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Principles, Methodology and Strategy for Promoting the African Green Revolution

A Design and Training Manual[1]

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1.0 BACKGROUND

1.1 Why a working manual on triggering GR in Africa

Now and again, it has been argued that lack of appropriate/improved technologies and non-use of complementary improved inputs are the root causes of the African vicious circle of low agricultural productivity, food shortage, low income and perpetual poverty. These constraints necessitate the African countries putting the applications of science and technology at the core of their vision and strategies for food security, poverty eradication and sustainable development. In most of those African economies agriculture is the leading sector, contributing 36% to GDP as compared to industry, 28% and manufacturing 7%. Moreover in Africa, the Agriculture sector has key roles and functions of providing food, employment and sources of income for rural populations (who are 60% to 80% of total population), major sources of foreign exchange, provisions of raw materials for manufacturing and the initial capital investments for the economic growth. So, if any African country strives to achieve its goal of food security, the fastest route of agricultural development in the world today, is via Green (Agricultural) Revolution. However, it is understood that as Africa moves through the stages of economic development from agricultural development to industrialization stage, like it was in Asia and South America, the Green Revolution stage cannot be by passed. But, unlike the Asian, causing a Green Revolution in Africa through harnessing science and technology, is not exactly the same as adapting importable technologies from outside. Instead we must address ourselves to key challenges like differences in commodities and agro ecological zones, complex farming systems and diversity of socio-economic and cultural context. It is therefore important to design our own home grown African Green Revolution Initiative. Although an African Green Revolution may benefit from lessons learnt in GR Asia and elsewhere, it needs to be designed with the necessary unique features fitted and galvanized to withstand shocks in the irrespective zones. However in order to instill the inherent mechanisms and forces to create a momentum that can cause AGRI to be wide spread and sustainable, the design principles must be the same, although different versions of GR may be designed to fit the different situations. The design, needs to be comprehensive, intersectoral and encompassing the scientific, economic, environmental and social issues as well as the linkages between systems of production, input supply, market outlets, consumer welfare, infrastructure, institutional and consumer welfare.

Purpose and objectives

The purpose of this GR design manual for the African Green Revolution is to guide and help enhance the capacity of African countries to design and implement a Green Revolution in their respective areas of jurisdiction.

The objectives of this GR design manual are:

(i) to identify the core building blocks and the methods for the design of African Green Revolution.

(ii) to identify the prime movers (technological, infrastructural, institutional and policy (TIIP) and leverage factors that must go into such a design and how?

(iii) to propose a strategy for African countries to design and cause a Green Revolution to happen in Africa starting with their respective areas.

1.2 Lessons learnt from the Asian Green Revolution – the case of Indian experience

In 1967 the first Green Revolution occurred in Asia. It offered farmers in some Asian and S. American countries improved/high yielding rice, wheat and maize crop varieties that enabled them (farmers) to double their yields from 0.5t/ha to 1t/ha/year. Earlier in 1966, International Development agencies like Ford and Rockefeller Foundations, USAID etc had the vision of creating and funding International Agricultural Research Centres like IRRI and CIMMYT where critical teams of researchers bred the new varieties and developed the technologies needed to accompany the new crop varieties. The International Centre researchers together with their sponsors were pursuing a noble goal of enabling the developing countries to attain "FOOD FIRST". Meanwhile between 1960 – 66, about 60% of the Indian rural population were hungry and poor. The Indian nation depended on donated US food/grain. In 1962 rampant famines broke out in India, caused by severe droughts. Coincidentally, in 1966, under a new political leadership of Indira Gandhi, the new Minister of Agriculture in collaboration with the Director General of Agricultural Research of India, imported small amounts of wheat and rice seeds from CIMMYT Mexico and IRRI – Philippines respectively. Then the improved wheat and rice seeds were multiplied and subsequently distributed to farmers. In 1967 – 68 there was large scale adoption of improved varieties of wheat and rice. That year, crop yields were more than doubled. There was a bumper harvest. The 1968 production was so high that all the available storage was fully utilized and schools had to close temporary to allow more space to store the grain. Thereafter the Indian Authorities spread and consolidated the achievements of their Green Revolution by:

(a) building strong national research institutions to maintain the momentum of R & D,
(b) investing in infrastructure for national irrigation system,
(c) provision of rural feeder roads,
(d) formulating price stabilization policies to create incentives to farmers while protecting the interests of consumers,
(e) formulation of policies and financial institutions to support credit and to expand its rural branches and provide rural agricultural credit at subsidized interest rates for key agricultural inputs like improved seeds, fertilizers, farm tools and irrigation.

