie charts, etc. Venn diagramming is one form, identifying individuals and institutions.
- **Well being or wealth ranking**
- **Analysis of difference:** by gender, social group, wealth/poverty, occupation and age, identifying differences between groups, including their problems and preferences.
- **Scoring and ranking:** using matrix scoring for ranking of constraints, solutions, etc.
- **Key local indicators and probes**
- **Stories, portraits and case studies:** household history and profile, conflict resolutions, etc.
- **Presentations and analysis:** where maps, models, diagrams, and findings are presented by villages, or outsiders, and checked, discussed and corrected.
- **Participatory planning, budgeting, and monitoring:** Villages with (if necessary) external assistance prepare their own plans, budgets and schedules, and monitor progress.
- **Brainstorming by villages, with/without outsiders.**
- **Short, simple questionnaires**
- **Field visits:** Field visits are organized for farmers to sites where they can discuss with farmers who are using the technologies/methods which are proposed for introduction, and form an opinion.
- **Use of development Support Communication Tools:** farmers are shown and debate videos, slides, etc. on the SPFS, on proposed technologies, etc.

## ACTIVATING THE RRA/PRA/PEM PROCESS

---

### 1 Appointment of the multi-disciplinary team

This team should include a social/behavioural scientist, a technical discipline (irrigation for this purpose) expert and an agricultural/economic discipline expert, and local government representatives. In essence similar profiles should be represented for both the agency and the donor or for the parties included in the project(s).

In practice, it will often be necessary, if the national team of the SPFS and local agents of the national institutions participating in the SPFS are not familiar with RRA/PRA/PEM methods, to structure the RRA/PRA/PEM exercise as a learning-by-doing experience, in which, after an initial stage of formal training in the methodologies, SPFS agents under the guidance of RRA/PRA/PEM specialists, will design and perform the appraisal and planning system. This process will ensure that SPFS agents are familiarized with the methodologies and take advantage of training to get acquainted with demonstration sites and to plan and implement the pilot phase together with participating farmers.

### 2 Study of the available secondary sources of information in order to draw up a basic framework for designing the structure of the RRA/PRA/PEM.

These sources are:

- census;
- maps;
- population projections;
- land use patterns and potential; and
- specialised reports.

At this stage gaps in availability of secondary data should be identified and RRA/PRA/PEM methods and tools to fill these gaps should be thought of (hydrological maps, resource maps, seasonal diagramming, etc.)

### 3 The Multi-Disciplinary Team (MDT) should visit the area for observation.

This has the purpose of getting the feel for the economic base of the area and the spatial elements of the village/settlement area.

Watch and observe the obvious patterns of interaction i.e. fetching water, working in the lands, shopping, congregations, centres of

importance such as local administrative headquarters, clinics, schools, gathering places, etc.

Writing reports at the end of each of these steps are important, and will assist in (i) building the basis for the appraisal (ii) guiding the MDT in directing their focus for the interviews and other methods.

It should be remembered that, at this stage, the national team of the SPFS is supposed to have formed an hypothesis on what the focus of water management and irrigation development demonstrations should be, and that the purpose of the visit of the area is to:

- verify in a preliminary fashion the hypothesis which has been made;
- design the following sequence of formal RRA/PRA/PEM and “classical” investigation necessary for the planning and implementation of the pilot phase.

Verifying the appraisal hypothesis is important in the sense that all the members of the MDT should agree on the basic paradigm to be used. This will in turn assist in minimising the number of tools and questions asked in the questionnaires and interviews. Often far more questions are asked than are necessary and this process of limitation and discussion focuses the process on what is absolutely relevant. This depends (as explained above) on the minimum data sets required for detailed economic and technical monitoring and evaluation of pilot phase activities.

## **DATA**

---

The first round of data which should be gathered through questionnaires, structured/semi-structured interviews or other methods include the following:

### **1** Basic community profile on:

- demographics (age and gender of farmers);
- employment (especially patterns of off-farm employment and household wage income);
- education level of farmers;
- agricultural production/marketing;
- population settlement patterns;
- problems experienced in the community;
- needs in the community;
- self identified and self initiated activities;
- problem solving; and
- resource utilisation and allocation (land, labour, capital).

## 2 Institutional/organisational profile:

- local political structure;
- local administrative capacity;
- formal/informal groups;
- relationship in the community leadership (formal/informal) opinion formers, interaction; growth relationships, conflict resolution, factions.
- institutional skills
- planning;
- management;
- decision-making;
- representation;
- implementation; and
- prioritization.

It is vital that the prototype RRA/PRA/PEM sequence be finalized in consultation with key personnel/informants in the community/location/selected site.

Questions/issues should be discussed with these people prior to identifying community groups for administering the appraisal/planning component of the RRA/PRA/PEM.

## **SEQUENCE DEVELOPMENT**

---

Once the investigation content is specified, research methodology finalised and availability of secondary information determined, a community appraisal sequence must be developed and tested. These guidelines can avoid many potential problems:

- 1 Carefully check the appraisal system with the agreed upon content of the study and the availability of secondary data. It may become evident that some information cannot be collected or that the form in which it can be collected is different from the agreed upon.
- 2 Avoid the temptation to add questions thus complicating data collection and coding. This will leave less time for report writing, which is usually more time consuming than expected. It is usually better to cut questions than to add them.
- 3 Certain questions are unsuitable for group interviews or methods and should be avoided or answered by other investigation methodologies:
  - specific quantities, i.e. kilograms of beans produced, number of industries, number of inhabitants (e.g. by social mapping);



- specialised knowledge unlikely to be shared by a group i.e. problems concerning specific industries, or the type of water distribution systems (e.g. by resource mapping/modelling or transects);
- information about attitudes: do the people of this community, for example, feel that things are getting better, worse or staying the same (e.g. by social mapping, time-lines, trend analysis, stories, portraits and case studies, etc.);
- also be careful of questions that are:
  - too vague;
  - combine two questions into one;
  - indicate too many choices, and
  - are too long.

A good appraisal schedule should resemble a conversation - the words used should reflect the vocabulary and categories of the people who are interviewed.

Once a draft of the appraisal system including sequencing of interviews and other methods is ready, it should be tested. Errors can usually be detected by noting which questions are not understood or which tools do not function. Once a workable appraisal schedule is written, it should be tested by the team. Team members should be quizzed regarding problems with each question/tool. The appraisal schedule should be tested and retested until the study director is comfortable with it.

### ***APPLICATION OF RRA//PRA/PEM***

---

The RRA/PRA/PEM could be done in three ways at this point:

- 1 In a well-structured community, key individuals may be asked to identify representative groups to administer interviews/tools. This would be more effective, and would not necessarily need more time.
- 2 The appraisal schedule could simply be administered to a single group in the community, which will include typically the teachers, farmers, local administrators, business men/women, extension officers, health workers, local associations/group leaders, committee representatives and other individuals deemed necessary by the MDT and the key informers of the community.
- 3 It is realized that the community is composed of heterogeneous groups with conflicting interests. In this case, focus or stakeholder groups are identified and appraisal/negotiation/planning processes are adapted.



## ***ANALYSIS AND APPRAISAL***

---

Information analysis and appraisal completion are vital to implementing the research methodology.

Reporting should be clear and information and action should be directly linked.

The same groups should be used as sounding mechanisms to verify findings and the groups used to operationalize the information and actions identified.

The MDT must address the main issues in the report by jointly assessing and verifying, with identified community leaders and representatives of the stakeholders' groups the principal issues to be addressed.

## ***PLAN OF ACTION***

---

The final stage of the appraisal is the formulation of a plan of action with the active involvement of the groups in the beneficiary community. The "plan of action" which the pilot phase in the selected sites of the SPFS consists of, will typically include step-by-step approaches in the improvement/intensification of farming systems, based on the improvement or introduction of new water/irrigation management methods, for various target groups in demonstration sites, with accompanying training and local institution building activities.

Therefore, the formulation of the demonstration phase on the selected demonstration sites should not be considered as a straight-forward process. It is indeed the outcome of a complex process where RRA/PRA/PEM methods and "classical" socio-economic and technical investigation methods are implemented in a complementary fashion.

**APPENDIX 1 - illustrations of RRA/PRA/PEM method**

Prototype RRA/PRA sequence for socio-economic and production system diagnostic study - FAO 'AGLN) Ethiopia 1995

Data Item	Secondary Data	RRA	PRA
<b>Study Area:</b> history of settlement location and infrastructure land forms & land use land tenure distribution of HHs <sup>1</sup> by farm size soils	maps agric census agric census agric census maps	horal history: old men  transec walk key informants key informants local terminology	time line social map land use map  card sorting
<b>Climate:</b> monthly calendar rainfall & temperature frequency of good, avg. & bad years	records of meteorological stations	group meeting	calendar time line
<b>Demography:</b> number of HHs & population, ethnicity, literacy, household composition & development eyele distribution of HHs by HH type migration	population records	key informants key informants key informants	pie chart?
<b>Social Organization:</b> kinship, marriage, inheritance traditional social organization modern political organization (PA leadership) indigenous groups (ekub, edir, exchange labour)	ethnographic monographs	key informant interviews (elders, leader)	
<b>Economic Activities:</b> farm & non-farm population rural artisans shopkeepers, tea houses labour market and employment		key informant interviews & focus groups, HH interviews with labourers	enter shops, artisans on social map
<b>Infrastructure and Services:</b> roads, communications, transport, schools, health care PA buildings (seed store, office etc.) location of government agents (extension etc.) veterinary services, AI water points for humans & animals irrigation system input suppliers, consumer shops banking and credit churches/mosques	maps official reports of Government	key informant interviews	enter each item on social map
<b>Farming Systems:</b> Ethno-history of agriculture Distribution of HHs by production system	map of AEZs agricultural census sthnic maps	key informant -	time line pie chart
<b>Cropping patterns:</b> crop calendar crop mix trends in cropped area crop rotations ranking of crops in order of priority varietal preferences	crop calendar MOA statistics MOA statistics	group meeting HH interviews HH interviews	calendar pie charts line graph  matrix ranking matrix ranking
<b>Planting Decisious:</b> factors determining what farmers plant and where how much farmers plant of each crop pure stand versus mixed cropping timing		semi-structured interview or group discussion complemented by household interview	
<b>Cultural Practices and Labour Use:</b> land preparation method cultural practices by crop timing of key operations gender division of labour labour caledar of men & women on-farm hired/exchange labour, sharecropping	MOA crop budgets	semi-structured interview - - -	calendar bar graph
<b>Use of Technology:</b> equipment: oxen, cart, treactor, pump, thresher farm manure: production, to which crops applied fertility management strategies levels of input use: seeds, chemicals, fertilizer input source, cost, availability, how financed reason for not using more, % of HHs using none	%of HHs owning equipment: agricultural census, MOA statistics	key informants focus groups focus groups HH interviews	

**APPENDIX 1 - illustrations of RRA/PRA/PEM method (cont'd)**

Prototype RRA/PRA sequence for socio-economic and production system diagnostic study - FAO 'AGLN) Ethiopia 1995

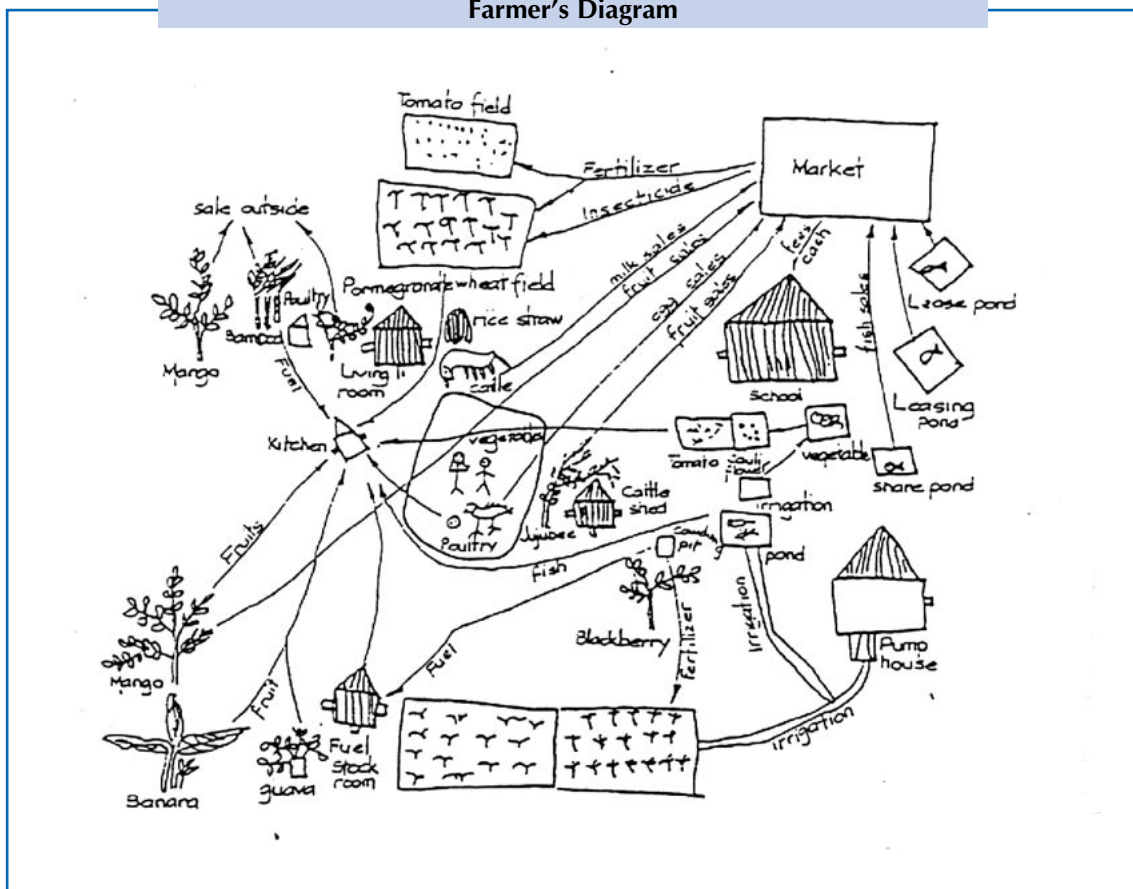
Data Item	Secondary Data	RRA	PRA
<b>Production and Yields:</b> Production and yields by crop & land type Yield variation: distribution of HHs by yield variation between years variation by socio-economic strata	MOA statistics on area, prod & yields (5 years series)	focus group interview household interviews (purposive sample)	
<b>Utilizations of Farm Products:</b> End use of crops (food, seed, sale, feed etc.) End use of straw (feed, mulch, manure, fire etc.) Ranking of crops (best for food, sale, feed etc.) Factors determining end use of products Variation by socio-economic stratum		focus group complemented by HH interviews (purposive sample) - -	Matrix ranking
<b>Marketing:</b> Crop marketing (proportion sold, price, timing sales, buyers, reasons for selling/non-selling)	MOA statistic on marketed output price variation	Focus group + HH interviews	Calendar of crop sales & prices
<b>Animal Husbandry:</b> Ranking of purpose of keeping each species Distribution of HHs by livestock ownership Calendar of herd movements, feed sources, milk production, calving, diseases, livestock sales, hay Livestock production parameters Marketing (livestock & by-products) Pasture management & forage Crop/livestock interactions Variations between production system Variations between socio-economic strata	MOA statistics on livestock numbers agricultural census  MOA production parameters market statistic	focus group key informant focus group  breeding history focus group focus group HH interviews HH interviews HH interviews	matrix ranking pie chart calendar
<b>Food preferences &amp; Level of Self-Sufficiency:</b> Staple foods in order of preference Seasonal food calendar Distribution of HHs by degree of self-sufficiency Variations between average, bad and good years Seasonality of supply & price of food Hungry season coping strategies	MOA statistics: convert root crops to grain equivalent divide total grain production by	verbal ranking  focus group + HH interviews	Food calendar
<b>Other Sources of Farm &amp; Non-Farm Income:</b> Permanent crops (tree crops, coffee etc.) Forestry, forest management & use rights Hunting, fishing, food gathering Agricultural wage labour Brewing Petty trading	MOA statistic	key informant or focus group	Calendars of cash inflow by source
<b>Household Economy:</b> Calendar of income sources & amounts Calendar of expenditure by type Variations by socio-economic stratum Livelihood pie diagrams, by socio-economic stratum Wealth ranking Savings/investment/process of capital accumulation Process of impoverishment		focus groups focus groups focus groups  HH interviews case histories case histories	calendar calendar pie chart wealth ranking
<b>Communication Networks:</b> Major agricultural innovations (5 main enterprises) Sources of innovation (identify actors) Linkages between village & sources of innovations Degree of contact with different services	% of HHs owning radio/TV	key informants  focus groups	time line circle actors linkage map venn diagram
<b>Problems &amp; Priorities:</b> Ranking of problems, by socio-economic stratum Causes of problems & possible solutions Farmer/HH ranking of proposed interventions Ranking of problems & priorities by village leaders	list of problem & priorities as seen by Government	focus group + HH interviews  village leader interview	problem tree
<b>Best Bet Options:</b>	List existing technologies	focus group discussion of technologies	validation & restitution

PRA and RRA methods for rapid catchment analysis

Group and Team Dynamics	Interviewing and Dialogue	Visualisation and Diagramming
<ul style="list-style-type: none"> <li>• Team contracts</li> <li>• Team reviews and discussions</li> <li>• Interview guides and checklists</li> <li>• Rapid report writing</li> <li>• Role reveals/Work sharing (taking part in local activities)</li> <li>• Villager and shared presentations</li> <li>• Process notes and personal diaries</li> </ul>	<ul style="list-style-type: none"> <li>• Semi-structured interview</li> <li>• Focus groups</li> <li>• Key informants</li> <li>• Direct observations</li> <li>• Transec walks</li> <li>• Ethnihistories and biographies</li> <li>• Oral histories</li> <li>• Local stories, portraits and case studies</li> </ul>	<ul style="list-style-type: none"> <li>• Participatory mapping and modelling</li> <li>• Farm sketches and profiles</li> <li>• Social maps and wealth ranking</li> <li>• Seasonal calendars</li> <li>• Daily routines and activity profiles</li> <li>• Trend analyses</li> <li>• Matrix scoring</li> <li>• Preference of pairwise ranking</li> <li>• Venn diagrams</li> <li>• System diagrams</li> <li>• Network diagrams</li> <li>• Systems diagrams</li> <li>• Flow diagrams</li> <li>• Pie diagrams</li> </ul>