Then after realizing the Cereal Green Revolution of 1966 – 1985, India, used the same technology generation and dissemination procedures to obtain other revolutions namely:
(i) 1980 – 1990 Horticulture development – Fruits and vegetables
(ii) 1985 – 1995
- White revolution – Dairy sector
- Yellow revolution – Oil seed sector
- Blue revolution – Fisheries sector

(iii) 1995+ - Applications of Biotechnology

Analysis of the Indian GR Experience indicates the following four essential components that made the revolution a success. Those components are:

(a) Biological technological improvements
(b) accompanying complementary technologies
(c) provision of the necessary inputs
(d) provision of basic infrastructure to provide the supporting and complementary roles and facilities.

1.3 Conceptual framework of African Green Revolution initiative

The concept of African Green Revolution is a system Sustainable Modernization of Agriculture and Rural transformation. It is an extension of scientific achievements of 1966-85, where there were dramatic increases in crop yields of wheat, rice and corn through high yielding modern varieties and their accompanying technologies. The African Green Revolution has four major components:-

1 (a) The biological technological component – where high yielding elite/improved crop varieties through selection and modern biotechnology such as tissue culture, transgenic plants, gene transfer and genetic marking technologies. The improved varieties must have the correct attributes, with respect to climatic and soil conditions/agro ecological zones plus specific pests and diseases.

1 (b) Crop-livestock integration – elite/hybrids/exotic breeds with respect to the productivity/sustainability of a mixed/integrated crop-livestock farming systems.

2. The organic and/or inorganic chemicals fertilizers – which may be applied separately or in a combination to replenish the soil. For livestock component there should be a complementary improved pasture system. Plus soil fertility management regimes.

3. Biophysical technologies – such as irrigation – (tube/well, river and harvested water irrigation) complementary services/inputs like irrigation, rural credit, rural feeder roads, electrical power and supporting services like price stabilization policies and market outlets. Also a strong national research system is needed to provide, to maintain Research and Development and ensure continuous sources of improved technologies.

It has also been suggested that the whole set of indicators of the African Green Revolution could be grouped into four categories known as "TIIP" (GR indicators Kampala workshop 2003)

T = technology/innovation
I = infrastructure (market, roads, energy …)
I = institutions (R & D, ext, farmer organization)
P = policies (governance, input …….)

2.0 THE GR DESIGN BLOCKS

2.1 The African Green Revolution prime and secondary building/design blocks

The African Green Revolution means evolving/designing an improved farming systems which can sustainably produce increased output of more than 40% per unit input or over and above total output and which can receive mass or large scale adoption by farmers.

According to our analyses, there are six prime design blocks which can be used to design and trigger off An African Green Revolution (GR).

The six GR prime design blocks are:
Technology, institutions, policies, agro-ecological zone, tuned/primed farm communities and access to an effective market. Those are complemented by secondary design blocks which include a marketable surplus of a given commodity, infrastructure and land resources. See table 2.1 and their description below.

(i) Technology:– biological like crop variety or animal breed, or chemical technology such as fertilizers or animal feed or physical technology which may have been generated from national research or having adapted an imported technology to the local conditions. The technology block must be complemented by an adaptable crop or livestock commodity that is capable of producing strong/robust sustainable/replicable results in the target zones.

Table 2.1: The African Green Revolution prime and secondary design blocks

Prime design blocks	Attributes/complementary/secondary design blocks
1. Technology crop/livestock - Biological technology - Chemical technology - Physical technology - S + T adapted imported technology	- adaptable crop/livestock commodity - robust sustainable replicable results - complementary technologies or cultural practices
2. Effective institutions - R + D - Extension/technical information - Farmer organizations	- infrastructure/support economic social services - transport services
3. Effective policies - support policies - political will/support	- allocation of human, financial and material resources to design and implement GR
4. Agro-ecological zone/climate - rainfall - temperatures - vegetation	- positive evapotransperation duration - critical crop growth period - favourable land resource
5. Tuned/primed farm communities - large aggregate farmers' vision, knowledge + skills	- adequate management/entrepreneur skills - adequate capital/credit access
6. Effective market demand - domestic/export markets - size/purchasing power	- potential crop/livestock marketable surplus commodities same as in (1)

(ii) Institutions:- the second prime GR design block is having effective institutions such as Research and Development, Extension/flow of technical information, farmer organizations, training and credit institutions. In addition there should be a set of infrastructure to provide economic, social and transport support services as it complements the effective institutions.

(iii) Policies:- another GR prime design block is effective policies along with political will/support. For African Green Revolution to happen, it also requires adequate allocations of human, financial and material resources for the design and implementation of GR.

(iv) Agro-ecological zone:- the successful GR designs must be fitted to their respective agro-ecological zones. They should complying with the rainfall pattern/distribution, temperature ranges and the general vegetation – the climatic GR design blocks needs to have uninterrupted duration of soil moisture surplus to cover the critical crop growth period plus availability of favourable land resources.

(v) Tuned/primed farm communities.. The farm communities must be primed and tuned to demand and receive the GR designs. In addition, the participating farmers require visions, knowledge, skills and entrepreneurial spirits to host and manage the GR improved farming systems designs. This GR design block also requires adequate capital as well as access to credit to produce a marketable surplus of a potential crop or livestock commodity same as that required for the technology design block.

(vi) Effective market demand:- last but not least of GR prime design block is to have access to an effective domestic or export markets with a sizeable population that has sizeable purchasing power of the marketable surplus crop/livestock commodity supplied by the GR designed/improved farming systems.

2.2 Design principles of African Green Revolution

2.2.1 Geopolitical and geo-economic favourable environment

From all points of view, it has been argued that there must be political leadership and political support for any national development and more so for Green Revolution to happen in a country.

The political leadership and support needed to provide vision, direction and attainable goals. They ensure mobilization of the necessary financial, material and human resources and the continued commitment by all sectors for the GR goals. Geo-economic environment such as a substantial domestic market and commodities that can create opportunities for export markets. So the GR design teams should solicit support from the regional and national political leadership who in turn should provide favourable macro-economic policies and economic incentives to attract the private sectors' donations and private capital investment when opportunities arise during the GR implementation phase.

2.2.2 Critical mass of science and technology institutions and human resource capacities of research for development

- There should be a critical mass and capacity of public and private agricultural institutions with multidisciplinary teams mandated to conduct public agricultural research systems for technology generation.
- The national institutional set up may also include

(i) stations and regional coordination sites
(ii) universities with agricultural research
(iii) private agricultural research institutions

The national research teams need to be having a long term priority focused research programmes. The teams must be having human resource capacity of research for development. The teams must be facilitated to do its work. Besides there should be national capacity to mobilize adequate human, material and financial resources with a minimum of 2% of GDP of any given country.

2.2.3 Formation of focused/consistent long term standard policies

The formation of a well focused national development goal backed by a long term vision. These two are usually incorporated in a long term 20-50 years national strategic master plan.

For planning and implementation of policies for agricultural research and development

- There are short-term (5 yrs) and medium tem (10 yrs) policies
- Then development objectives and annual work plans.

The national science and technology policies, which are linked to national education policy need to include

(a) National education policy – education builds up:
  (i) capacities of users of science and technology potential
  (ii) entrepreneur skills to political investors/developers
  (iii) education stimulates communities to make demands and consume processed products
(b) Science and technology policy – which provides strategies for generating more advanced technologies. Such strategies or more focused policies are (adaptation of improved technologies, biotechnology and bio-safety policies) or deploying national experts to acquire skills from advanced laboratories in developed countries.
(c) Development policy guidelines/work plans/objectives activity
(d) Investment/development budgeting policies/instruments.