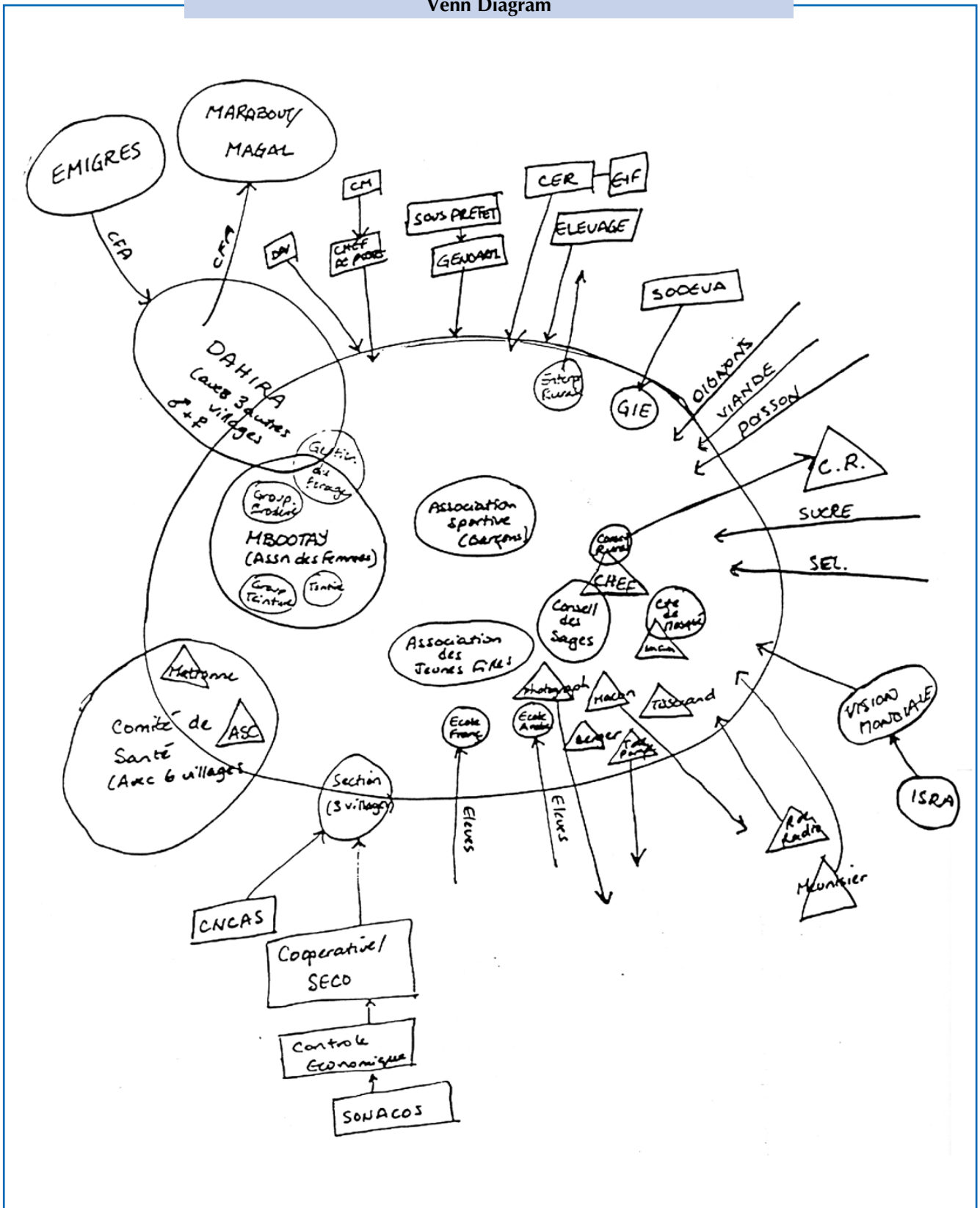
Source: Pretty, Kiara and Thompson, 1994.

Farmer's Diagram



Source: Lightfoot, Feldman and Abedin, 1991

Venn Diagram



Source: Village in Senegal: Schoonmaker, reudenberger, 1991

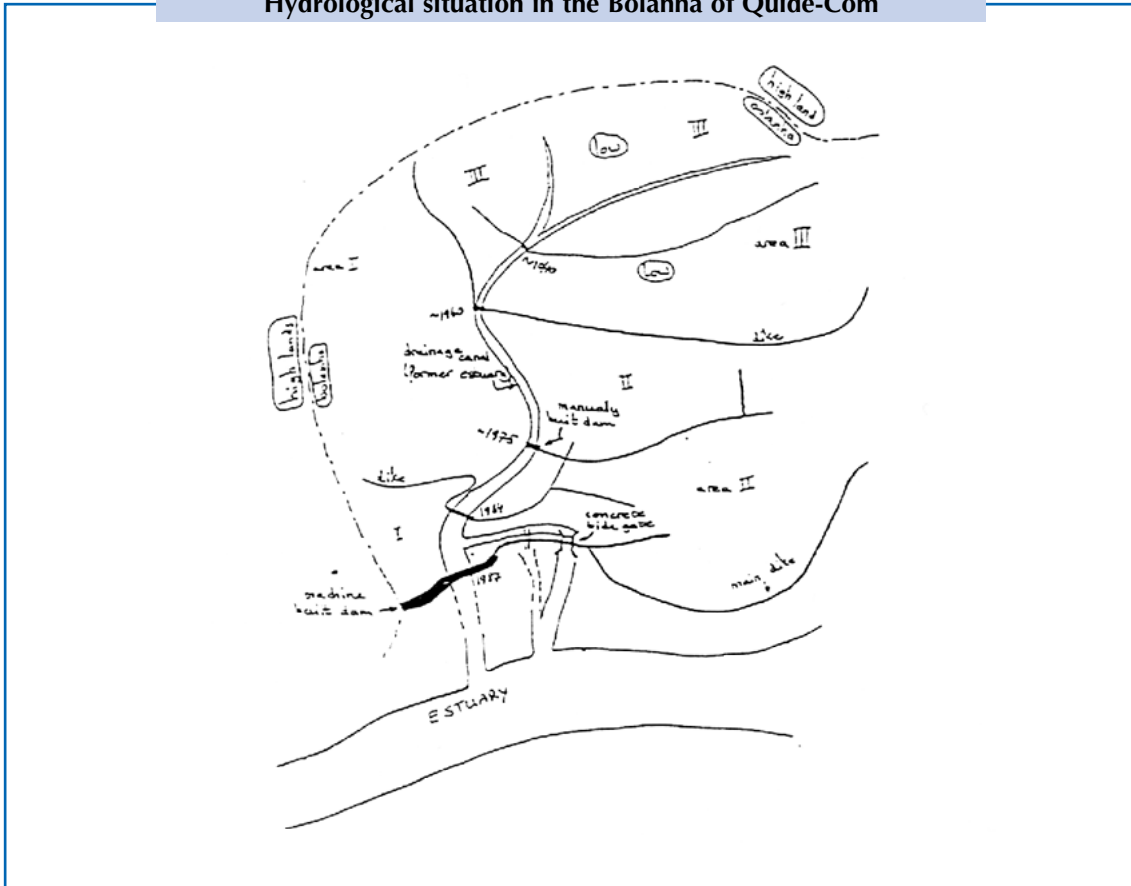
Land management decision-making levels

DEFINITION DU TERROIR	TERRE EN FRICHE	TERRES CULTIVES	ARBRES	CHEPEL	NIVEAU DE DECISION
-	Utilisation; Paturage Bois Cueillette	Speculation Rotation Enrichissement des sols	Entretien et Exploitation	Investissement Utilisation de fumier Pouvoir de gestion délégué aux bergers Trois	
-	Consensus sur rotation des friches entre familles	-Droit d'aînesse pour attribot* des terres familiales -emprunter des terres aux personnes intér.	Possesseur de terre controles plantation des arbres	? ----- Berger gère fumier et lait	
-	Negotiation en cas de conflit  Informé de toutes décisions	controles emprunts par pp. extérieures  Attribution du HAK MOOH	conflits: negotiations entre familles	-	
Negotiation avec autres villages.  Negotiation avec C.R.	Negotiation avec les villages environnants	-	-	-	
Decide Conflits entre Terroirs en Dipute  LOI SUR LE DOMAINE NATIONAL	Decide sur conflits sur parcours  LOI SUR D.N. DECRET SUR PARCOURS ET	PATURAGES	Interdiction d'abattage  CODE FORESTIER	Vaccination obligée pour bovins  CODES PASTORALX	

Source: Schoonmaker, Freudemberger, 1991



Hydrological situation in the Bolanha of Quide-Com

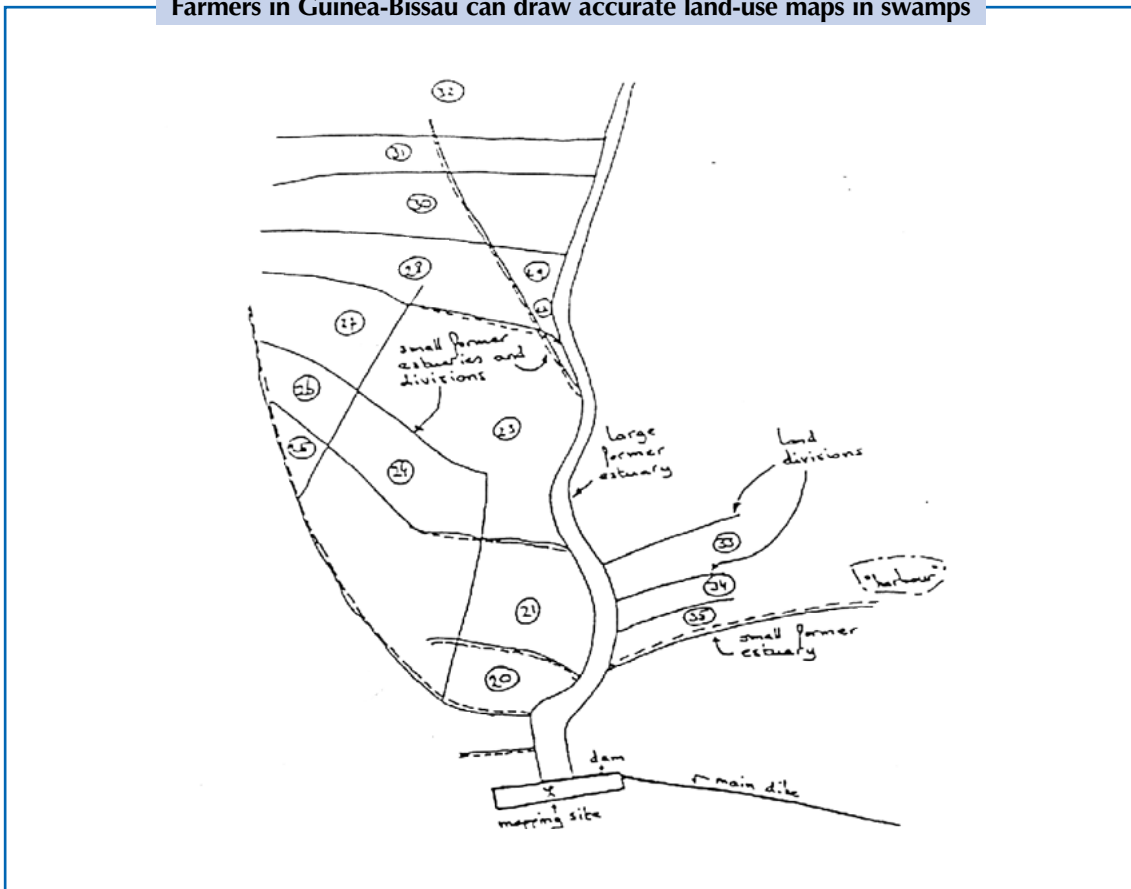


Source: K. Neefjes, 1991

Note: Hydrological units in swamp can be zoned accurately by farmers in Guenea-Bissau



Farmers in Guinea-Bissau can draw accurate land-use maps in swamps



Source: K. Neefjes, 1991

Step-by-step approach to appraisal, planning and implementation of inland valley bottom development

N°O	ETAPES	ACTIVITES A MENNER	PARTENAIRES ET LEURS ROLES			ACTIONS D'ACCOMPAGNEMENT
			COMMUNAUTES VILLAGROISES	STRUCTURE LOCALE DE DEVELOPPEMENT CARDER/ONG	PROJET	
1	- Sensibilisation	<ul style="list-style-type: none"> <li>- Informations sur les systèmes de dégradations des ressources naturelles</li> <li>- Faire connaître les sys d'aménagement disponibles et les</li> <li>- Formes d'assistance disponibles</li> </ul>	<ul style="list-style-type: none"> <li>- Les leaders préparent les rencontres avec les techniciens</li> <li>- Assistent nombreux et s'informent</li> </ul>	<ul style="list-style-type: none"> <li>- Aide les populations à recenser les problèmes du milieu</li> </ul>	<ul style="list-style-type: none"> <li>- Prépare les outils pédagogiques</li> <li>- Rencontre les leaders</li> <li>- Donne les informations et répond aux questions</li> </ul>	<ul style="list-style-type: none"> <li>- Identification des leaders</li> <li>- Inventaire des bas-fonds et terroirs</li> </ul>
2	Prise de conscience	<ul style="list-style-type: none"> <li>- Identification des problèmes liés à l'exploitation des bas-fonds (inondation des cultures par les crues ; retrait précoce des eaux) et à la dégradation des sols du terroirs</li> <li>- Expression des besoins en matière d'aménagement</li> </ul>	<ul style="list-style-type: none"> <li>- Mise en place d'une organisation d'aménagement et de gestion</li> <li>- Réunions de concertation</li> <li>- Prises de décision</li> <li>- Formulation de la requête d'assistance</li> </ul>	<ul style="list-style-type: none"> <li>- Animation</li> <li>- Conscientisation</li> <li>- Vérifie la conformité de la requête par rapport aux objectifs de développement de la localité</li> <li>- Aide à formuler la requête d'assistance</li> </ul>	<ul style="list-style-type: none"> <li>- Réunions d'information.</li> <li>- Séances de formation et projection de film et diapo.</li> </ul>	<ul style="list-style-type: none"> <li>- Visite de sites déjà aménagés</li> <li>- Formation des leaders paysans</li> </ul>
3	- Recherche de solutions	<ul style="list-style-type: none"> <li>- Analyse des besoins</li> <li>- Etudes socio-économiques et techniques du milieu</li> <li>- Elaboration de solution avec variantes</li> <li>- Choix final (type et système d'aménagement plan et structure de financement)</li> </ul>	<ul style="list-style-type: none"> <li>- Fournitures des informations et appui aux études des topographes</li> <li>- Analyse des contraintes techniques et sociales avec les techniciens et prise de décisions sur le choix final</li> </ul>	<ul style="list-style-type: none"> <li>- Appui aux populations dans la collecte des données</li> <li>- Vérification de la solution retenue</li> </ul>	<ul style="list-style-type: none"> <li>- Réunions avec les populations</li> <li>- Collecte des données socio-économiques</li> <li>- Proposition de variante</li> <li>- Finalisation de la solution retenue par les populations</li> </ul>	<ul style="list-style-type: none"> <li>- Formation des paysans et des agents</li> <li>- Elaboration de dossier technique d'aménagement et de mise en valeur sur la base de données techniques et des préoccupations des populations</li> <li>- Etude du plan de financement du volet crédit avec CLCAM/CRCAM</li> </ul>

Step-by-step approach to appraisal, planning and implementation of inland valley bottom development (cont'd)

Suite

N°O	ETAPES	ACTIVITES A MENER	PARTENAIRES ET LEURS ROLES			ACTIONS D'ACCOMPAGNEMENT
			COMMUNAUTES VILLAGOISES	STRUCTURE LOCALE DE DEVELOPPEMENT CARDER/ONG	PROJET	
4	- Programmation opérations (travaux et actions d'accompagnement)	- Définition des modalités de réalisation technique : . planning d'exécution . tâches des divers partenaires . relation des partenaires	- Analyse de leurs temps de disponibilité et prises de décisions  - Signature du contrat de développement	Signature du contrat de développement	- Etablissement du contrat de développement  - signature du contrat de développement	- Etablissement avec CRCAM/CLCAM, FDV, FAIB, des dossiers de crédit (demande de crédit présentée par les populations) - Formation des paysans et des agents aux techniques d'aménagement et de la mise valeur
5	- Réalisation des opérations (travaux d'aménagement, de mise en valeur et des actions d'accompagnement)	- Organisation - Exécution des travaux d'aménagement - Répartition des terres - Mise en valeur y compris (labour, planage des parcelles)	- Mise en place d'équipes de travail  - Construction des diguettes  - Seules responsables, décident des spéculations  - Organisent l'approvisionnement en intrants  - Réalisent les opérations culturelles	Animation  Conseil	- Formation et appui à l'organisation - Conseil technique - Financement	- Formation des paysans et agents aux techniques d'aménagement - Implantation des ouvrages et diguettes - Réalisation des ouvrages par des équipes spécialisées - Réception des travaux - Formation des paysans aux techniques culturales améliorées - Mise en place des parcelles de démonstration
6	Evaluation des opérations	- Analyse des données de la campagne sur le plan de la production du fonctionnement technique de l'aménagement - Analyse de l'impact financier ; économique et sanitaire sur les populations et le milieu physique	- Prise de décision et recommandations		Assistance technique et conseil	- Collecte tout au long de la campagne de production des données sur le fonctionnement des aménagements et sur les résultats de production

Source: Benin

## Selected bibliography/references

### *ASOCON*

1990. Indigenous conservation Farming Practices. ASOCON report 7, RAS/86/027 Goroka, New Guinea.

### *Carley Michael*

1993. Policy Management Systems and Methods of Analysis for Sustainable and Rural Development, Rome. FAO.

### *Chambers R.*

1992. Methods for Analysis by farmers: The Professional Challenge, farming Systems Association Conference. Michigan USA.

October 1992. Rural Appraisal: Rapid, Relaxed and Participatory. IIED.

1993. Changing the Professions: Frontiers for Rural Development. London I.T.

### *Coastal Resources Centre, USAID*

1994. A Participatory and Adaptive Approach to Integrated Coastal management. Ecuador's Eight Years of Experience. Paper presented at the International Symposium on Coastal Resources Management, Guayaquil, 15-17 Nov.94.

### *Cornwall A., Guijt I. and Welbourn A.*

1993. Acknowledging Process: Challenges for Agricultural Research and Extension Methodology. Sustainable Agriculture Research Series 1(1):21-47. Sustainable Agriculture Programme, IIED London.

### *DDC/FAO*

199? Sociological Analysis in Investment Projects. DDC/FAO, Rome.

### *FAO*

1986. Guide for Training in the Formulation of Agricultural and Rural Investment Projects.

1986. Guide for Training in the Formulation of Agricultural and Rural Investment Projects. Planning Tools.

1989. Farming Systems Development: guidelines for the conduct of a training course in Farming Systems Development.

1992. Guidelines for the Design of Agricultural Investment Projects. Investment Centre Technical Paper No.7. FAO, Rome.

*FAO*

1992. Sociological Analysis in Agricultural Investment Project Design. Investment Centre Technical Paper No.9. FAO, Rome.

1992. Programmation et préparation de petites opérations de développement rural. TMAP 28, Rome.

1993. Guidelines for Participatory Nutrition Projects.

1994. Participatory Rapid Appraisal of Farmers' Agricultural Knowledge and Communication Systems, Project report (TSS-1) and draft case study, DSC Branch, FAO. A two page poster summary on the same experience which will be published in the proceedings of the International Symposium on Systems-Oriented Research in Agriculture and Rural Development (Montpellier, Nov. 1994).

*FAO/DHI/92/TO1*

Participatory Rapid Appraisal of Farmers' Agricultural Knowledge and Communication Systems.