2.2.4 Planning the sustainable use and conservation of natural resources

To cause a Green Revolution in Africa and to maintain Green Revolution benefits, the natural resources (land, soil fertility, water, forests, wildlife and wetlands) must be planned and used in a sustainable manner to satisfy the benefits/needs and aspirations of the present and future generations. In this regard, there is need for:

- (i) Land use planning according to type of use (settlement, grazing, intensive cultivation, forests, wildlife) should be mapped against the relative soil fertility transect and the population density.
- (ii) Land tenure system and land reforms/socio-economic reforms
- (iii) Land and socio-economic reforms should incorporate their cultural, social, political and economic perspectives
- (iv) Replenish soil fertility for sustainable use and benefits of the present and future generations
- (v) Water use planned for agriculture (crop and livestock), human, wildlife and environmental protection.

2.2.5 Long-term national investment plans

There is need for master plan for all national public and private investments to ensure coordination

- (i) in harnessing the natural resources land, water, forest, and wetlands for the development of national irrigation systems
- (ii) for the provision of social and economic services
- (iii) development of feeder road network and other infrastructural network.

2.2.6 Use of appropriate methodologies and procedures

There is need for the use of appropriate methodologies and procedures for

- (a) identification of priority commodities, their major constraints, technology gap and possible technical interventions
- (b) technology generation, validation and transfer must be demand driven. That is as technical solutions be addressed to stakeholders/target beneficiaries needs.
- (c) technology generation can use basic ideas or as adaptation of imported technologies refabricated to address local beneficiary's needs and priority settings – using participatory technology development and transfer process.
- (d) But the commodities produced by the local beneficiaries of that technology must be market oriented.
- (e) The application of science and technology of simple and/or advanced levels of Green Biotechnology carries the achievements of agricultural research and development through a lot of mileage.
- (f) Conduct participatory and networking in on-farm research programme bringing about better researchers – extension = farmer linkages.

2.2.7 Tuning up the rural communities

There must be:

- Tuning up the rural communities to participate in technology generation and to receive/adopt improved technologies.
- Analysis of developmental themes of common interest between communities, researchers, extensionists, policy makers and donors.
- The themes may be in agriculture, education, health and/or under natural resource management.
- Criteria and selection of target regions/geographical areas.
- Mobilization, sensitization and empowerment of farmer communities
- Formation of farmer groups with an improved organizational structure and a shared group goal, community vision and work plans.

2.2.8 Designing of farming systems and farm enterprises

Designing of agricultural systems and farm enterprises. The African Agricultural/farming systems are most times subsistence and very complex and with a very low productivity. These systems must be redesigned to make them productive and compatible with modern farming methods.

(a) Demarcate the whole country into agro-ecological zones based on prevailing rainfall patterns, vegetation, and cropping systems.
(b) Re-design both the farming enterprises, cropping pattern, farm operations and the entire farming systems. Re-design also the farming activities.
(c) Use both community participatory methods, field technical assessment coefficients, then design technically, economically and socially viable activities.
(d) Incorporate agro-ecological parameters (temperature, rainfall, eva transpiration and water harvesting)

2.2.9 Designing Green Revolution Core Components

(a) Biological and improved crop-livestock component
  - Identification of elite germplasm (collection, analysis of characteristics, gene bank).
  - Selection of priority commodities
  - Formulation of protocol of conventional breeding methods
  - Identification of biotechnology facilities for crop propagation, genome mapping, gene transfer and transgenic applications + their expected outcome.

(b) Designing the rate/method of application of inorganic and organic fertilizers.
(c) Designing mechanical farm tools.
(d) Designing the simple and complete water control irrigation and water harvesting systems.
(e) Designing the technology supporting components – infrastructure, input supply and management practices.

2.2.10 Designing an on-farm research programme

- Net working of on-farm testing sites in and outside the country.
- Incorporating participatory testing, and adaptation of those farming systems being designed.

2.3 Strategy for implementing African Green Revolution

In order to cause a green revolution to happen in any African country, there should be a sequence of strategic initiatives.

First there should be an interface between key actors among the stakeholders – that is between researchers, political leadership and entrepreneur spirit of industrial and commercial sectors.

1. The researchers can be organized into multi disciplinary "research teams" based on stages of technological development/transfer – put in place.
2. The "design team may be led by GR design or/initiator. All research teams should keep networking.
3. From the political leadership – GR may be championed by somebody between PS, Prime Minister or head of Government business from the executive arm of government put in place.
4. The development related entrepreneur spirit from the industrial and commercial sector is expected to make quick investments where economically viable opportunities arise.

Second, the GR design team begins with pilot areas to tune up and framer communities and solicit their participation for involvement in;

- Problem analysis/technological needs
- Technology generation, testing and promotion.

The design team also takes the lead responsibilities for identification for entry points for technological interventions.

Third, generation of the green revolution core technological ingredients by biological/biotechnological research teams using simple to advanced applications:

- Biological component, chemical component

Fourth – designing of the principle GR components by design team.

Fifth – designing a complete on-farm research programme to test the technologies. Networking of on-farm testing sites, in and outside the country

- incorporating community participatory testing and adoption of those farming systems being re-designed.

Sixth, implementation work plan for African Green Revolution
Mobilize and organize a stakeholders within/outside country.

- (a) Set partnership modalities.
- (b) Priorities for science and technology policies/programs.
- (c) Identify/agree on germplasm, biotechnology exchanges.
- (d) Identify strategic research and testing centers.
- (e) Divide/agree on roles and reciprocity of product and services.
- (f) Develop a plan of action for networking.
- (g) Lobby for national governments and donor communities for human, material and financial support.

Seventh, Launching of Green Revolution plans

2.4 Green Revolution design teams

2.4.1 Team Formation Process (factors and required skills)

When forming Green Revolution design/implementation teams, there are some basic factors to be considered and the corresponding skills that are required in that given team, the team must (1) Identify a site, then identify systems constraints/gaps (2) re-design a complete system (3) introduce the necessary technological interventions (4) promote/mainstream the re-designed and tested systems.

2.4.2

Factors	Required Skills
- Agro-Ecological Factors	An Ecologist
- Communities/Sociological Factors	Sociologist
- Agricultural Farming Systems	Agricultural Economist
- Crop Production System	Agronomist
- Livestock Production System	Veterinary Service/Nutritionist
- Physical Factors	Engineer
- Biological Factors	Breeder
- Pathological Factors	Pathologist
- Institutional Factors/Policy issues	Policy Analyst

2.4.3 Team Composition/Team size

The team composition should contain the most essential skills as dictated by the location specific dominating factors.

The team size should not be too small nor too large. The average team size should contain four to eight members. A team member must have team spirit, be a team player and may have one or two or three types of required skills.

The normal practices is to form a core team of four full time members and have additional four as part time members providing 5% to 50% of the full time equivalent.

2.4.4 Pilot sites for Green Revolution Design Teams

Teams are usually formed on the basis of their pilot sites of operation. Green Revolution teams in a given African Country may have one to five pilot sites of operation. An individual can be a member of more than one team and thus operate two or more pilot sites either playing a similar role at all the sites or change his/her role from site to site. Different sites within a zone or a country may be independent of each other or one may be complementary to the other.

2.4.5 Partners

The design team must work hand in hand with key partners. Among the key partners/collaborators with whom the design team should network are;

a) Technology generation or research teams, agricultural technical service providers like public extension workers, private agricultural researchers, NGOs, CBOs, Technocrat teams from technical government Ministries, Policy makers and Donors.

2.4.6 Level of Site development

The development at a given site can be classified into three categories.