*FAO, Plant Nutrition Management Service*

February 1995. Socio-Economic and Production System Diagnostic Study.

*Franzel S. and Van Houten H.*

1992. Research with Farmers - Lessons from Ethiopia. Inst. of Agri. Research, Ethiopia.

*Freudenberger K.*

1994. Community Field Manual 4. Tree and Land Tenure: Rapid Appraisal Tools. Rome, FAO.

*Fujisaka Sam*

1994. Will Farmers Participatory Research Survive in the International Agricultural Research Centres? Gatekeeper Series 44. Sustainable Agriculture Programme, IIED, London

*Gill G.J.*

1993. The Data's Lousy, But it's all We've Got (Being a Critique of conventional methods). Gatekeeper Series 38. Sustainable Agriculture Programme, IIED, London.

*Gosling L.*

1993. Assessment, Monitoring, Review and Evaluation Toolkits. Save the Children Fund. London

*Grandstaff Terry and Messerschmidt Donald*

May 1993 (draft). Managers Guide to the Use of Rapid Rural Appraisal. FAO, Rome.



*Guijt Irene*

1992. Gender Difference. IIED, 3 Endsleigh Street, London WC1H ODD.

*IIED*

1991. RRA note, Number 13: Participatory Rural Appraisal, Proceedings of the February 1991 Bangalore PRA Trainers Workshop. London. 143 p.

1991. RRA notes, Number 14. Participatory Methods for Learning and Analysis. London. 66P.

1992. From Input to Impact: Participatory Rural Appraisal for Action Aid the Gambia. 182 p.

1994. RRA Notes 19: Special Issue on Training. Sustainable Agriculture Programme, IIED, London. See specially:

- *Duggan Bill.*  
Rapid Rural Appraisal Training for Baseline Data Collection and Target Group Identification (pp. 79-84).
- *Guijt Irene.*  
Making a Difference: Integrating Gender Analysis into PRA Training (pp. 49-55).
- *Kievelitz U. and Forster R.*  
Some Insights into Training for Rapid and Participatory Appraisal in A Northern Setting (pp. 61-65).
- *Shah P. and Shah M.K.*  
Training of Village Analysts (pp. 88-93).

*Kasivelv S., Howes R. and Devavaram J.*

February 1995. PLA notes #22. "The use of PRA in rehabilitating minor irrigation tanks"

*Lamin A.S.*

January 1996. Multidisciplinary approach to the classification and selection of IVS for sustainable agricultural production. Sierra Leone.

*Mascarenhas James, et al*

1991. Overview of workshop: PRA in India, RRA Notes 13.

*Molnar, August*

1989. A Review of Rapid Appraisal Tools for Use in Natural Resources Management Planning and Project Design and Execution. FAO, Rome.

*Narayan Deepa*

1993. Participatory Evaluation Tools for Managing Change in Water and Sanitation. World Bank Technical Paper. World Bank. Washington DC.

*Neefjes K.*

1991. Examples of Participatory Rural Appraisal (PRA) in Wetland Development in Guinea Bissau.

*Oakely P.*

July 1985. Manual for the Monitoring and Evaluation of a People's Participation Project (draft). FAO. Rome

*Pretty J.N.*

1994. Alternative Systems of Inquiry for Sustainable Agriculture. IDS Bulletin 25(2):37-49.

*Pretty J.N. and Chambers Robert*

1993. Toward a New Learning Paradigm: New Professionalism and Institutions for Agriculture. Sustainable Agriculture Research Series 1(1):21-47. Sustainable Agriculture Programme, IIED, London

*Pretty J.N. and Guijt I.*

1994. New Horizons: the Economic, Social and Environmental Impacts of Participatory Watershed Development. Summary of an International Workshop, Bangalore, India, 28 Nov.-2 Dec. 1994.

*Pretty J.N. Thompson J. and Kiara J.k.*

1994. Agricultural Regeneration in Kenya: The Catchment Approach to Soil and Water Conservation. *Ambio* (forthcoming).

1994. Agricultural Regeneration in Kenya: the catchment approach to soil and water conservation.

*Quinney S.*

1994. PRA Methods and their Application to Participatory Monitoring and Evaluation. *RRA Notes* 19:85-89. IIED, London.

*Schoonmaker M.K., Freudenberger, IIED*

1993. Champs, jachères et flexibilité: La gestion des ressources naturelles à Noame Mor Fademba, Sénégal.

*Scoones, I. and Thompson J. (eds)*

1994. Beyond Farmer First. Rural People's Knowledge, Agricultural Research and Extension Practice.

*Shah Parmesh*

1991. Participatory Rural Appraisal and Planning (PRAP): The Experiences of AKRSP (India). *RRA Notes* 13.

*Stilwell T. and Du Toit W.*

January 1993. A Manual for Irrigation Planning in Developing Areas, Annexure III: Human and Institutional Resource Base; Initial Social Analysis.



*Thomas G.*

1990. Participation in Practice. Lessons from the FAO People's Participation Programme, FAO Rome.

*Thompson J.*

1994. From Participatory Appraisal to Participatory Practice: viewing Training as Part of a Broader Process of Institutional Development. World Development.

*Thompson J., Shah J. and Foellmi E.*

1994. Planning for a Change: Participatory Rural Appraisal for Community Based Sustainable Development (See Especially Chapter 6: Follow-up) IIED, London and KIDP, Islamabad.

*Thomson R. - Dorman*

1992 #3. Participatory Rural Appraisal. A.I.D. Evaluation News.

*Thrupp L.A., Cabarle B. and Zazueta A.*

1994. Participatory Methods and Political Processes: Linking Grassroots Actions to Policy-making for Sustainable Development in Latin America. In: I. Scoones and J. Thompson, eds., Beyond Farmer First: Rural People's Knowledge, Agricultural Research and Extension Practice. Intermediate Technology Publications. London.

*Tolley Elizabeth and Bentley Margaret E.*

1992. Participatory Methods for Research on Women's Reproductive Health RRA/PRA. RRA notes 16, p 63-68.

*Uphoff N.*

1989. A Field Methodology for Participatory Self-evaluation of PPP Group and Inter-Group Association Performance, prepared for FAO by Rural Development Committee, Cornell University, Ithaca, New York.

## **ANNEX 8: Training and extension**

### ***INTRODUCTION***

---

To achieve a successful introduction of the new irrigation techniques and technologies a process of technology transfer need to be initiated which will involve the adaptation of the technologies to the socio-economic and cultural environment as well as putting in place the support services to ensure a successful and sustainable introduction of new technologies in the farmers' field.

Training will play a decisive role in this process of technology transfer and in building the necessary capacity in the various supporting institutions and agencies. To provide adequate technical knowledge and support in the selection of the technologies and in adapting the techniques to the specific conditions in the field, the various staff categories need to be trained in line with their specific role. To have farmers accept the new techniques, and to ensure their full participation in the installation, operation and maintenance of the new irrigation equipment and techniques farmers need to receive special training adapted to their socio-cultural background and support over an extended period of time.

An essential element of the SPFP programme will be therefore the training of staff of the various institutes and agencies as well as the training of farmers. The staff training programme consists of a series of well prepared training sessions for each category of staff, technical as well as extension staff. The farmers training is implemented as an integrated part of the extension programme and is scheduled in line with the various activities of the Irrigation Component and the staff training programme.

Training concerns not only the transfer of knowledge and skill development, but more importantly is the tool to prepare the different staff categories on their specific role and tasks in the SPFP irrigation programme, to schedule the various activities and to monitor the implementation of the IC programme, to identify constraints and to adjust the programme.

The ultimate aim of the training will be to ensure a sustained support to farmers in the successful introduction of the new techniques and technologies to will create the support structure which will guarantee to initiate the expansion of the techniques on a national scale.

## OBJECTIVES

---

The overall objective of the Irrigation Component SPFP training programme can be formulated as :

- to develop the institutional capacity to provide adequate support to the implementation of the SPFP Irrigation Component (IC-SPFP)

More specifically the training aims to:

- to provide information on the concept of the SPFP programme and the modalities in the implementation of the Irrigation Component,
- to enhance the technical knowledge and skills of staff of technical and extension agencies in the various irrigation technologies,
- to develop an appropriate programme and work plan with the concerned staff and farmers in the implementation of the irrigation technologies,
- to familiarize farmers with the benefits of the new irrigation technologies and to provide adequate support to adopt and sustain the technologies,
- to establish a system of monitoring and adjustment in programme implementation in which progress and constraints are closely and continuously monitored.

Details of the objectives of the individual training courses are worked out below.

## THE TRAINING PROGRAMME:

---

The establishment of the training programme for the Irrigation Component, requires adequate preparations and includes a number of essential components as indicated shortly below:

### **Institutional Support Analysis,**

includes the identification and evaluation of the various agencies and institutions involved in irrigation and irrigated agriculture and their role and tasks in the implementation of the IC activities (training need analysis).

### **Training Plan,**

the schedule of the various training sessions is determined by the IC workplan and follows closely the various growing seasons. The first farmers training is implemented in preparation of the first irrigation season, preparatory staff training is carried out prior to the farmers training.

**Staff Training,**

based on the tasks assigned to the various agencies and staff and the workplan, the objectives and curriculum and schedule for each of the various training courses is worked out. Training sessions are short and practical, directed to the immediate tasks at hand and the evaluation of tasks completed.

**Farmers Training,**

the farmers training forms a central element of the implementation of the IC programme and is directly linked to the staff training activities. Much attention needs to be given to an appropriate approach and methodologies to fully involve farmers in the process of introduction of the new irrigation technologies.

**Monitoring and evaluation,**

linked with the training activities are the monitoring and evaluation of the technology transfer process. Each training activities includes the evaluation of the results and constraints in the implementation of the programme on which adjustments in the programme are made and agreement on the reporting requirements for the subsequent activities. The details of the various steps are further worked out below.

## ***INSTITUTIONAL SUPPORT***

---

To determine the role and tasks of the various institutes and agencies to be involved in the implementation of the IC programme involves the following steps:

### ***Institutional Structure***

To determine the role and tasks of the various institutes and agencies to be involved in the implementation of the IC programme an assessment need to be made of the actual institutional structure and the support required to implement the programme.

**The Irrigation Agency** will usually have the responsibility in all technical matters concerning water resources development and construction, operation and maintenance of major irrigation structures. An assessment need to be made of the responsibilities of the different departments and the decentralized functions of the units at provincial, district and scheme level.

**The Agricultural Agency** will have responsibilities in providing various technical support services in relation to agricultural inputs such as agricultural research and agricultural extension. Supply of agricultural

inputs such as seed, fertilizer and mechanical equipment is increasingly provided through the private sector. Key department will be the extension department as the extension agents, will maintain the direct contacts with the farmers and be directly involved in the training of the farmers.

**Decentralization Structure**, the various agencies will have in general a decentralized structure in with typically at central, provincial, district, sub-district and village level, staff is allocated specific tasks and support services along established lines of command and procedures.

An evaluation needs to be made of the staff at each level and their present tasks and responsibilities.

### Support Functions

Includes the definition of the role and tasks of the various staff of each of the agencies to be assigned in the implementation of the programme.

Table 1 provides an example of the various staff involved in the implementation of the IC demonstration programme.

**TABLE 1 - Staffing involved in the implementation of the Irrigation Component in Zambia**

Central	IRRIGATION ENGINEERING SERVICE				Staff
	<ul style="list-style-type: none"> <li>• Irrigation Coordinator (Head IES)</li> <li>• Irrigation Staff</li> </ul>				2 IE
Province	CENTRAL PROVINCE		LUSAKA	SOUTHERN	3 PIE 3
	<ul style="list-style-type: none"> <li>• Pr. Irrigation Eng</li> <li>• Irrigation Assist.</li> </ul>		<ul style="list-style-type: none"> <li>• Pr. Irrigation Eng</li> <li>• Irrigation Assist.</li> </ul>	<ul style="list-style-type: none"> <li>• Pr. Irrigation Eng</li> <li>• Irrigation Assist.</li> </ul>	
District	MKUSHI	CHIBOMBO	KAFUE	KOSOMO	4 DAE 8 SMS
	<ul style="list-style-type: none"> <li>• Agr.Eng</li> <li>• SMS</li> </ul>	<ul style="list-style-type: none"> <li>• Agr.Eng</li> <li>• SMS</li> </ul>	<ul style="list-style-type: none"> <li>• Agr.Eng</li> <li>• SMS</li> </ul>	<ul style="list-style-type: none"> <li>• Agr.Eng</li> <li>• SMS</li> </ul>	
Blocks	• Block Off.	• Block Off.	• Block Off.	• Block Off.	10 BO
CAMPS	4 PILOT*s • 4 C.O.'s	2 PILOT*s • 2 C.O.'s	3 PILOT*s • 3 C.O.'s	6 PILOT*s • 6 C.O.'s	15 CO
PILOT Area	PILOT • 20 farmer	PILOT • 20 farmer	PILOT • 20 farmer	PILOT • 20 farmer	300

In cases where insufficient staff is available to secure the adequate and timely implementation of the IC programme, consideration may be given to assignment of special staff under auspices of the SPFP programme. Adequate insurances need to be given however that such staff is required for the purpose of the pilot phase only and does not effect replicability in the expansion phase.

An example of the detailed tasks and terms of reference is given in box 1.

**Box 1 - Irrigation engineer (DIO)****Tasks**

Will participate on a daily basis in the planning and implementation of the irrigation management programme for SPIN in the district. He will coordinate with the FAO Field Coordinator and ensure the necessary link and support from the District Irrigation Office. His specific tasks will include:

- to provide technical guidance in the implementation of the various irrigation improvements work proposed under the SPIN programme.
- to supervise and provide technical guidance to the FAO field engineer
- where appropriate to prepare terms of reference for surveys and designs to be made for the irrigation improvement works and advise on eventual tendering procedures for construction.
- to advise on the quantities and procurement of the various construction materials for construction works to be carried out by farmers.
- to assist in the conductance of the various seasonal and technical farmers training courses in the field of irrigation.
- to advise and assist in the preparation the necessary training and extension materials in irrigation
- to attend the seasonal and technical training courses organized for the SPIN district Team
- to advise on specific technical training needs in irrigation related to the implementation of the SPIN programme

**Agricultural (Extension) Officer (S.M.S.)****Tasks**

Will participate on a daily basis in the planning and implementation of the SPIN programme in the district. He will be the direct counterpart of the FAO Field Coordinator ensuring the necessary link and support from the District Agricultural Office. His specific tasks will include:

- to advise on the appropriate agricultural technologies to be introduced for irrigated agriculture
- to plan and conduct the various seasonal and technical farmers training courses
- to prepare the necessary training and extension materials
- to attend the seasonal and technical training courses organized for the SPIN district Team
- to advise on the procurement of the necessary agricultural inputs (seeds, fertilizers)
- to advise on specific technical training needs related to the implementation of the SPIN programme
- to provide technical guidance and supervision to the JT and JTA's of the Agricultural Service Centres involved in the SPIN programme

## Coordination

Implementation of the Irrigation Component under the SPFP requires the involvement of different department and ministries, with often quite different interests. Adequate attention needs to be given in the implementation of the programme to ensure coordination between the various departments participating in the programme.

The establishment of a Steering committee is recommended to ensure coordination between the various agencies and guide and advise on the implementation of the irrigation component. Such steering committees need to be established at national level, as well as at district and village level.

The Box 2 provides an example of the tasks of the District Coordination Committee in Nepal.

### **Box 2 - District Coordination**

In order to ensure the necessary coordination and support from the various line agencies in the District, a District Coordination Committee will be established which will meet regularly for the following purpose:

- to be briefed on the concepts and objectives of the SPIN programme and the proposed SPIN activities in the District, and in consecutive meetings on activities, progress and results and constraints encountered,
- to provide advise on the implementation of the SPIN programme in relation to ongoing development priorities and programmes in the district,
- to advise on the feasibility of the programme, to indicate areas of support and cooperation and to provide solutions to overcome constraints

In the training programme adequate provisions need to be included of the briefing and information of the various coordination committees.

## *Training Plan,*

The schedule of the various training sessions is determined by the workplan of the irrigation component which follows closely the various growing seasons. The first farmers training is implemented in preparation of the first irrigation season , preparatory staff training is carried out prior to the farmers training.

An example of how the various training activities can be scheduled in a training plan is shown in fig 1.





## **STAFF TRAINING**

---

Based on the tasks assigned to the various agencies and staff and the workplan, the objectives and curriculum and schedule for each of the various training courses is worked out. Training sessions need to be short and practical and directed to the immediate tasks at hand and include an evaluation of the tasks completed.

It is useful to make a distinction between Seasonal training and Technical training :

**The seasonal training** relates to the training, where staff receives briefing on the programme objectives for the coming season and jointly targets and procedures are worked out. At the same time an evaluation is made of the results and constraints experienced in the implementation of the workplan over the past season.

**The technical training** is more specifically oriented towards in the development of knowledge and skills in the introduction of specific techniques. The need for technical training is determined during the seasonal training and is related directly to the identified technologies to be introduced and the agricultural and technical constraints to be addressed. Timing of such technical training can be arranged during the growing season.

Separate training courses need to be given to each of the staff categories. In general separate training is provided to the technical irrigation staff and the agricultural extension staff as each staff category has quite distinct tasks in the implementation of the programme and quite different backgrounds.

### **Technical Staff Training**

The Technical staff training is carried out by the central team with help from selected resource persons. For each training season the specific objectives need to be set and includes a mixture of seasonal and technical training. The technical staff is in its turn responsible for the implementation of the training of the agricultural extension staff and adequate attention needs to be given to provide guidelines for the training of the extension staff.

An example of an outline of the training of technical staff is included in the following table:

**TABLE 5 - Technical Staff Training**

Training Session	Dates	Objectives
TST1	5 -9 Febr >96	<ul style="list-style-type: none"> <li>• to introduce staff to objectives and activities of the irrigation component</li> <li>• to provide training on the various irrigation techniques and technologies to be introduced</li> <li>• to train staff in the implementation of the first training course for extension staff and the implementation of the selection and rapid rural appraisal techniques of the pilot areas</li> <li>• to evaluate results of the irrigation inventories in the selected districts</li> </ul>
TST2	25 - 29 March	<ul style="list-style-type: none"> <li>• to evaluate results of the first training for extension staff</li> <li>• to introduce concepts and procedures of the participatory farmers training</li> <li>• to train staff in the implementation of the second training for extension staff</li> </ul>
TST3	3 - 8 June	<ul style="list-style-type: none"> <li>• to evaluate results first farmers training</li> <li>• to evaluate the proposed irrigation improvement plan</li> <li>• to prepare training on specific technical subjects</li> </ul>
TST4	5 - 9 Aug	<ul style="list-style-type: none"> <li>• to evaluate results monitoring visits and field reports</li> <li>• to prepare training on specific technical subjects</li> </ul>
TST5	21 - 25 Oct	<ul style="list-style-type: none"> <li>• to evaluate results and constraints of the first irrigation season</li> <li>• to prepare and budget requirements for next year programme</li> </ul>

Each of the training sessions need to be worked out in more detail and will include the preparation of a timeschedule in which the various topics are allocated a certain time and an appropriate balance between lectures, groups activities, practical exercises and field demonstration are worked out.