1 = Site has been identified
2 = Site at level of being redesigned
3 = Site at level of technological intervention
4 = Wide spread adoption of technological interventions

2.5 Time frame for triggering off an African Green Revolution by a given African country

1. Preparatory Activities (see section 3.3). 1st year
2. Characterization of the existing farming systems – community participatory problems analysis and development communications – field technical assessment and estimation of parameters of leverage factors. 1st year
3. Identification of technologies of commodities (crops, livestock, activities, services) for which the pilot side has a comparative advantage measured by domestic resource cost to earn (export) foreign exchange from commodity 1st year
4. Testing of the biological components of the re-designed improved farming systems in on-farm trials at pilot site(s). 2nd to 3rd years
   - Adjustments of the designs
5. Launching of the Green Revolution plans at National or regional levels 4th year

3.0 THE DIAGNOSIS OF THE MAJOR COMPONENTS OF THE AFRICAN AGRICULTURAL PRODUCTION (FARMING) SYSTEMS

3.1 The major components and factors of influence of the African farming systems

The three categories of the major components (factors) of the African farming systems are: internal, external and natural factors of influence.

3.1.1.0

The internal or core components of the African farming systems and their specific factors of influence within each component. (see Figure 3.1).

3.1.1.1 Farmers' (communities) roles/goals

The farmers' (communities) goals and priorities for his farm family or the farmers' demands from the whole farm include:

- Food
- Income from all farm enterprises
- Basic social needs such as sense of belonging, self-esteem, social status and general welfare in the communities
- Risks management – farmers desire to manage the agricultural risks by diversification and application of appropriate technologies to have stable sources of their livelihood

The farmers' (communities) roles/responsibilities towards the whole farming system are to provide:

- Labour
- Management or supervision
- Capital
- Entrepreneurship for integrating all the components of the farming systems.

3.1.1.2 Land resources

The demand linkages for the land resources are:

- Land use plan by type of soil
- Labour
- Capital
- Replenishments in form of organic and inorganic fertilizers

The land resources supply linkages are:

- Soils
- Soil nutrients
- Soil water
- Soil physical properties

3.1.1.3 Crops component

The types of crops include legumes (beans, cowpeas, pigeon peas, field peas), cereals (maize, rice, sorghum, millet, wheat), root crops (sweet potatoes, cassava, yams, irish potatoes); fruit/trees include (bananas, coffee, mangoes, passion fruits). The demand linkage of the crops components comprise of seeds, soil, fertilizers, soil water, (crop production, labour, capital).