An example of such detailed curriculum is provided in the attached figure 2.

### ***Extension Staff Training***

The agricultural extension staff will be involved directly with the implementation and day-to-day follow-up of the programme at field level. Their training will be aimed to transfer the necessary knowledge in the irrigation techniques and agricultural practices for irrigated crops as well to familiarize staff with the participatory farmers training and rapid rural appraisal techniques. The training will be organized and implemented by the technical staff at provincial and district level.

The specific objectives need to be defined for each training session and will include a mixture of seasonal planning and technical training. An example of the objectives of the various training sessions for the agricultural extension staff is given in table 3.

FIGURE 2 - 3.3 Agenda first seasonal district training course (SDT1)

	DAY 1	DAY 2	DAY 3
	<b>I. AGRICULTURE DEVELOPMENT PLAN</b>	<b>II. IRRIGATION MANAGEMENT PLAN</b>	<b>III. FARMERS TRAINING</b>
9:00 - 10:00	<b>Opening Session</b> - Welcome by Chief DADO - Introduction to SPIN Objectives	<b>Presentation:</b> - Irrigation and Crop Production - Concepts of On-farm Water management	<b>Presentation:</b> - Schedule of seasonal and technical training - objectives and requirements
10:00 - 10:45	<b>Presentation</b> - SPIN Workplan and Schedule of activities - Tasks and role of the SPIN District Team <b>Discussion</b>	<b>Presentation:</b> - Description Irrigation System starter project, - Problems in the irrigation system - Operation and maintenance procedures	<b>Presentation:</b> - selection of contact farmers - involvement of women
10:45 - 11:00	Coffee Break	Coffee Break	Coffee Break
11:00 - 11:45	<b>Presentation</b> - Results Agro-socio Surveys of SPIN starter projects - Proposed Agric. Demonstration Programme - preparing cropping plan for winter season	<b>Presentation</b> - water distribution and irrigation blocks - function of regulating structures - interpretation irrigation map	<b>Presentation:</b> - Concepts in adult training techniques - participatory rural appraisal - problem identification, solutions finding
11:45 - 12:15	<b>Groups Exercise</b> - Prepare Cropping Calendar	<b>Groups Exercise:</b> - preparing sketch map and irrigation map	<b>Groups Exercises</b> - preparing problem tree
12:15 - 13:00	<b>Presentation</b> - Appropriate Varieties and Seed Procurement - Crop cutting procedures	<b>Presentation:</b> - Water Users Group - Role and task WUG	<b>Presentation:</b> - Presentation Farmers training programme - Procedures and Set-up of training schedule
13:00 - 14:00	Lunch Break	Lunch break	Lunch Break
14:00 - 14:45	<b>Presentation</b> - Soil Fertility and Fertilization for various crops	<b>Presentation:</b> - Development of Irrigation Improvement Plan - Reducing water losses in the irrig. system - rotational distrib. & irrigation schedules	<b>Presentation:</b> - procedures development and implementation of agricultural plan with farmers - procedures for irrigation management plan
14:45 - 15:45	<b>Groups Activity</b> - Crop cutting procedures - Estimating Fertilizer rates	<b>Groups Activity:</b> - proposing irrigation improvement plan - preparing a workplan for irrigation improv.	<b>Groups Activity:</b> - prepare detailed training procedure - assess requirements and constraints
15:45 - 16:00	Tea Break	Tea break	Tea break
16:00 - 17:00	<b>Presentation:</b> - Procedures in the SPIN demonstration programme <b>Discussion</b>	<b>Presentation:</b> - procedures in the introduction and implementation of the irrigation plan <b>Discussions</b>	<b>Groups Presentation:</b> - discussions and finalization plans <b>CLOSURE</b>

TABLE 3 - Extension Staff Training

Training Session	Dates	Objectives
EST1	19 - 23 Feb >96	<ul style="list-style-type: none"> <li>• to familiarize extension staff on the objectives and activities of the small-holder irrigation programme</li> <li>• to provide basic training in irrigation and irrigation techniques</li> <li>• to train ext. staff in selection and rapid rural appraisal of pilot schemes</li> </ul>
EST2	1 - 5 April	<ul style="list-style-type: none"> <li>• to evaluate suitability proposed pilot schemes and to the results of the rural appraisal studies</li> <li>• to familiarize staff with procedures for participatory training of farmers</li> <li>• to prepare staff for the implementation of the farmers training and conditions for the implementation of the irrigation techniques</li> </ul>
EST3	17 - 21 June	<ul style="list-style-type: none"> <li>• to evaluate results first farmers training and proposed irrigation improvement plans</li> <li>• to train staff on specific technical and agricultural aspects related to the implementation of the programme</li> </ul>
EST4	23 - 27 Sep	<ul style="list-style-type: none"> <li>• to evaluate results of the first irrigation season</li> <li>• to make proposals for the programme of next year</li> </ul>

Similarly as with the technical staff training, a detailed curriculum and timeschedule need to be worked out for the training sessions of the extension staff.

## **FARMERS TRAINING**

The farmers training forms a central element of the implementation of the SPFP programme and is directly linked to the staff training activities. Much attention needs to be given to an appropriate approach and methodologies to fully involve farmers in the process of introduction of the new irrigation technologies.

The specific objectives of the farmers training are:

- to evaluate with farmers present short comings in the irrigated farming system
- to introduce to farmers the potential benefits of new technologies and improvements in the irrigation system and agricultural practices
- to define a work plan to introduce new irrigation technologies and improve the irrigation system including an agreement on the contributions and participation of farmers in the improvement plan
- to define an agricultural development plan which will optimize crop production under the improved water supply conditions



FIGURE 3 - 4.6 Schedule first seasonal farmers training course - 20 October to 10 November 1995

	1st Farmer Training Day	2nd Farmer Training Day	3rd Farmer Training Day	4th Farmer Training Day
<b>Time Schedule</b> (tentative)				
08:30 - 09:30	<b>INTRODUCTION SPIN</b> Selection Collaborating Farmers	<b>AGRICULTURAL PLAN</b> cropping and demonstration plan	<b>Irrigation System</b> Irrigation Management Plan	<b>SPIN Winter Season Plan</b> agreement
09:30 - 10:00	<b>Opening &amp; Introduction</b> - by Chief District Agr.Dev.Off - by FAO Team Leader/Field Coord. - by Village Officials	<b>Block Presentation</b> - presentation by block representatives of proposed winter crops and areas - presentation of problems	<b>Block Presentation</b> - presentation by each block of proposed cropping and demonstration plan for rabbi season	<b>Block Presentation</b> - proposed block irrigation improvement plan - proposal WUG contributions
10:00 - 11:00	<b>SPIN Team Presentation</b> - Presentation SPIN programme - Schedule of activities - Criteria for selection collab. farmers - Presenting (Sketch) Map of command area	<b>SPIN Team Presentation (SMS,JA)</b> - Cropping plan, crop rotation, harvest rice and planting date rabbi crops - Rice Yield estimates, crop cutting - Potential for increasing area and yield of winter crops	<b>SPIN Team Presentation (DIO)</b> - Irrigation management and O&M - Role of the WUG - Common problems irrigation system - flood and drainage problems	<b>SPIN Team Presentation (DIO)</b> - Workplan Irrigation Management Plan for Rabbi Season - Strengthening of the WUG organization - contribution SPIN
	<b>Groups Activity</b> - division in blocks and sub-group - listing of farmers for each block	<b>Groups Activity</b> - Field walk on proposed cropping plan - Listing of requirements in seeds and fertilizers, - land cultivation constraints	<b>Groups Activity</b> - Field Walk along irrigation system - Listing of problems in the irrigation system - Maintenance and repair requirements	<b>Groups Activity</b> - elaborate on water fees and O&M tasks for each water user
11:00 - 11:30	<b>SPIN Team Presentation</b> - Agreement of block and group formation - Outline of the Farmers groups - Problems in Agricultural Production	<b>SPIN Team Presentation</b> - Evaluation of requirements to achieve targets for winter season - Fertility and Fertilization requirements - Varieties and Seed Procurement	<b>SPIN Team Presentation</b> - summary of proposed improvements - urgent repair and later improvements - contribution WUG, contribution WUG - Problems in Rabbi Irrigation	<b>SPIN Team Presentation (DADO)</b> - Workplan implementation - Agricultural Plan - Procurement and delivery inputs - contribution WUG ad conditions for receipt seeds and fertilizers
11:30 - 12:30	<b>Groups Activity</b> - Prepare outline cropping plan rabi - Listing of Problems	<b>Groups Activity</b> - draw soil fertility map and soil requirements - select preferred varieties - define production, demonstrations and trial requirements	<b>Groups Activity</b> - preparing workplan for the improvement works - role and responsibilities WUG - list problems in rabbi irrigation	<b>Groups Activity</b> - Formulation of priority issues and required support and technical training for the rabbi season
12:30 - 13:00	<b>Block Task</b> - Proposed plan for winter season and listing of problems in the cultivation of the winter crops.	<b>Block Task</b> - for each block finalize cropping plan and adoption of demonstrations	<b>Block Task</b> - discuss with other farmers proposed block irrigation improvement plan and the contribution of each WUG member	<b>Closing Session</b> - presentation consolidated SPIN plan - agreement on inputs and contributions - address WUG leader



## Participatory Approach

The introduction of the new technologies will be done in full consultation and consent of the farmers. For that purpose a process of participatory rural appraisal will be implemented through a range of well scheduled and prepared training sessions, in which farmers will determine which technologies will be introduced where, who will contribute and how much and where problems and constraints arising during the introduction of the technologies will be jointly analyzed.

The groups and communal operation and management of the water and land resources will be strengthened in order to ensure a sustainable resource base. Where appropriate Water Users Associations (WUA) will be formed to manage and operate the irrigation system.

## Farmers Training Schedule.

In following table an example is given on the schedule of proposed training activities for farmers

**TABLE 6 - Farmers Participatory Training**

Training Session	Dates	Objectives
FT1	8 Apr - 10 May	<ul style="list-style-type: none"> <li>• to discuss with farmers the potential for irrigation development</li> <li>• to prepare an irrigation improvement plan for the dry season</li> <li>• to determine support and further training required</li> </ul>
FT2	24 - 28 June	<ul style="list-style-type: none"> <li>• to monitor progress and constraints</li> <li>• to introduce specific techniques and technologies</li> </ul>
FT3	5 - 9 Aug	idem
FT4	2 - 6 Sep	idem
FT4	1 - 12 Oct	<ul style="list-style-type: none"> <li>• to evaluate results and constraints over the season</li> <li>• to prepare a tentative improvement plan for next year</li> </ul>

Various aspects need to be considered in the preparation for the farmers training and are shortly elaborated below:

Farmers participation, the selection of collaborating farmers need to be given due attention in order to have a lasting impact of the training and demonstration programme. Women representatives, block repartition, the formation of subgroups and the involvement of non-participating farmers need to taken into account.

## **Farmers Training Schedule**

In consultation with farmers an appropriate schedule of training session need to be worked out, taking into account various seasonal and socio-cultural activities. In general five training session scheduled over a five week period on a fixed day per week, will be optimal to formulate and agree on a first water management improvement plan. The successive training sessions with farmers will be agreed according requirements and follow closely the various growing seasons.

**Training Approach and Methodologies**, will be an essential element in the success of the farmers training. The approach will be based on the Participatory Rural Appraisal (PRA) concept which guarantees an active participation of farmers and promotes groups activities as basis for greater farmers\* collaboration.

Various techniques and pedagogic methodologies need to be included based on the adult training techniques and include the problem-identification-solution finding procedures which have proved most successful in the systematic development of a irrigation improvement plan which has the support of the farmers.

An example of the farmers training schedule with indication of the various presentation, groups activities, field exercise and block presentations is provided in fig 3.

**Training Aids and Materials**, in support of the farmers training, various training aids and materials need to be prepared.

## **MONITORING AND EVALUATION**

---

Linked with the training activities are the monitoring and evaluation of the technology transfer process. Each training activities includes the evaluation of the results and constraints in the implementation of the programme on which adjustments in the programme are made and agreement on the reporting requirements for the subsequent activities.

### **Reporting**

Close monitoring of the programme will be an essential element of the IC programme. A series of progress reports are need to be scheduled and prepared by the respective technical field staff. An example of such reporting schedule is given:

## Technical Backstopping

As part of the monitoring and evaluation, a number of technical backstopping visits need to be planned in order to closely follow-up on results and to assist in the formulation of the expansion phases. Such visits may be carried out by Headquarters staff in close cooperation with regional officers or by regional experts and TCDC consultants.

**TABLE 7 - Schedule of Camp and Field Reports in Zambia**

Camp and Field Reports	Tent. Date	Objectives
CR1 - FR1	1 February	<ul style="list-style-type: none"> <li>• Inventory District Irrigation Potential</li> </ul>
CR2 - FR2	1 April	<ul style="list-style-type: none"> <li>• RR Appraisal proposed pilot sites</li> </ul>
CR3 - FR3	1 June	<ul style="list-style-type: none"> <li>• Results Farmers training</li> <li>• Irrigation Plan</li> </ul>
CR4 - FR4	1 Augustus	<ul style="list-style-type: none"> <li>• Progress</li> </ul>
CR5 - FR5	1 October	<ul style="list-style-type: none"> <li>• Results First irrigation season</li> </ul>

## National Workshop

National workshops provide welcome opportunities to evaluate at a national level results of the SPFP programme and to draw wider attention to the potential for expansion.

## **ANNEX 9: Financing Irrigation Development**

### **with Special Reference to Sub-Saharan Africa**

#### ***BACKGROUND: INVESTMENTS IN IRRIGATION IN LDCS***

---

During the past 50 years, the increasing emphasis on irrigation has been one of the major trends in agricultural development globally. As a result of massive investments in water development schemes, irrigation provides today supplementary water to one-fifth of the world's cultivated land, from which one-third of the world's food is harvested. Much of this investment has taken place in developing countries, and many of the world's poorest people are dependent on food produced on irrigated land.

Irrigation has been an extremely important development investment area in recent years. In many developing countries, especially in Asia, domestic spending for irrigation has dominated agricultural budgets during the past decades. In several large countries such as China, India, Indonesia and Pakistan, half of agricultural investment goes into irrigation. Similarly, a significant portion of international development assistance has been used to implement irrigation projects. In the 1970s and 1980s, some 25-30 percent of World Bank agricultural spending was allocated into irrigation. Most of these and other donor funds were spent in Asia, while Africa's share of total external funding has been in the range of 10 percent.

The peak in investment in irrigation was reached during the mid-1980s, when some USD 2,500 to 3,000 million were committed per year by external funding agencies globally. However, since the 1980s, total investments have substantially decreased. The World Bank is now investing less than USD 1,000 million per year in irrigation projects, and total spending by all donors and financial institutions averages around USD 2,000 million per year. This development partly reflects the general decline in agricultural finance since the mid-1980s. However, there are also specific reasons for the declining trends in spending in irrigation. The rapid growth of irrigation and optimism over food production is being replaced by a more pragmatic evaluation of irrigation prospects. While some irrigation systems have operated successfully for long periods of time, high and increasing construction costs of the schemes, poor production performance of many irrigation systems, falling real prices of crops and concerns about negative environmental impacts of projects have significantly reduced the willingness of donors and international financial institutions to invest in irrigation activities. At the same time the increasingly tight financial position of many LDC governments has

adversely affected their possibilities to raise funds for irrigation projects from local budgets. Reflecting partly these financial constraints, global irrigation expansion has declined in recent years and now stands at 0.7% per year against 2.5% in the 1970s.

On the African continent, the total irrigated land is estimated to be about 12.4 million hectares. The importance of irrigation varies a great deal from country to country, and while Egypt has 99 percent of its cultivated land under irrigation, a large country like Zaïre has only 0.2 percent of its arable land under irrigation. Furthermore, a wide range of water management situations can be observed in Africa, from simple traditional ones to highly-sophisticated full-control irrigation schemes. In many African countries, the absence of medium-sized, commercial operators means that irrigation systems are polarized between a few, large-scale government schemes and numerous very small-scale independent irrigators. The sharing of experience between these two types of irrigation systems has proved to be very difficult in most African countries.

The problems experienced in many large and medium-scale irrigation schemes in Sub-Saharan African have raised the question whether irrigation schemes represent an appropriate policy solution in the African context. In Africa's more remote environments one often finds that many earlier irrigations projects have failed, that the environment itself is fragile, that transport costs are high, that implementation of an externally designed project will exacerbate social tensions, that marketing is poorly organized, and that the institutional capacity to manage irrigation is almost nonexistent. These factors would support the investment of scarce resources in Africa to other projects than irrigation systems.

On the other hand, various factors may lead to a 'second generation of water projects' in Africa that can be more successful than the first one. The macro-economic climate has improved in many countries in comparison with the last 20 years and the agricultural sector is less discriminated against through overvalued exchange rates, poor farm gate prices and other policies. Simple appropriate irrigation technology has become better known and expensive internationally designed schemes are becoming unnecessary. The importance of including the intended beneficiaries in the design and implementation of new projects is now more generally recognized, as is the need of realistic, uncomplicated project designs. The institutional capacity of governments, NGOs and the private sector to work together is improving. These factors would support continued investments in irrigation in Africa especially as without investment in water infrastructure, the prospects for increasing food production and improving food security are in many countries remote.

## ***IRRIGATION AND FAO'S PROGRAMME TO INCREASE FOOD PRODUCTION***

---

FAO's Special Programme on Food Production (SPFP) aims at achieving sustainable increase in food production and productivity in LIFDCs through dissemination of existing and proven agricultural technology. The water development component of the SPFP, more specifically, recognizes the following features:

- water development is essential for food security;
- focus should be on low-cost solutions and development models which stimulate self-reliance and management responsibility;
- economic viability of investments and private sector involvement should be emphasized; and
- there must be a holistic approach addressing constraints at technical, institutional and economic level.

As a part of the guidelines for the design of water development components to improve food security, the present paper addresses some major issues related to (i) the financing of small scale irrigation activities especially in Sub-Saharan Africa and (ii) the policies of FAO for organizing financial services for these components. As the implementation activities will take place in very different countries and circumstances, the focus of the paper is on basic principles and concepts. The paper discusses next the current trend towards farmer-financed irrigation. Chapter 4 deals with the main cost categories in irrigation investments. Next, the methods of assessing the viability of irrigation investments is discussed. The topic of Chapter 6 is the methods of financing direct irrigation costs. In the long Chapter 7, the types of financial services required by irrigators, and the potential internal and external sources of finance for small-scale irrigation schemes are discussed. The last chapter presents some basic recommendations on how to organize financial services in a FAO-supported water development components, with the aim of improving the overall implementation performance.

## ***TOWARDS FARMER-FINANCED, FARMER-MANAGED IRRIGATION***

---

Irrigation can be financed by public and/or by collective or individual private investment. The main reason why large-scale irrigation projects have in the past been financed from public sources is because the scope of work was beyond private endeavour. Economics of scale in water resource development (falling average costs with increased size) often made the scope of work so massive that only government could command the resources necessary to get to the optimum level of investment.



Today, however, severe financial difficulties in the large-scale irrigation sector are common, often leading to declining irrigation performance. These difficulties are primarily linked to the fact that public irrigation is heavily subsidised. For developing countries these subsidies almost always include not only the investment cost of the irrigation facilities, but also part or even all of the expenditure required to pay operation and maintenance costs. Repetto (1987) points out that governments collect from user fees on average less than 10 percent of the full cost of irrigation services; government subsidies range from 74% to 99%.

While such subsidies are commonly found also in industrialized nations, the financial problems linked to them are greater in developing countries because of greater overall budgetary constraints. Investments to expand irrigation over the past few decades have significantly increased the total amount of funds needed to meet the recurrent costs of public irrigation schemes. As a consequence, levels of subsidies that were acceptable when the total amount of irrigation was small have become increasingly burdensome to government budgets. Many governments especially in Africa have faced severe economic and fiscal pressures particularly since the early 1980s and have reduced the funding for operation and maintenance of irrigation schemes to levels that are inconsistent with the sustained satisfactory performance of irrigation facilities.

Most African governments have reached a stage in which the scope for continuation of many of the direct and indirect financial subsidies of the past is extremely limited. But to allow irrigation facilities to deteriorate and to stop the development of new facilities in these countries at a time when there is urgent demand for increased food and cash crop production would be irrational. Therefore, most governments in developing countries are being forced to reconsider their policies towards farmer payments for irrigation investments and services. In this situation financing irrigation with funds provided by farmers through one means or another becomes nearly inevitable.

While the above situation makes farmer-financed schemes a necessity, other factors recommend a bias towards assisting small-scale projects and technologies, traditional as well as modern. Small projects such as an individual open well, or the joint construction by villagers of a furrow diverting water from a stream, have always been financed and managed by individual farmers and communities, and millions of such schemes are in existence. Various theoretical and practical studies have made a case in favour of small-scale irrigation in Africa and emphasized various advantages small projects may enjoy. However, the actual performance in the 1970s and 1980s on officially sponsored small-scale irrigation was not nearly as positive as the proposed advantages would have suggested. In many government and donor-supported small projects, many of the mistakes of the large-scale schemes were just repeated on a smaller scale.

There is, however, considerable evidence that since the mid-1980s, new irrigation technologies have made small-scale irrigation schemes a much more viable alternative in many developing countries. The advent of cheap, dependable motors and pumps and the increasing availability of fuel and electric power has revolutionized irrigation more than any technological or managerial innovation. In many parts of the world, large areas of land could not be economically irrigated by gravity flow. A case in point is land located on the banks of large rivers where construction of diversion structures is not feasible for technical and economic reasons. Such land is now available for pump irrigation.

In many African countries small pump schemes, individual or communal, have begun to play an increasingly important role in augmenting food production. The traditional view that pump irrigation is bound to fail in Africa has been proven wrong. These schemes are easy to install and simple to operate. Experience has shown that pump schemes with small number of farmers having small land holdings are more productive in terms of yield per hectare and more efficient in terms of water use than large gravity schemes. Various studies also indicate that individual farmers using private pumps were able to apply water in a more timely fashion than in public schemes. Furthermore, they were able to schedule crop planting so that better prices were obtained at harvest. Although these farmers faced much higher operating costs since they had to cover the costs of the pump set plus those operating them, higher returns through increased flexibility of water delivery compensated for the higher costs. Studies also indicate that best returns to small irrigation investments in Africa have been generally obtained from schemes with formal and effective participation of farmers in the affairs of managing the scheme.

In a summary, the experience of the past decade would suggest that at the scheme level, public authorities will continue to be responsible for construction and operation of such major facilities as dams, headworks and main irrigation and drainage channels, but with a higher level of cost recovery from participating farmers. Even in these large-scale operations, water-users' associations and the private sector in general will increasingly be responsible for financing, building and operating the final distribution system. In small-scale operations, the financing and managing of the systems will be to a high degree the responsibility of the smallholders and their associations.

**In line with these development trends, an appropriate target for FAO's support and interventions are the small farmer-financed, farmer-managed decentralized irrigation schemes which aim at increased food production with intermediate, water saving technologies.** Working with this target group, the role and importance of financial services to participating farmers increases significantly as compared to the standard situation in the past. A wider range of financial services is required by the smallholders than

before, including not only seasonal credit to cover the costs related to annual crop production but also longer term investment finance for procurement and construction of irrigation facilities. Consequently, while the discussion on irrigation finance has traditionally centred almost solely around the question of how to recover the direct costs of irrigation services, a wider perspective to rural banking is needed when discussing the financial services to farmer-financed small-scale irrigation schemes. With this approach to irrigation, the emphasis changes from irrigation-specific questions much closer to the topics that are covered when generally discussing the provision of rural financial services in developing countries.

### ***MAIN COST CATEGORIES IN IRRIGATION INVESTMENTS***

---

Investments in irrigation require expenditure for the creation, operation, upkeep and occasional upgrading of irrigation facilities. These costs are commonly grouped into two categories: capital costs and recurrent costs. **Capital costs of irrigation** are those associated with the initial construction, upgrading and major rehabilitation of the irrigation facilities. They are incurred at the time the irrigation project is first constructed, and then sporadically over the life of the project.

Recurrent costs, on the other hand, are annual costs of operating the scheme, maintaining the facilities and producing the crops. For practical reasons they are in this paper divided into two groups. First, there are **water costs** and other expenses directly related to the irrigation services. Second, there are the **seasonal crop production costs** which include all other variable costs of production such as field machinery services, land preparation, seeds or plants, fertilizer, chemicals, transport, fuel, labour and marketing costs.

Both capital and recurrent costs are part of the real economic costs of irrigation, so that when a proposed irrigation project is being evaluated from the economic perspective, the distinction between capital and recurrent costs is important only to the extent that the difference in the timing of costs affects their present economic value. But when a project has been built, the initial economic cost becomes a sunk cost, meaning that no future decisions can affect its magnitude. Therefore, during much of the project life, decisions about the recurrent costs of irrigation are the most important investment-related decisions affecting the productivity of the existing irrigation infrastructure.

## ASSESSING THE VIABILITY OF INVESTMENT

---

Prior to the investment decision, the standard procedure is to assess the viability of the proposed irrigation project through financial and economic analysis. These, together with social and environmental assessments, are used when rationing scarce development funds and deciding whether to accept or reject a project. Project analysis translates all benefits and costs of a project into monetary values. This process basically consists of the following stages:

- 1 identifying all benefits and costs arising from the physical effects of a project;
- 2 measuring the monetary values, where possible, of such benefits and costs;
- 3 putting these values in current or constant monetary terms; and
- 4 comparing the benefit and cost streams of the project through the use of the project decision criteria.

Time is critical to any irrigation project's benefits and costs because money received at the present time is preferred over money gained in the future. The concept of the time value of money is directly incorporated into project analysis through the use of a discounted cash flow. It is essential for all project analysis to use either discounting (use of year 1 prices as the base) or compounding (projecting prices to year n) if benefit and cost streams are to be added across years - otherwise "apples" and "pears" are being added together and much of the validity of the analysis is lost.

When assessing a project, financial analysis considers only the prices for costs and benefits as given by the private market. In contrast, economic analysis is concerned with the full social opportunity costs of a project. Thus in an economic analysis, the target groups widens from the immediate investor to society, and for critical inputs and outputs social values must be estimated and used if private and social values differ significantly. In irrigation projects this commonly leads to major differences between financial and economic analyses regarding the treatment of such categories as capital, environmental costs and benefits, foreign exchange, market subsidies, taxes and equity issues.<sup>2</sup>

Assessing project worth against alternative projects or development funding constraints requires some common rules of comparison or decision criteria. In financial and economic analysis the most commonly used criteria are the net present value, the benefit-cost ratio, the payback period and the internal rate of return of the project.

---

2: For a detailed review of project analysis in irrigation projects, see G.K. Coetzee; 'Economic Analysis of Projects: An Overview', in M.J. Copeland (ed.), *A Manual for Irrigation Planning in Developing Areas*.

Most of the implemented irrigation projects in Africa have been evaluated with one of these techniques and have passed the criteria set by the governments and financiers for investments of these types.

In recent years, the large number of poorly functioning irrigation projects in Sub-Saharan Africa has been seen to indicate that the procedures and methodology used to design and appraise such projects has not been sound. In spite of initial estimates of 20+ percent economic internal rates of return, ex-post analysis has revealed few projects that remain positive under the compromises and realities of implementation. Various studies have pointed out that greater attention should be paid to how projects fit to existing social, institutional and farming systems. FAO Investment Centre (1986) in its review of irrigation south of Sahara emphasized the need for institutional and design changes that are better adapted to local capacity for operations and maintenance. Since the greatest number of avoidable problems arise from failure to understand the local economy and factors affecting the income of farmers, project designs should pay particular attention to farmer incentives, reactions and practices. In Sub-Saharan Africa this should include a careful financial analysis of the returns to the farmer and the organization managing the irrigation scheme. In practice this would essentially mean that the standard design process should be reversed. Rather than begin with design of the irrigation system based on what is technically optimal, planners should begin with the participants and institutions responsible for implementation. Only after the strengths and weaknesses of each of these have been identified and the incentive structure clearly understood, should technical design begin. Or as Moris and Thom (1990) concluded, problems in Africa in most cases arise from the failure to prepare irrigation projects adequately and to conduct a rigorous financial analysis of the final design. Economic, financial and institutional analyses should not be seen as substitutes but as complements. The institutional analysis should reveal whether institutions and individuals have the **capacity** to respond as expected. The financial analysis should reveal whether they have the **incentive** to respond as expected. Once the technical design of the project has been adjusted so that it is both institutionally and financially viable, then and only then does it make sense to do an economic analysis.

While in large government projects it is rare for the water users to be responsible for the complete costs of the projects, the relative stakes of the farmer in investment decisions are generally much higher in small farmer-financed irrigation systems. Faced with uncertainty and lack of knowledge about the outcome of the investment decisions, the water users in farmer-managed projects are apt to give great weight to the financial risks that they personally must bear. Risk aversion and conservative attitude towards uncertain irrigation investments obviously is a rational and justified attitude for smallholders living near the poverty line. Therefore, a major objective of the participatory planning processes should be to create a clear



understanding with the farmers of not only the potential benefits but also of the financial risks of participating in a farmer-managed and farmer-funded irrigation operation.

## ***METHODS OF FINANCING DIRECT IRRIGATION COSTS***

---

Governments as well as private and public irrigation scheme operators have established specific funding mechanisms to be used for collecting payments for the irrigation services. While a great variety of financing methods can be found in LDCs, Small and Carruthers (1991) grouped them into five basic types. Direct financing methods require the beneficiaries of irrigation services to make payments linked either to the use of irrigation services, or to the benefits received from the existence of irrigation facilities. In the former case, the payments are in the form of **user charges** (called also water charges, irrigation charges or irrigation service fees), while in the latter case they are in the form of a **benefit tax**.

The most common method of direct irrigation financing are the user charges. The basic variants of these charges are:

- 1 Area-based charges, with payments affected by cropping decisions made at the beginning of the season. The fee schedule tends to be very simple, with a single fixed amount per hectare cropped per season. A fee of this type shares one key economic feature: throughout the cropping season, the fee for water is a fixed cost of production, regardless of the actual amount of water used. Consequently, the fee has little impact on the amount of water used by the farmers.
- 2 Water prices, with payments affected by water-use decisions during the season. This system is primarily suited to systems that have an ability to allocate and deliver water in response to user demand and measure the actual amounts used by each farmer. In this system the cost of water becomes a variable rather than a fixed cost of production, creating a financial incentive to use less water for the individual smallholder than might be the case under fixed fees.
- 3 Output-based fees with payments affected by the level of production achieved at the end of the crop season. This system can be used for instance in cases of single crop production, and the fee could be calculated as a percentage of total production. In many ways, the system is similar to crop-sharing arrangements for the rental of land.

Benefit taxes are less commonly used alternative to user charges. The two most common financing methods of this type are **area-based taxes** and betterment levies. Area-based taxes are superficially similar to area-based user fees. However, the amount of the tax to be paid does not necessarily



bear any relationship to the use of irrigation. Payment is due simply because of the presumption that land lying within the command area of the irrigation system has benefitted - either because it has actually been irrigated or because it now has the potential to become irrigated. Tax of this type is a fixed fee to the farmer, unaffected by water-use decisions.

**Betterment levy** is a payment or a series of payments made by the beneficiaries of irrigation specifically for the increase of the capital value of their land resulting from irrigation. A betterment fee can be spread over a number of years, often with a grace period for some years after the commencement of irrigation.

The selection of the method to finance irrigation services must reflect the objectives set by the scheme operators. Small and Carruthers (1991), in their study of appropriate irrigation service finance policies, have listed five criteria to be considered when selecting the financing method: resource-mobilizing efficiency, quality of investment decisions, cost-effectiveness of operation and maintenance, water-use efficiency, and equity. A particular problem in LDCs, however, is that any of the direct financing mechanisms mentioned above can be implemented without actually being tied to irrigation financing. It is common in various developing countries that revenues from irrigation service fees become part of the general government revenue. They cannot be used to provide funding to operate and maintain irrigation facilities but can be seen, in effect, just as another tax on rural people. This situation stresses the need of financial autonomy of the body that operates the irrigation scheme, so that user charges can actually be used to pay for the costs of irrigation.

In small, farmer-financed schemes, a major concern should be that the water users perceive the financing system for irrigation services to be equitable. Water prices could be normally consistent with this target and at the same time encourage efficient use of water by smallholders. However, a variety of implementation difficulties, such as problems in measuring the amounts of water used by a large number of small users, make the use of water prices relatively rare. Therefore, user fees based on the amount of land under irrigation tend to be the most common basis for charging and paying for irrigation services in small and medium-size schemes.

Irrespective of the selected mechanism, even in small-scale irrigation schemes in developing countries it is realistic to expect that cost recovery will be difficult and often painful to all concerned. Therefore, other things being equal, the project design with the lowest recurrent cost is to be preferable. To improve the chances of successful and smooth cost recovery operation, recovery devices should be preplanned to coincide with times when farming households have access to ready cash.

## FINANCIAL SERVICES FOR SMALL-SCALE IRRIGATORS

---

In farmer-financed small irrigation schemes, smallholders' needs for funding vary significantly from one project to another. Factors such as the location of the project site, the climate, the size of plots, the crops cultivated and the selected irrigation technology considerably affect the size and type of financing required. Generally speaking, however, the farmer on schemes of this type require financial services to cater for the three basic needs:

- 1 medium-term credit for the initial construction, upgrading and major rehabilitation costs of the irrigation facilities;
- 2 short-term credit for the seasonal costs of crop production (which include irrigation charges); and
- 3 regular savings facilities to create possibilities to self-finance part or whole of the medium and short-term financing needs.

When paying for the costs of irrigation, the basic options for the farmer are of course either to use the own funds of the household or to borrow from external sources. In the 1960s and 1970s, providing credit at low rates of interest was widely believed to be the only essential function of financial intermediaries in the rural areas of less developed countries. However, the widespread failure of subsidized and heavily regulated credit programmes to achieve the goals of increased production and more equitable income distribution have been lately considered to reflect the basic weaknesses of the credit-centred approach to banking in LDCs. This has meant more emphasis on savings mobilization, "the forgotten half of rural finance"<sup>3</sup>, and during the past decade there has been an upsurge in policies and programmes aimed at increasing deposit collection by financial intermediaries in developing countries. Rural and non-wealthy households in particular have become the focus of policies to promote savings, as the myths that the poor have no margin over consumption for saving and that the poor do not respond to economic incentives are increasingly being questioned. There are now various examples that poor households benefit from improved deposit opportunities provided by safe, liquid, interest-bearing savings products. Deposits help people to accumulate funds, which are then available for investments in physical capital and for the funding of cash flows associated with consumption. At the same time the increased use of the financial system generates social efficiencies through the pooling of risks and through information economies in the allocation of funds for investment.

---

3: For studies on the problems of the credit-centred approach in LDCs, see J.D. von Pischke; **Finance at the Frontier**, The World Bank, EDI Development Studies, Washington D.C., 1991; and R.C. Vogel; 'Savings Mobilization: The Forgotten Half of Rural Finance', in D. Adams, D. Graham and J.D. von Pischke; **Undermining Rural Development with Cheap Credit**, Westview Press, London.

Consequently, in farmer-financed small irrigation schemes, activities aiming at increased self-financing of investments through active savings mobilization should be essential components which, if successful, may have a major positive impact on the sustainability of the whole irrigation project. On the other hand, when working with the poor of the rural communities, the need for external funding for irrigation investments is in many situations a prerequisite for smallholders' participation in the scheme. Below, various options on how to mobilize capital both from farmers themselves and from external sources to finance short and medium-term small-scale irrigation investments are discussed.

### *Informal Savings Groups and Linkage Schemes*

The most basic facility that can potentially provide financial services to small-scale irrigators are the informal savings and credit groups (ROSCAs), which are common in most developing countries. In these groups, farmers save and pool contributions in regular meetings, and each member receives his or her share of the pooled funds either in rotation, by lottery or on demand. Members are usually from the same location, ethnic group, sex and age, and share often the same occupation and income status. Savings amounts are small, and as there is little need for financial management, transaction costs are low in amount and time. ROSCAs generally are self-sufficient with funds and have very good credit discipline.

The more developed ROSCAs pool funds for longer periods to be able to issue larger loans to members. However, most of these groups have a limited life span and all funds are usually redistributed at the end of the cycle. While this is advantageous from the point of security, it is a serious constraint for financing irrigation investments as no loan fund is available at the beginning of a new cycle. Another constraint is that the liquidity of the group is linked direct to the economic activity of the rural community, and the supply of funds from low income earners is limited. This liquidity is especially tight during the time of the year when farmers purchase inputs for their cultivation activities. As a consequence, the capacity of ROSCAs to issue seasonal loans at the same time to many farmers is very restricted. In the absence of linkages to sources of finance, there is no way of gearing up liquidity when the demand for loans is highest. This seriously reduces chances to use informal groups as instruments in financing small-scale irrigation.

During recent years, serious attempts have been made in many developing countries to assist informal groups to upgrade their operations and link them more closely in the banking system. In an appropriately designed linkage scheme, trained farmers' groups are requested to make regular savings for a specific time into a group savings account before obtaining a loan from a financial institution. It is expected that though this exercise groups become gradually familiar with banking procedures, that

the bank staff and the group representatives get to know each other, that banks have access to at least some collateral in case of default, and that groups build their own capital base and improve their financial self-sufficiency over time.

Donors and NGOs including the World Bank and IFAD have frequently provided re-financing facilities for linkage schemes, in addition to specific group and bank staff training components. More recently, donor support has often concentrated in promoting group formation and deposit mobilization for informal groups, together with support for bank staff but without external credit lines. For FAO's interventions in small-scale irrigation, support of this type to linkage schemes can be a particularly appropriate and cost effective approach that would aim both at increasing farmers' self-financing share in their short and medium-term investments and at arranging external funding from formal banks for smallholders' irrigation investments.