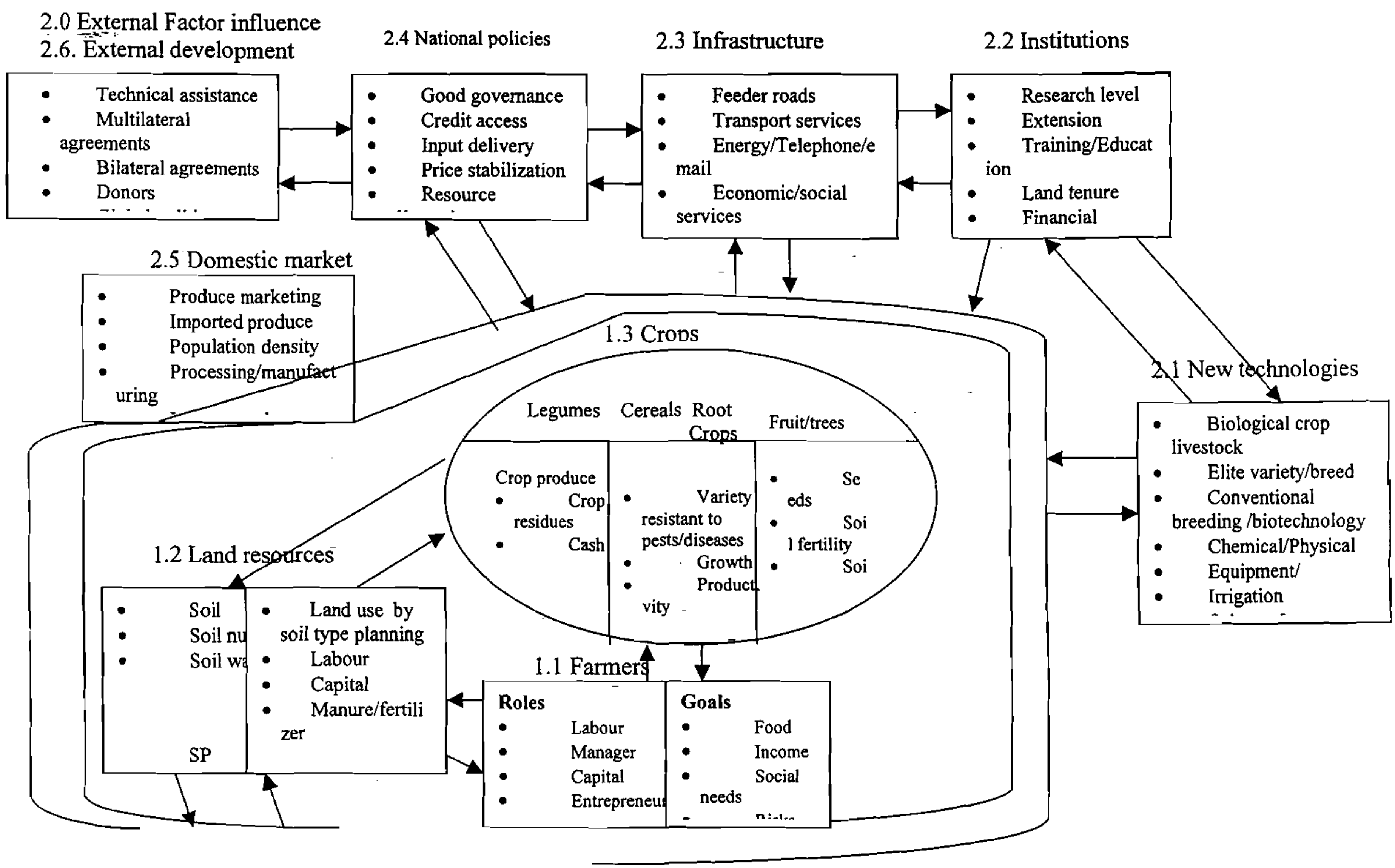
The supply linkage of the crops component comprise of crop produce, crop residues and cash.

The possible entry points and/or change parameters through which the Green Revolution design team can operate within the crops component are:

- Variety
- Growth parameters
- Resistances to pests and diseases
- Yield and/or unit productivity

3.1.1.4 Livestock component

The types of livestock within the African farming systems are (goats, cows/cattle, sheep, pigs and poultry). The demand linkages under the livestock component are: rearing, nutrients, feeds/pastures, vet services, land, capital. The supply linkages under the livestock components are: milk, meat, animal manure, animal traction and cash.


2.0 External Factor influence
2.6. External development
Technical assistance
Multilateral agreements
Bilateral agreements
Donors
2.4 National policies
Good governance
Credit access
Input delivery
Price stabilization
Resource
2.3 Infrastructure
Feeder roads
Transport services
Energy/Telephone/e mail
Economic/social services
2.2 Institutions
Research level
Extension
Training/Education
Land tenure
Financial
2.5 Domestic market
Produce marketing
Imported produce
Population density
Processing/manufacturing
1.3 Crops
Legumes
Cereals
Root Crops
Fruit/trees
Crop produce
Crop residues
Cash
Variety resistant to pests/diseases
Growth
Productivity
Seeds
Soil fertility
Soi
2.1 New technologies
Biological crop livestock
Elite variety/breed
Conventional breeding /biotechnology
Chemical/Physical
Equipment/
Irrigation
1.2 Land resources
Soil
Soil nu
Soil wa
SP
Land use by soil type planning
Labour
Capital
Manure/fertilizer
1.1 Farmers
Roles
Labour
Manager
Capital
Entrepreneur
Goals
Food
Income
Social needs