### ***Cooperative Savings and Credit Arrangements***

Credit unions and savings and credit cooperatives are cooperative, voluntary financial organizations owned and operated on a non-profit basis by members. The purpose is to encourage savings by creating local deposit facilities and then using the pooled funds to make loans for productive, consumer and social purposes to their members. Cooperatives and credit unions may be rural-based or urban-based, depending on the underlying motive for their creation. Rural cooperatives operate as farmers' grassroots organizations, aimed usually at meeting the seasonal needs of their members which banks do not satisfy.

In successful credit schemes globally, high recovery rates are have frequently been ascribed to strong village cooperative systems which have provided the required repayment incentives and enforcement mechanisms. Important factors for success of credit cooperatives include bottom-up institutional development, extensive training at all levels, reliance on savings mobilization and equity contribution rather than external funds, slow and controlled expansion of cooperative activities, and strict monitoring and auditing. While many of these factors were lacking in various highly unsuccessful cooperative credit operations of the 1970s and the early 1980s, their importance has been increasingly understood during the past decade.

Donor support to grassroots level financial cooperatives may in various countries be one of the few practical interventions which on a sustainable basis have the potential to promote savings mobilization and to reduce both the transaction costs of lending to smallholders and the risks

involved. In FAO-supported projects, promotion of cooperatives which provide savings and credit services can often be an appropriate way of channelling assistance to farmer-financed irrigation schemes. Through savings mobilization, cooperatives can improve the chances of self-financing of irrigation investments and from the pooled cooperative funds, loans can be issued to members especially for seasonal needs. Further, in various African countries, external funds from the central cooperative bank can be channelled to farmers through their local cooperatives for both medium-term and seasonal purposes.

### ***NGOs and Irrigation Finance***

Small-scale irrigation has been often regarded as an area which is particularly suitable for NGOs participation. A wide range of voluntary organizations, private companies and religious institutions, all of which have been referred to as Non-Governmental Organizations (NGOs), have been for many years been involved in the sector at the grass-root level. There is great diversity among these NGOs regarding objectives, skills, size and mode of operations. Some NGOs have demonstrated considerable skill in reaching rural households, introducing community planning and establishing networks for dissemination of information on new irrigation technologies. The strong point of NGOs is the flexible and responsive way in which they provide support for local groups and initiatives. On the other hand, these organizations have not been free from the vices of governments and larger donors, creating dependency among rural communities through provision of free gifts or free community services. The main limitations of these NGOs tend to be that their objectives, target group and area of operations are often very specific; that their capacity in terms of staff and material resources is rather small; and that they depend heavily on, not always reliable, external grant funding.

In various developing countries, NGOs offer also savings and credit services to the participants of small-scale irrigation schemes. Many have been active in savings mobilization and some have provided loans from their own funds to farmers for investments in irrigation. A few large NGOs have proved to be useful partners in these operations as they operate more like banks in terms of management sophistication, yet maintain their socially oriented goals. However, a set of problems has come to be associated with finance projects run by NGOs. Their staff have good outreach in poor communities, but little business experience and capacity to operate credit funds. In their activities, welfare and business goals get often mixed, with adverse effect on the recovery of loans. Projects run by NGOs also tend to be expensive, highly subsidized and of limited duration. Furthermore, in many developing countries they lack the mandate to collect deposits, which biases their operations towards credit activities.



All this calls for a detailed analysis before involving NGOs as agencies to implement financial services components in irrigation projects. Box 1 describes how one NGO, the Smallholder Irrigation Scheme Development Organization (SISDO) in Kenya, has evolved from the actual operator of

#### **Box 1 - Smallholder Irrigation Scheme Development Organization (SISDO)**

Smallholder Irrigation Scheme Development Organization (SISDO), a Nairobi-based NGO, provides technical, management and financial services for the development of small-scale irrigation schemes. SISDO is a relatively new organization, which started its operations in July, 1992. Currently, it employs a total staff of 32. SISDO's finances are based almost solely on donor grants, mainly originating from the Netherlands. At the end of 1993, these grants totalled KES 46.8 million. In the financial year 1993, SISDO's total income (excluding grants), earned mainly as interest on bank accounts and outstanding loans, covered 66% of the organisation's total expenditure.

In addition to its engineering and management services, SISDO operates four different lending programmes to smallholders. All loans are issued from SISDO's funds received from donors as grants. **The Group Based Gravity Irrigation Programme** is currently operated in Eastern and Central Provinces, with plans to expand it to Kilifi and Taita Taveta Districts. The scheme provides investment credit for small irrigation schemes. **The Farm Input Programme** provides funding for seasonal inputs for smallholders operating on irrigated land. **The Pump-Fed Irrigation Programme** SISDO mobilizes clusters of 7-15 farmers to start irrigation activity of this particular type. Finally, **the Pilot Zero-Grazing Programme** provides loans to farmers for the purchase of in-calf heifers to such farmers in irrigation schemes who possess a zero-grazing unit and have access to adequate fodder and water resources. In total, SISDO's lending operations have been on a relatively small scale. In 1995, the cumulative total disbursements amount to KES 11.4 million.

To improve the efficiency of banking arrangements in the irrigation schemes and to allow the organization to focus on its core business of irrigation development, SISDO signed in August, 1995 an agreement with the Cooperative Bank of Kenya Ltd (CBK), according to which the bank will in the future handle all the savings and loans operations related to the SISDO-managed schemes. From its large, donor-donated liquid funds SISDO will place a fixed deposit in the CBK which will provide initially a 70% security for the loans. If the loan repayment will be at least 95%, the guarantee requirement will annually be reduced by 10%, but shall not go below 45% of total outstanding loans. Farmers will have to deposit 15% of each individual loan to CBK as an additional security. The farmers will pay in this new arrangement the market interest rate + 4% on investment loans and the market rate + 15% on seasonal loans. The extra percentages are the farmers' payments for SISDO's extension services, which the CBK will collect and refund monthly to SISDO. The new arrangement, if successfully implemented, will (i) introduce a more professional and efficient approach to SISDO's lending activities; (ii) include the supportable element of full cost recovery in extension services; and if the loans perform, (iii) provide an opportunity to double the lending volume in SISDO's schemes.



savings and credit activities to a more supportive and promotional role which better suits its institutional capacities. Generally, in FAO-supported small-scale irrigation projects, NGOs can play a major role in the field of identifying, training and graduating potential depositors and borrowers to financial services operations. In some countries, NGOs specialized in rural finance may be the only option available to actually operate the savings and credit component in the projects. However, the involvement of formal or cooperative financial institutions is vital for efforts that aim at reaching a significant part of the target group in the long run, and the core business of lending and managing deposits should be entrusted to bank or non-bank financial institutions.

### **Commercial Banking Sector**

In most Sub-Saharan African countries, commercial banks control the savings from the large-scale farming sector and through their wide branch network, are important deposit collectors also from the smallholder farming community. At the same time attempts to involve commercial banks to smallholder credit operations have been largely unsuccessful. Due to lack of acceptable securities, high transaction costs and unfamiliarity with this client group, commercial banks have issued credit only sporadically to smallholders. As mentioned above, the group lending approach and linkage scheme between farmers' groups and commercial banks aim at changing this situation.

In donor-funded projects, however, there are obvious positive factors related to funding arrangements that should be more clearly expressed by missions when negotiating with potential candidates to implement the financial services components. These positive factors include the following:

- The funding in FAO-executed projects is almost always grant-based. When lent out at market terms, there is room for a large spread for the financial institution, which creates a good cover for the potentially high costs and risks involved when operating with the project's target population.
- In the project document, allocation can be made for a technical support package for the financial institution to improve its chances to operate profitably the project rural finance component.
- It can be agreed in the project agreement that if the component performs well, the grant-based credit fund can at the termination of the project be used to boost the financial institution's own capital base. This creates a major incentive for the institution to take the project-related activities seriously from the beginning.

When a project has been presented to commercial banks as a package including features of the above type, a more positive reaction has often been attained regarding the banks' willingness to implement a financial services component to smallholders. This type of approach could produce better results also when negotiating with potential partners for the implementation of farmer-financed irrigation projects in Sub-Saharan Africa.

### ***Credit to Irrigation Schemes***

In the past, common policies by governments and donors included creating new institutions, especially agricultural development banks, to provide loans to rural areas to specific regions, beneficiary groups or commodities at subsidized interest rates. One sector which has benefitted in many countries of these subsidized credit schemes has been the irrigation sector. However, subsidized agricultural credit programmes in most LDCs have faced serious operational problems. Borrowers' interest to repay loans remained low as loans were commonly seen as "government money", and default was not seriously sanctioned by disbursing projects or development banks. Collection rates usually varied between 50 and 80 percent. At these rates the lending operations, often planned as revolving funds, lacked sustainability and remained without adequate development impact. The extensive use of agricultural credit schemes to transfer subsidies - in the form of low interest rates and slack loan recovery - attracted rent seekers and political opportunists who further undermined the integrity of these programs.

Furthermore, agricultural credit schemes in most countries did not achieve the target of creating strong institutions to provide financial services to rural areas on a sustainable basis. The continuous availability of external funds at below-market interest rates did not oblige rural finance institutions to operate under financial viability constraints. Together with the lack of competition and accountability, this led to extremely inefficient operations, high transaction costs, as well as in various cases to patronage and irregularities. Thus, when the economic stress in 1980s increased especially in Africa and donor funding started to decline, most of the rural public finance institutions have been obliged to radically cut back their lending and some of them have completely closed their operations.

Looking at the situation in the mid-1990s, the chances of smallholders to get subsidized irrigation finance from government and donor schemes have been radically reduced. In some cases there may be a justification for an agricultural credit line aimed at speeding up growth for instance when reforms are introduced to remove bottlenecks resulting from inadequate land tenure system. However, in most Sub-Saharan African countries the option of subsidized credit is practically closed and because of the current

policies in rural finance and the diminishing flows of donor funding, it is highly unlikely that such cheap credit would play a major role in financing small-scale irrigation in the future.

### ***Project-Managed Credit Schemes***

In donor-funded irrigation projects, a common method to on-lend funds to farmers has been to disburse loans to the target group by the project office itself or through a related government department. This approach continues to limit the chances of success in financing operations. Evidence of the inefficiency and the lack of impact of project-managed credit is substantial and convincing. The project staff does not have the capacity to operate these schemes, borrowers consider the loans as government and donor handouts which need not to be repaid, and the misuse of funds by scheme operators and farmers is a common feature in project-managed credit. Therefore, in the case that a financial intermediary (financial institution, cooperative, NGO) can not be identified during the project formulation to operate the loans scheme, other interventions than credit should be selected as project activities in operations supporting small-scale irrigation.

### ***Moneylenders and Traders***

Local informal moneylenders are well-established in the most Sub-Saharan African countries and provide loans also for the short-term investments of smallholders in irrigation schemes. In a recent study in Nigeria commissioned by FAO<sup>4</sup>, in which farmers formed the majority of clientele, 52% of loans drawn from moneylenders were used for agricultural production purposes. Moneylenders use mainly their own funds for lending activities but some borrow from local commercial banks for on-lending purposes. Most loans are for short term and interest rate level normally depends on the creditworthiness of the borrower. Recovery rates of loans by moneylenders are high and transaction costs low. Thus, on a superficial level, private moneylenders are ideally positioned as channels for credit for on-lending to smallholders. They do not suffer from the major disabilities - high overheads, lack of local presence and unfamiliarity with potential borrowers - which constrain banks and other institutional lenders. On the other hand, usurious interest rates make credit of this kind very expensive for the borrowers.

Among the informal operators, the trader who doubles up as a provider of credit to promote his trading activity holds out the best potential for development in the small-scale irrigation sector. If banks are induced to grant them additional credit, traders could be expected to sell more inputs

---

4: M.O. Ijere, 'Informal Financial Intermediation in Nigeria', a study for FAO, June 1991.

to farmers on credit than they would have done if they had to depend solely on their own capital. This would increase the total available smallholder credit although not necessarily reduce the borrowing costs. Following this thinking, both the World Bank and IFAD provide in some countries funds to local banks for on-lending to traders who would then be able to provide credit facilities for smallholders for procurement seasonal inputs and small investment items. As a temporary option this approach should be considered also in small-scale irrigation projects especially as in many remote irrigation schemes, the institutional providers of credit have not been successful in reaching the smallholder.

## CONCLUSIONS AND RECOMMENDATIONS

---

Deciding the best approach to irrigation financing in any given context requires careful consideration of many factors specific to that context. In each country, the nation's general macroeconomic environment, its agricultural and financial sector policies, its institutional context, and its past experience with financing irrigation all have a major impact on decisions on irrigation financing. In developing countries in general and in Sub-Saharan Africa in particular, however, it seems obvious that irrigation farmers must assume a much greater responsibility for providing finance for their irrigation activity than was the case in the past. In this new situation, smallholders in small farmer-financed schemes require financial services to cater for the three basic needs: (i) medium-term credit for the initial construction, upgrading and major rehabilitation costs of the irrigation facilities; (ii) short-term credit for the seasonal costs of crop production (which include irrigation charges); and (iii) regular savings facilities to create possibilities to self-finance part or whole of the medium and short-term financing needs.

When supporting the provision of financial services to small farmer-financed irrigation projects, the following basic principles should be given attention:

- 1 Before investments are made in small-scale irrigation, increased attention should be given to the profitability and risks of proposed investments, and the debt servicing capacity of the borrowers. Investments to be financed with credit must generate an adequate financial rate of return to allow for a project-supported credit intervention. In addition, the institutional analysis should clearly show that institutions and individuals have the capacity to implement the project.
- 2 User charges in small-scale irrigation schemes should cover the full costs of operating and maintaining the scheme. To improve the chances of successful and smooth cost recovery operation, (i) the project design with the lowest recurrent cost is preferable; (ii) water users should

perceive the financing system for irrigation services to be equitable; and (iii) recovery devices should be preplanned to coincide with times when farming households have access to ready cash.

- 3 Irrigation financing components should be operated by formal financial institutions, savings and credit cooperatives, or NGOs with experience and competence in financial intermediation. If the willingness of such an institution to participate in the project can not be secured during the project formulation, other interventions than credit should be selected for project activities. Disbursing credit direct through the project to smallholders is not an appropriate approach to irrigation finance.
- 4 NGOs can play a major role in the field of identifying, training and graduating potential depositors and borrowers to financial services operations in small irrigation schemes. In some countries, NGOs specialized in rural finance may be the only option available to actually operate the savings and credit component in the projects. However, to achieve sustainable results, the aim should be that the core business of lending and managing deposits should be entrusted to financial institutions.
- 5 Activities aiming at increased self-financing of investments through active savings mobilization should be essential components in small farmer-financed irrigation projects. The promotion of savings in the project areas can lead to an immediate improvement in the management of household finances and, in the longer term, will reduce the need for external funding for irrigation investments.
- 6 As a part of the support to savings mobilization, institutional support to local savings and credit clubs and cooperatives can lead to the involvement of local organizations that can at a later stage serve as important links between irrigators and formal financial institutions. Promotion of these linkages can lead to increased financing of irrigation investments by local banks without the need to provide any donor-funded credit line.
- 7 Especially in remote irrigation schemes, supporting local traders should be considered as an option to provide credit facilities for smallholders for the procurement of seasonal inputs and small investment items.
- 8 As irrigation financing activities seldom function in isolation from other financial sector operations, they should follow the prevailing policies of the financial market. The overall policy of these finance components should be to charge and pay market rates of interest on loans and deposits.



## **BIBLIOGRAPHY**

---

*Agnew, C. and Anderson, E.*

1992. *Water Resources in the Arid Realm*, London.

*Chambers, R., Saxena, N. and Shah, T.*

1989. *To the Hands of the Poor: Water and Trees*, London.

*Coetzee, G.*

"Economic Analysis of Projects: An Overview", in M.J. Copeland (ed.),  
"A Manual for Irrigation Planning in Developing Areas".

*Copeland, J. (ed.)*

"A Manual for Irrigation Planning in Developing Areas", Pretoria.

*FAO*

1995. *Guideline for Water Management and Irrigation Development*;  
Draft .

1995. *Water Development for Food Security*, Advance unedited version,  
march.

*Meinzen-Dick, R. and Svendsen, M. (eds.)*

1991. *Future Directions of Indian Irrigation: Research and Policy Issues*,  
Washington, D.C.

*Moris, J. and Thom, D.*

1990. *Irrigation Development in Africa: Lessons of Experience*,  
Boulder, U.S.A.

*Repetto, R.*

1987. *Skimming the Water: Rent-seeking and the Performance of Public  
Irrigation Schemes*; World Resources Institute, Washington, D.C.

*Sampath, R. and Young, R.*

1990. *Social, Economic and Institutional Issues in Third World Irrigation  
Management*, Boulder, U.S.A.

*Small, L. and Carruthers, I.*

1991. *Farmer-Financed Irrigation : The economics of Reform*, Cambridge.



## ANNEX 10: Approach to economic analysis of water management and irrigation development under SPFP

Economic criteria are often decisive for planning of irrigation expansion to secure sustainability of irrigation development for food security. Systematic assessment, translatable into monetary terms, of merits and weaknesses of the irrigation development programme, is therefore required. Economic assessment is normally focused on analysis of investment projects, however the approach for economic evaluation need to be adopted to be consistent with the approach of the Special Programme on Food Production (SPFP) for demand-driven, farmer-managed development programmes, based on motivation through visible incentives that are well understood by the farmers. In this manner the economic analysis will serve as an important base for the dialogue between farmers, private sector agents and NGOs and Government officials.

The economic assessment need therefore to focus on private market aspects with financial assessment at the farm level and include considerations on equity. Economic analysis for economic growth, from social and national economy perspectives, on the other hand becomes less relevant for SPFP. In particular economic evaluation criteria need to reflect the three basic conditions for food security, namely **(i) availability, (ii) stability of supply, and (iii) access to food.**

A general requirement for water management and irrigation development under SPFP is to reduce the costs for irrigation investment and operation. However these costs need to be compared with the irrigation benefits at farm level, such as improved productivity and higher yield, diversification to financially more attractive crops with reduced financial risk for the farmers. Irrigation development under SPFP is responsive to markets and sensitivity analysis for variations in produce prices and market demands as well as in costs for irrigation need to be included in the assessment. The analysis is expected to form the basis for participatory discussions with the farmers and the private sector and it will be necessary to use terms that are relevant and can be well understood by the farmers.

In the cases where irrigation development under SPFP will rely on public investments, also economic analysis of the investment projects or sub-programmes under the irrigation programme need to be included. In this case the economic assessment follows classical and well entrenched approaches for economic analysis of projects.

A summary presentation of classical approach to economic analysis of projects is given in the following together with suggestions on how to adapt and simplify the economic assessment for the requirements of the water management and irrigation component under national SPFP.

### ***Scope of Economic Analysis***

Economic assessment is normally used as a decision making tool aimed at making wise rationing of scarce capital and other resources. The underpinning assumption is that good programmes will result in improved economic growth and maximise social and private welfare by addressing goals and constraints in relation to both aspects. The economic analysis translates, to the extent possible, the benefits and costs into monetary values. The analysis approaches are based on benefit-cost methodology with comparison of benefits and costs with and without projects.

There are implicit links between economic project analysis and macro-economic planning. In project analysis these links are normally ignored explicitly and introduced through shadow prices for production factors, such as labour and foreign exchange, to express differences between social and private benefits and costs to reflect impacts of market failures in the economy. Some economist argue against shadow pricing, to artificially change particular benefit and costs streams claiming that if there are private versus social distortions the case is for macro-economic policy changes rather than shadow pricing of particular flows.

However when social opportunity costs are equal to private market values, and no externalities or market distortions exist, or social values are simply impossible to quantify the analysis is simply carried out with the market price. With the focus on private farm economies under SPFP the problem is not applicable as the assessment is based on farm level financial analysis.

The financial assessment should be viewed as a static form of analysis that aims at presenting results at given moments in time. This is important, as a programme that could be favourable starting in one year may be unfeasible if started in a later year.

### ***Valuation Perspectives***

As mentioned, with the target groups under SPFP focused on private sector farmers the valuation perspective is limited to private market, financial benefit-cost analysis. The focus is on farm level financial analysis that look at the programme from the private standpoint of the farmers. The objective is normally to maximize private profits for the farmers, who take

the initiative, provide the inputs for the programme and stand to gain or lose in the private market. Therefore, in a sense the financial analysis describes the incentive for the programme.

### *“with” Versus “without” Comparisons*

A “with” or “without” programme comparison is used consistently throughout the analysis. For example two alternative technological options for irrigation development may be compared, and these are also compared to a situation where none of the options are implemented. The characteristics of the “with” or “without” method are to provide a comparison which shows what will happen over time and to identify needs for adjustment for expected changes in benefits and costs over time, for both the with and without situation.

### *Time Horizon*

The time value of money is incorporated into project analysis through the use of discounted cash flow (DCF) and the time horizon need to be clearly stated for project analysis.

However, as mentioned, DCF assessments may be less applicable for short term, demand-driven and market-responsive SPFP programmes.

### *Valuing Benefits and Costs*

- 1 Benefits and costs need to be identified, quantified in monetary values and compared, which involves:
  - identifying the benefits and the costs arising from the physical effects of the programme;
  - measuring the monetary values, where possible, of such benefits and costs and putting these values into current or constant monetary terms;
  - comparing benefits and costs through the use of project decision criteria;

For the financial analysis the following benefits and costs are included:

- private market values for benefits and costs;
- capital costs spread over the project life (amortized as annual payments over the loan period if debt financed);
- taxes and other transfer payments between groups paid by the farmers;
- private discount rate is applied - ( if discounted values are applicable);

Equity concerns, such as the income distribution effects of a programme, are a social objective that could be relevant for the assessment of SPFP programmes. The approach includes weighting of benefits and costs to give more or less emphasis depending upon the beneficiaries and there are alternative methods for handling income distribution impacts, including: (a) weighting of net benefits by income class, group or region; (b) estimation of non-weighted net benefits by income class, group or region; and (c) a constrained maximum or minimum target approach which maximises economic efficiency, subject to income constraint;

- 2 Capital is a category of costs referring to investments under the SPFP programme and includes typically equipment, building construction, material, engineering, and installation. Such factors are considered capital expenditures if investments, eg. loans or equity, were made for their purchase at any time. In contrast to capital expenditures, operation and maintenance expenditures (O&M) include annual or recurrent cash flows paid directly under the programme. A problem in the treatment of capital in financial analysis of SPFP programmes is that the borrower may or may not be the group maintaining and operating the system.

However with SPFP is focused on private sector programmes borrowers are in principle the same as the user group, and where the investing unit pays the debt service. However, if, as in the case of public or aid-sponsored projects, the loan recipient do not pay off the loan and if the equipment capital is not being replaced by the user, a debt service should not included in the financial analysis for the user with outside financing. For this aspects SPFP should give preference to direct users' financial responsibility as a pre-condition for the sustainability of the programme.

Regardless of debt or equity financing there is usually the need to replace the capital (equipment) at the end of its productive life through gradual repayment or writing off or "amortizing" the original investment for recovery of the capital. To secure self-sufficiency of the programme and enable replacement of the capital a capital recovery factor need to be used in the financial analysis. As the cost of money is normally expected to grow in future years the capital recovery factor need to include an interest or money growth component as well as a principal component. However a common problem in replacing the original asset is that unless the cost of the asset has increased less than the rate of interest, future replacement costs will not cover the sum of capital charges set aside over the asset's life. This problem can be avoided by using the average inflation rate rather than the economy-wide interest rate.

- 3 Taxes and market subsidies are forms of transfer payments between different groups within the economy and they are included in a financial analysis in market prices, since they are paid or received by the private sector and the farmers.

- 4 While the SPFP programmes are focused on using family labour and individually owned agricultural land, the prevailing labour wage rate and private market prices for other factors of production such as land and capital are used in the financial analysis. Like most shadow pricing, determining the social value of labour, capital or land is fraught with problems. One argument against the use of a zero opportunity cost approach in areas with high unemployment, which may be applicable under SPFP programmes, is based on the “household decision making model”. It is argued that official statistics on unemployment are inaccurate when generalised to project level and that a household income approach should be followed. As people derive income from many sources the most accurate quantification of this is at household level.
- 5 Many project inputs are imported and outputs contributing to small farmer income and therefore food security are exported to foreign markets. The official exchange rates often under- or more often overvalue the domestic currency with distortion in foreign exchange related prices. While this will not have any impact on the financial analysis of SPFP programmes it will effect programmes financed with foreign loans, which normally have to be paid back in foreign exchange.
- 6 Similar to other projects a SPFP programme may generate multiplier effects on benefits and costs, such as creating additional jobs or increase productivity beyond the programme area. The analysts should in principle avoid using multipliers on benefits and costs, that could be misleading and result in double accounting, that could be done simply by expanding programme boundaries to include such factors as employment or alternatively report such multipliers as along with other net benefits.

### **Decision Criteria**

Economic criteria are important to accept, reject or redefine programmes. Therefore a combination of relevant decision criteria, to compare benefits and costs and demonstrate the financial attributes of different technological options for irrigation expansion, need to be selected and used carefully. The decision criteria include:

- **Net Present Value (NPV)**, the probably best known and most widely accepted criterion, as the difference between the discounted values of project benefits and costs, with the decision criteria to choose projects with NPV greater than zero;
- **Benefit-cost ratio (B/C)**, as the sum of discounted benefits divided by the sum of discounted costs, with the decision criteria to choose projects with B/C greater than one. When, as in the case of many



SPFP programmes, capital, both for capital and future cooperating funds, is the limiting factor, a useful variation of B/C is  $(B-O)/K$ , where O refers to operating and maintenance costs and K refers to the capital costs. If capital budget constraints exist, in this way one chooses a programme from highest ratio until the budget is exhausted or until the  $(B-O)/K$  ratio falls below one.

- **Payback period** is a popular criterion in financial analysis, relevant for SPFP, which tells at what time period the project recovers its costs, with the selection criterion as the project with the shortest payback period. While the criterion is biased against projects with large benefits occurring in later years and therefore shortsighted for economic analysis, it is well suited to reflect the risk exposure of the farmers in demand-driven and risk-responsive, irrigation development.
- **Internal Rate of Return (IRR)**, as the rate of discount that sets the present value of benefits equal to the present worth of costs. While there are problems and valid criticisms of IRR this decision criteria is well entrenched in financial analysis and many projects rely heavily on it. The reason here for is that IRR provides a yardstick to be compared with existing markets for capital investment and to its analogy to private or government sector return on capital. As a result IRR may not be very relevant for decision on small-scale irrigation programmes financed by the farmers.
- **Break-even Analysis**, to derive the minimum price for a benefit or a cost at which the sum of discounted benefits equals the sum of discounted costs. The selection criterion is then to accept the programme option, if the price for break-even is judged to be realistic and can be sustained according to the understanding of the farmers.
- **Cost-effectiveness**, which evaluates the programme on the basis of costs alone. It is relevant for a situation where the benefits are difficult to monetise and may be employed in a situation where two or more options exist for accomplishing the same desired result. The decision rule is then to choose the least-cost option.

### *Comparing Programmes*

Irrigation development under SPFP is by and large based on private household-managed and self-evolving development of a number of different technical options, that are not competing or mutually exclusive. However different options may compete for limited resources e.g. capital and there is the need to compare the options to make wise investment decision. As mentioned the NPV is generally agreed to be the preferred



criterion, assuming that the technical options are independent and that there are no constraints on capital costs, since it seeks to maximise the net gains to the private investor. However, as mentioned, for the small-scale farmers under SPFP programmes, capital costs are a major constraint and NPV need to be combined with other decision criteria including estimates of payback period and cost effectiveness.

### ***FORMAT FOR ECONOMIC ANALYSIS***

---

A format for economic assessment of water management and irrigation component under national SPFP is suggested in the following. As there are many differences between SPFP programmes, it should be seen as a general guide that need to be adapted to suit the specific requirements and not as a blue-print.

#### ***Programme Environment***

The broad objective of SPFP is to improve the access by all categories to food and to meet the three conditions, namely (i) availability, (ii) stability of supply, and (iii) access to food. To improve the stability of food supply, an obvious objective of the water management and irrigation component is to reduce the seasonal and year-to-year variability linked to inadequate water control for food production. To be sustainable the water management and irrigation development programme need to provide sufficient incentives for farmers to expand food production with a minimum external or government intervention.

A description of the agricultural environment is required to present an economic perspective on physical, political and demographic and social considerations affecting the programme and upon which the programme will impact at the different levels; local, district and national level.

#### ***Farm Model Analysis***

The effects of the programme on farm income are demonstrated through the budgetary analysis of farm models which translate the farm plans into financial terms. The financial health of the farm are analyzed in cash flows which shows the present and future surplus of cash inflows over outflows and the cash balance after repayment of credits. it provides for a discussion of the features of the budget projections and identifies the financial situation especially in critical years. One obvious requirement to provide incentive for farmers to participate in the programme is that the net cash position should not be worse than in any year prior to the programme started. While the financial rate of return may be indicated by

the financial rate of return, long-term cash flows are not meaningful measurements for small farms. Immediately visible indicators of financial viability such as net return per man-day of family labour and reduction in production risk from weather variability may be relevant and be well understood by the farmers. Specific indicators related to critical inputs could be useful, for example for balancing capital or costly energy operational costs with labour input.

The inputs to the farm model analysis should be based on the results identified and demonstrated during the preparation phase, with forecasts of:

- land use or cropping patterns;
- yields;
- input and output prices;
- input requirements during investment and operation;

Additional information on labour balances, that are often critical to increased production, and other information relevant to food security such as on-farm-consumption of farm's output, income from off-farm sources, costs of replacement of investments, and costs of charges not directly related to items of production, e.g. water charges and taxes, that would enhance or limit cash availability on small farms are highly relevant to economic analysis of SPFP programmes.

The farm level model need to include data on:

- 1 input quantities for investment and operation costs per farm;
- 2 volumes and prices/values of production:
- 3 farm level cash flow projections

at different moments of time for the conditions during years of normal rainfall, years of drought, and - for drainage programmes - extremely high rainfall.

The farm cash-flow is important to demonstrate that the programme provides improved income to meet farm expenditures and provide the incentive to the farmers to expand the programme, and increase the volumes of production to support **enhanced availability of food**. The variation in production between normal and dry years, with and without irrigation provides the indication of the **stability of food supply** and also gives a measure of risk exposure of farmers. Values and produce prices, when compared with net farm income, indicate the level of the local **access to food**.

## ***REFERENCES AND FURTHER DETAILED READING***

---

### *SECOSAF*

1993. "A Manual for Irrigation Planning in Developing Areas"; Working Group on Agricultural Resources and Land Utilization. Pretoria

### *FAO*

1985 "Preparing Agricultural Investment Projects" FAO Investment Centre; Technical Paper no 1.

# ANNEX 11: Monitoring and evaluation

## INTRODUCTION

---

This annex intends to provide some orientations on how to apply monitoring and evaluation to the irrigation development activities that will be undertaken within the context of the Special Programme for Food Production (SPFS) in support of food security in LIFDCs.

Monitoring and evaluation are essential activities in any development process particularly when local circumstances may have a decisive impact in the implementation of projects or programmes. Proper monitoring permits to stir the direction of the project or programme and avoid unwanted results and negative evaluations.

Monitoring and evaluation was a highly popular subject in the later part of the eighties but has lost part of its popularity due to the fact that good monitoring requires reliable and relevant data collected on regular bases. Unfortunately this has been the weak point and quite a number of serious effort made to monitor the development of irrigation projects or irrigated agriculture have not found the necessary continuity mostly due to the difficulty of obtaining the required data. It is therefore of utmost importance that the data to be collected are restricted to the minimum indispensable to serve the intended purpose.

## A REVISION OF THE TERMINOLOGY

---

A certain degree of misunderstanding exist between the terms of monitoring and evaluation. For this reason it may be appropriate to review the commonly accepted definitions for these terms.

**Monitoring** is the continuous or periodic review and surveillance by management at every level of the hierarchy of the implementation of an activity to ensure that inputs deliveries, work schedules targeted output and other required actions are proceeding according to plan.<sup>5</sup>

---

5: As defined in the Monitoring and Evaluation. Guiding Principles for the Design an use in Rural Development projects and Programmes in Developing Countries.

**Evaluation** is a process for determining systematically and objectively the relevance, efficiency, effectiveness and impact of activities in the light of their objectives.

Evaluation can be carried out during implementation (ongoing evaluation) at completion (terminal evaluation) and some years after completion (ex post evaluation)

While monitoring is a continuous or regular activity, evaluation is a management task that takes place at critical times of the life of a project or programme.

The main purpose of monitoring and evaluation is to ensure that the project or programme fulfil the stated goals, and objectives within the financial parameters that are set at the beginning of project.

### **CONDITIONS FOR SUCCESSFUL MONITORING AND EVALUATION**

---

There is considerable material written on principles and necessary conditions for successful implementation of M&E system. There is no need to repeat them here but such criteria are often thought for the activities at national level or project level. Their application within the SPFP requires revisiting of some of the conditions.

- The first important element is to define clearly and univocally what is going to be monitored and evaluated. For example, is the Preparation phase, or the Demonstration Phase, or the Expansion Phase or all of them ?. The latter option may bring different requirements for each phase.
- Indicators are extensively used in monitoring and evaluation activities but in order to be able to apply them the collection of regular information is indispensable. The project should foresee who, when and how this information will be collected and compiled. Unless the necessary steps are taken to guaranty that the information will be collected the chances for a successful M&E system are nil. A related consideration about indicators is that they do not all need to be quantifiable, qualitative indicators are as useful as numerical ones.
- Because of the difficulties in collecting information in the field and related costs, the number of indicators should be kept to the minimum required. Existing channels and procedures should be utilized to accommodate monitoring routines rather than establishing new ones.

- Indicators should be clearly defined and must be clearly related to the objectives that the project intends to achieve.
- Within the context of SPFP two systems of M&E may be required:
  - a. one oriented to monitor the implementation of the irrigation component in a given country, and
  - b. another one to monitor how effectively the operations (field missions, reports, staff and financial resources used, etc..) were carried out.
- Evaluations can be undertaken at regular intervals or at critical times of the life of the project. In the case of the water management activities it seems logical to undertake an evaluation at the end of every major phase before initiating the new. The need for additional evaluations should be assessed in every specific case.
- Evaluation should be undertaken by staff that are not associated with the project as otherwise a bias view will be unavoidable. Normally, evaluations are carried out by a multidisciplinary team and their cost and timing should be foreseen in the annual work programme. This may be too costly in the case of small projects. In such cases the possibility of using local staff rather than international should be considered. Other ways of reducing associated costs should be considered.

### ***DEFINING THE M&E COMPONENTS***

---

The first important point to be considered is that the irrigation component of the Special Programme for Food Production is one of the possible components of the programme in a given country. Therefore when devising the monitoring and evaluation for the irrigation component one has to consider that similar exercises may have been developed for other components. In such cases it will be necessary to ensure the homogeneity in approach of all M&E systems proposed but even more important will be to ensure that no duplications occur in the collection of information.

Therefore the reader has to keep in mind that the orientations here given are specifically addressed to the M&E of the irrigation component of the SPFP.

A brief summary of the irrigation component in the SPFP



Within the irrigation component three major phases are differentiated, namely:

1. **Preparation phase**
2. **Demonstration phase**
3. **Expansion phase**

The **preparation phase** aims at preparing the way for the Demonstration phase. It reviews the irrigation development policies of the concerned country, establishes an institutional framework for the future implementation and formulates the plan for the pilot\ demonstration phase. Essentially the preparation phase produces one or several documents and makes local arrangements for the future demonstration phase. Although no specific duration is assigned to this phase a time horizon of one year could be a reasonable assumption. The M&E requirements are limited in this stage as the main output of this phase is a plan. One can check if the documents and work plan meet the expectations.

The **demonstration phase** aims at putting in place a certain irrigation technology and increase agricultural production of the benefited farmers. In this phase the M&E is of great importance as there is much to be learn in terms of how the pilot area has contributed to: the adoption of the proposed technology, to improve the capacity for the self management of the project, to improve the performance of existing schemes (in case of rehabilitation improvement projects, to increase farmers benefit and welfare, and other related objectives. The M&E system should permit to learn lessons that will be essential for the Expansion phase. The duration of this phase will be in the order of 3 to 4 years

Lastly, the **expansion phase** will try to apply the lessons learn in the previous phase to a larger scale. this phase will be more conventional in the sense that once the approach is properly defined the expansion project will have financial requirements that will require substantial investments to be provided either nationally or through international financing. The M&E system will be, therefore, more conventional and should be included in the document where the investments are project design are included. Conventional criteria for the M&E of irrigation projects could be applied here.

### ***M&E OF THE PREPARATION PHASE***

---

Having into consideration the remarks made above, the M&E system for this phase could be relative simple. A checklist or questionnaire addressed to verify that the stated objectives were achieved could be quite satisfactory. Team leaders could develop their own checklist/questionnaire or use the sample provided in **Appendix No. 1: Sample Check List for the Preparation Phase**.

It is very likely that to complete this phase more than one field mission may be required. The check list should be used at any intermediate mission but in the end the responses should be predominantly positive if the programme is going to be carried out.

### ***Monitoring of the implementation of the preparation phase***

As indicated earlier, in addition to monitor how effectively the objectives of this phase were achieved one may also monitor how financial and human resources were used in this phase. This should be a concern of the management of the SPFP. For such purpose a different kind of monitoring will be required. The following information will be relevant for this purpose.

#### ***Human resources allocated:***

- Total number of man/days dedicated by professional of different categories to the formulation of Preparation Phase and estimated contribution by General Service
- Number of man/days (FAO professionals and international consultants) expend in the field in support of the programme.
- Estimated number of man/days of national team dedicated by the national team to support programme.

#### ***Financial costs:***

- Estimated cost of the man/days allocated by international and national staff
- Estimated cost of travel missions (excluding staff since already counted above)
- Other associated costs (preparation of documents, training sessions, etc..)

#### ***Time control:***

- Control of the time required for each mission and for the completion of the Preparation phase should be kept.

## ***M&E IN THE DEMONSTRATION PHASE***

---

The establishment and effective functioning of a M&E system is essential in this phase. The pilot demonstration experiences aim at demonstrating that certain approaches and technologies are capable of improving the farmers income and increase the food security. If for any reason the demonstrations fail in achieving the objectives the whole expansion phase will be questionable and the efforts made in the demonstration phase will be of scarce usefulness.

The M&E evaluation system must be capable of identifying shortcomings and limitations in the implementation of the programme and be in the position of correcting them.

In order to be able to the device a suitable M&E system is necessary to spell out clearly the objectives of this phase as the system must monitor how these objectives are being progressively achieved. The stated objectives of this phase are:

- Objective 1:** To intensify and increase agricultural production on irrigated land;
- Objective 2:** To improved performance of existing schemes through on-farm irrigation technology;
- Objective 3:** To demonstrate technologies and methods of irrigation expansion;
- Objective 4:** To improve capacity of staff and local community for self-management and develop institutional base for irrigation expansion;
- Objective 5:** To assess constraints and evaluate results.

It is possible that in a given demonstration area some additional objectives may be required. In such case it should be clearly stated and additional information may be necessary to monitor its implementation. On the other hand Objective No 5 is the subject of the present annex and therefore is implicitly treated in the appendix 3 where the monitoring indicators are proposed.

Several of the above objectives state the action of “improving” and in order to assess this improvement is necessary to know the starting point. In other words **the first step in the M&E system is a survey that gives a “photography” of the present state of the agricultural and social conditions of the pilot demonstration area.** For this purpose the outline indicated in Appendix No. 2:” Outline for the Description of the Present State of the Pilot Demonstration Area” could be applied.

To monitor the achievement of the above mentioned objectives and other additional ones that may be required in some specific case, the monitoring system must be able to reveal the progress achieved but also to detect if there is any important deviation from the expected progress.

In Appendix No.3: “Proposed Monitoring System for the Demonstration Phase”, a number of indicators have been devised to assess the progress made in every of the stated objectives. For every indicator the information to be collected is also spelled out. As stated above, it will be the responsibility of mission leaders to agree with the national teams in how and when this information will be collected.

As in the case of the preparation Phase the management of the SPFP will be interested in monitoring how effectively the operations of this second phase were carried out. For this specific purpose a separate monitoring system will be required.

Such a system could be very similar to the one already outlined for the preparation phase under the heading :“Monitoring of the implementation of the Preparation Phase”. There is however a major difference and is that most of the required information will only be available locally and therefore it would be logical that such monitoring be carried out by the local team.

As far as the evaluation is concerned it would be seem appropriate to carry at least one progress evaluations per year. This should be preferably carried out at the end of each main irrigation season. Annual progress evaluations could be carried out by a national consultant with the support of the national teams. Results of the evaluation should be discussed at a joint meeting with the national team and where financially possible also attended by leaders of the preparation phase missions.

Considering that the Demonstration phase may last a period of 3 to 4 years a final evaluation appears indispensable. Such evaluation should be carried by an independent international interdisciplinary team. Results will be discussed with the national team and national relevant authorities. The report of the meetings and the evaluation report will also be forwarded to the management of the SPFP and after technical clearance submitted officially to the concerned government authorities.

### ***M&E IN THE EXPANSION PHASE***

---

A considerable lapse time will take place before arriving a this phase and as earlier indicated the monitoring and evaluation will be more conventional since in this phase will have more the characteristics of an investment project. The monitoring and evaluation system will be in consequence with the importance and magnitude of the project and considerable guidance exist for the establishment of appropriate monitoring systems in large irrigation projects. Therefore no need appears at his stage to formulate a detail proposal.

# APPENDIX 1:

## Sample check list for the prepartation phase

### ***IN RELATION TO THE OBJECTIVE NO.1: "DEFINITION OF THE FRAMEWORK FOR IRRIGATION DEVELOPMENT"***

***Was the collection of available information about the irrigation sector?:***

- Abundant,
- Satisfactory,
- Sufficient,
- insufficient

***Was the assessment of the potential contribution of irrigated agriculture to food security carried out?***

yes

No

If yes, was it?:

- highly positive
- positive
- no clear conclusion
- negative

If not, why:

---



---



---



---

***Are government policies in the water sector satisfactory for the development of the irrigation component?***

yes

No

If not indicate, what issues should be tackled during the Demonstration phase to make the Expansion phase feasible.

- 1. Water Legislation
- 2. Institutional reforms
- 3. Liberalization of private sector
- 4. Others  Specify:

---



---



---

***The rate of expansion of irrigation development in the last 3 years was:***

- greater than 2%,
- between 1 and 2%,
- between 0 and 1%,
- negative

***Indicate level of investment by External Support Agencies (ESAs) in irrigated agriculture and main donor countries***

U\$ millions invested in irrigated agriculture by ESAs in 1995 \_\_\_\_\_  
in 1994 \_\_\_\_\_

Main donor countries: \_\_\_\_\_

***How do you evaluate the role of the private sector in the development of irrigation.***

- Highly relevant,
- relevant,
- relevant if encouraged by government support measures
- irrelevant.

***The report covering the above aspects is :***

- Very complete and highly analytical of the irrigation sector
- complete and technically satisfactory
- Technically sound but not covering all the main issues
- assumes that all above issues covered by existing reports
- not satisfactory

***IN RELATION TO OBJECTIVE NO. 2: "DEVELOPMENT OF THE INSTITUTIONAL FRAMEWORK FOR IMPLEMENTATION"***

---

***Has the national team been formally established and responsibilities for implementation identified?***

Yes

No

If not, explain why:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_



***Has the government formally committed to carry out the demonstration phase?***

Yes

No

If not, explain:

---



---



---

***Were the national consultants identified?:***

Yes

No

If not, explain why:

---



---



---

***Will the national team require external technical assistance?***

Yes

No

If yes, was this need assessed financially?

Yes

No

***IN RELATION TO OBJECTIVE NO. 3: FORMULATION OF THE DEMONSTRATION/PILOT PHASE***

---

***Were the locations for the pilot programmes identify?***

Yes

No

If not, explain why:

---



---



---

***Were farmers informed and their potential interest in participate assessed?***

Yes

No

If not, explain why:

---



---



---

***Were the technological options to be demonstrated identified?***

Yes

No

If not, explain why:

---

---

---

***Was the Plan of Work for the demonstration phase completed for the envisaged period (3/4 years)***

Yes

No

If not, explain why:

---

---

---

## **APPENDIX 2: Outline for the description of the present state of the pilot demonstration area**

### ***GEOGRAPHICAL DESCRIPTION OF THE AREA***

---

- Location, morphological description(terrain , slope, vegetation, natural drainage, etc.), geological formation, accessibility;

### ***METEOROLOGICAL CHARACTERIZATION***

---

- Location of meteo station, summary meteo data (average, dry year, humid year), climatic classification;

### ***SOILS DESCRIPTION***

---

- Describe the main characteristics of the predominant soils. If this information is not available a rapid survey must be undertaken as the soils characteristics will be essential to determine irrigation amounts and soil management practices. Indicate any limitation that may affect crop production as result of the soil structure or composition.

### ***POPULATION***

---

- Describe the predominant features of the local agricultural population(level of education, health, living standard, cultural habits, attitude towards associativism, etc.) For the specific demonstration area report number of people involved, leaders, average income, participation in non agricultural activities and other relevant characteristic. Role of women in the society and particularly in agriculture.

## ***CROP PRODUCTION***

---

- Indicate the main crops that are being produced. The local agricultural practices used for every crop should be briefly described. Levels of production must be quantified as accurately as possible. Maximum levels of production obtained by 'good' farmers should be reported. National average production levels for the crops predominant in project area should be reported. Post harvest losses should be assessed. Production costs for every crop need to be collected and quoted.
- Cropping intensity (numbers of crops grown per year in the same plot of land) is also an important data to compare with future situation

## ***MARKETING AND PRICES***

---

- Report which part of production is for home consumption and for market selling. Describe predominant marketing system. Report known farm gate prices and market prices

## ***IRRIGATION INFRASTRUCTURE AND TECHNOLOGY***

---

- If the area is already under irrigation, a description of the irrigation system will be required. This description should be as complete as possible and with indication of the status of maintenance of the existing infrastructure.
- At farm level, the description of the traditional irrigation practices being used by farmers will be also necessary. Estimation, or determination of system and farm efficiencies are also important information. indispensable data.

## ***LAND OWNERSHIP***

---

- Describe traditional ownership pattern. Indicate predominant farm sizes. Report if farms fragmentation is a predominant feature. Possibility for accessing to credit facilities.

### ***INSTITUTIONAL SET UP***

---

- Describe the government services that are available for the farmers of the demonstration area with particular emphasis to those referring to irrigation management. Report number of staff available for the different services and area or population to be served. Report training and/or extension services facilities available to farmers.

### ***FARMERS ORGANIZATIONS***

---

- Report and describe the farmers organizations that are operating in the area of influence of the demonstration area.

### ***FARMERS INCOME AND WELFARE***

---

- Income from the agricultural production must be reported for the main categories of farmers. Other possible sources of income from non- agricultural activities should be estimated.
- Social services available to the community should be reported.

## APPENDIX 3: Proposed monitoring system for the demonstration phase

### **IN RELATION TO OBJECTIVE NO. 1: TO INTENSIFY AND INCREASE AGRICULTURAL PRODUCTION ON IRRIGATED LAND**

This is the main objective of the demonstration phase and therefore the indicators proposed here are of great importance in determining the degree of achievement of this important objective.

#### **1st Indicator: Increase over average production**

This indicator will measure the average increase (in percentage) that is being obtained in the demonstration as compared to the national averages and/or the production averages in the project area before the demonstration phase. The required data for its application are:

	<b>Project average (kg)</b>	<b>National average (kg)</b>	<b>Increase or decrease (kg)</b>	<b>Percentage</b>
Crop 1	P (1)	A (1)	P (1) - A (1)	100* [P(1) - A(1)]/A(1)
Crop 2	P (2)	A (2)	P (2) - A (2)	100* [P(2) - A(2)]/A(2)
Crop N	P (N)	A (N)	P (N) - A (N)	100* [P(N) - A(N)]/A(N)

The average percentage of increase/decrease for all the crops is the indicator proposed for agricultural production:

$$CP = \sum_1^N \left( \frac{P(N) - A(N)}{A(N)} \right) \frac{1}{N}$$

where N is the number of crops and the other variables have the values of table.



## ***2nd Indicator: Cropping intensity***

This indicator will provide an evaluation as to what extent second and third crops may take place. The indicator (CI) is defined as follows:

$$CI = [A(C1) + B(C2) + C(C3)] / CA$$

where: A(C1) = Total area harvested in the first season  
 B(C2) = Total area harvested in the second season  
 C(C3) = Total area harvested in the third season  
 CA = Cultivable Area

## ***3rd Indicator: Increase in Planted area***

The intensive use of irrigation water is a good indication that the change towards an intensive agriculture is taking place in an effective manner. Therefore this indicator aims at evaluating to evaluate to what extent this change is taking place. For this purpose the increase in planted area from one season to the next (expressed in percentage) will be a relevant indicator:

$$IPA = 100 * [AP(S1) - AP(S2)] / AP(S2)$$

where: IPA = Increase in planted area (in percentage)  
 AP(S1) = area planted during the current season  
 AP(S2) = area planted during the past season

In humid climates, the flow available during the wet season is considerably greater than the same during the dry season, therefore the AP(S1) and AP(S2) are considerably reater than the corresponding values in the dry season. It is therefore recommended that the IPA is calculated separately for the wet and dry season.

## ***In relation to Objective No. 2: To improve the performance of irrigation systems***

### ***4th Indicator: Overall irrigation efficiency***

Overall irrigation efficiency is a value that varies constantly through the year and is affected by the efficiency of the actual water distribution and farmers ability to apply water effectively. Still is always a good reference for how efficiently irrigation water is utilized.

The following indicator is proposed:

$$\text{OIE} = 100 * [\text{AIA} * \text{CWR} * 10000] / [\text{FI} * 3600 * 30 * \text{N}]$$

where: OIE = Overall irrigation efficiency  
 AIA = Actually irrigated area (during peak month)  
 CWR = Crop water requirements in m.m./month  
 (for the peak month)  
 FI = Average flow of main intake (l/s) in the peak month  
 N = Number of hours of irrigation per day

The above indicator will give the efficiency of the water use in the peak month. It will be desirable if in similar way is determined for every month of the year to have an indication of the variations of the OIE along the year.

This indicator will be particularly relevant when rehabilitation and improvements works have been undertaken as the greater physical efficiency of the system must be reflected in higher values of OIE.

### ***5th Indicator: Operation and Maintenance costs***

Operation and maintenance costs referred to the irrigated hectares are already a good indicator by themselves of how efficiently the financial resources are being utilized.

$$\text{OM} = \text{TC} / \text{AIA}$$

where: TC = Total annual costs incurred in O&M  
 AIA = Actually irrigated area (ha)

However once O&M costs have been determined one can get an indication of the farmers capacity to pay them by referring these costs to the farmers' income

$$\text{IFI} = 100 * \text{TC} / \text{FI}$$

where: IFI = Impact of O&M costs in farmer's income  
 TC = Total annual costs incurred in O&M  
 FI = Farmers income (assessed on the bases of a representative sample)

For values of IFI greater than 10% difficulties can be expected in the collection of fees.

### ***IN RELATION TO OBJECTIVE NO.3: ADOPTION OF IRRIGATION TECHNOLOGIES***

---

To monitor the achievement of this objective not only is necessary to have an indication of how many farmers adopted the technology but how well the farmers were able to assimilate the technology.

However, a precondition for a proper monitoring of this objective is that the technological package for irrigation must be properly defined.

For the first purpose the following indicator is proposed:

#### ***6th Indicator: Percentage of farmers that adopted the irrigation technology.***

A simple indicator would be the percentage of farmers that over the total participants in the demonstration area have adopted the technological package.

$$AT = 100 * FAT / TNT$$

where: AT = Percentage of farmers that adopted the technology  
FAT = Number of farmers that adopted proposed technology  
TNT = Total Number of farmers of the demonstration area

The apparent simplicity of this indicator is constrained by the fact that is not so simple to determine in a clear way whether a farmer has adopted or not a technology. As the technological packages will be likely different in each country or demonstration area the criteria for determining the adoption by farmers must be developed locally.

#### ***7th Indicator: Water use at farm level***

One important aspect of the demonstration phase is the efficient application of water at farm level. By this term we mean that water is applied at suitable intervals (which will depend of the technology used) and the necessary amounts to satisfy the crop water requirements are provided. If irrigation water is not applied with a minimum of technical bases is clear that the intended increases in crop production will not be reached. Therefore it is of great importance to document how irrigation water was applied.

As the number of farmers participating in the demonstration phase will be relatively large it will be practically impossible to monitor the water use by every farmer as this will be time consuming and costly. the only

feasible way will be to do it on sample bases. The sample should be statistically representative but this is again costly when the number of farmers is large.

For every farmer included in the sample the following records should be kept:

- 1 Number of irrigations, intervals and volumes to be applied to each crop. This should be calculated according to the soils characteristics and crop water requirements. For this purpose the CROPWAT computer program is a recommended tool.
- 2 Actual amounts, intervals (dates) and number of irrigations applied by the concerned farmer should be recorded. Here again the CROPWAT programme will be useful to keep these records but also to assess the actual efficiency achieved by the farmer.
- 3 Assess how closely the farmers have followed the recommended irrigation schedule. For this purpose three variables must be determined:
  - the relation between the total amount actually applied and the calculated
  - the relation between the amount of water applied and calculated for each irrigation
  - the relation between the number of irrigations applied and the calculated.

These three sub-indicators will give a view of how effective farmers adhered to the recommended schedule.

This is perhaps the most expensive of the indicators to be determined and therefore provisions should be made in the work plan for the demonstration phase to cover related costs.

### ***8th Indicator: Farm irrigation efficiency***

The determination of the irrigation schedules mentioned for the indicator No. 7 imply the application of the farmer's efficiency in applying the irrigation water. The tendency is often to apply this figure based on empirical or personal experience. However, for the demonstration phase a more accurate determination will be required. Farmer's irrigation efficiency should be determined for the farmers included in the sample above mentioned. These determinations should be carried out following standard procedures (see Irrigation and Drainage Paper No. 46 or other relevant manuals). It will be useful to determine these efficiencies yearly and monitor any progress made by farmers.

### **IN RELATION TO OBJECTIVE NO.4: TO IMPROVE CAPACITY OF STAFF AND LOCAL COMMUNITY FOR SELF-MANAGEMENT**

Two main aspects have to be monitored in relation to this objective: firstly how much training has been carried out to improve the capacity of the local staff and farmers and secondly the impact of the training in promoting self management.

#### **9th Indicator: Training activities carried out**

The number of training activities that have been carried out, the type of activity, its duration and number of participants should be reported here. The number of participants should be related to the potential number of them to have an indication of what percentage has been covered.

#### **10th Indicator: Self management**

The aim of this indicator will be to assess the degree of self-management that has been achieved in the pilot demonstration areas. The underlying assumption is that an effort was made to establish a WUA and through the criteria proposed below the degree of self management is assessed.

The WUA functions satisfactorily and 80-90% of the water rates are collected	fully independent
The WUA is established, the water distribution is effected by farmers at tertiary level but secondary canals and upward are operated by government staff, only minor maintenance works are carried out by farmers, 65 to 80% of water rates are collected	semi-independent
The WUA has been established but acts mainly as a consultative and information body. Decisions are still made by government officials, 50 to 65% of water rates are effectively collected	low degree of independency
The WUA has been established on paper but none of its tasks are carried out in practice	dependent, it needs explanation
The WUA has not been established	needs justification

#### **Frequency**

The above mentioned indicators should be determined yearly but some of them require input data that need to be collected with intervals of few days as indicated in the respective sessions.

## Ranking systems

The above mentioned indicators generate numerical values or qualitative statements. In order to have an overall view of the performance of the demonstration areas is convenient to assign a point system to every one of the indicators. For instance, for the crop production indicator the following point system could be adopted:

CP Value	Points
greater than 50%	8 - 10
30% to 50%	7 - 8
15% to 30%	5 - 6
0 to 15%	4 - 5
-15% to 0%	3 - 4
smaller than -15%	0 - 2

and similarly for the other indicators. By adding all the values obtained an overall estimation of the performance of the demonstration area is achieved.

Any point system has a certain degree of subjectivity and will be influenced by local factors but once established and adopted the results for a given location are comparable. On the other hand to prescribe a point system is a dangerous approach as in a given country certain indicators may have more relevance than others and this cannot be taken into consideration before hand. Therefore it is recommended that the point system to be applied in a given country be developed locally.

Alternatively, a qualitative system may be developed for every indicator. For instance for the cropping intensity indicator the following criteria could be used:

CI	Criteria
greater than 200	highly satisfactory
170 to 200	significant
140 to 169	satisfactory
120 to 139	acceptable
100 to 120	unsatisfactory
smaller than 100	highly unsatisfactory

This system is more flexible but makes it more difficult to have an overall view of the demonstration area as it will be made by a list of qualitative statements which makes the comparison with other areas difficult.