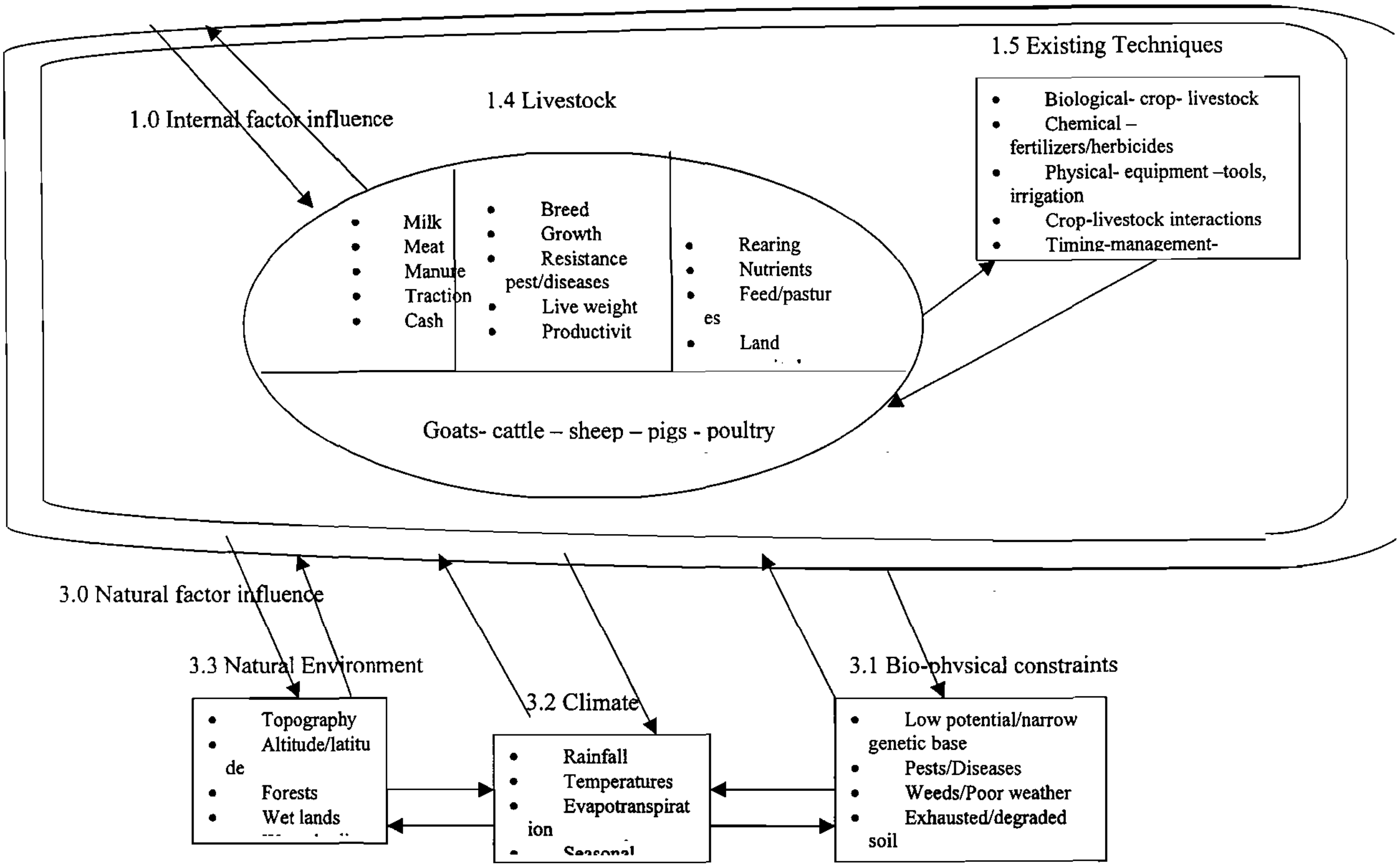


Fig. 3-1. Major components (and factors within) of the African farming systems

3.1.1.5 Existing technology component

One of the sets of factors within African farming systems are existing technologies for both crop and livestock components. Those include:

- Biological technologies for crops and livestock
  Crop varieties, animal breeds, the characteristics and genetic potentials of biological technologies
- Chemical technologies – organic and inorganic
  Fertilizers, herbicides, pesticides etc.
- Physical technologies – equipments plough, weeder, harvester, hauler and tools
- Crop-livestock interaction technologies e.g. converting animal manure, converting crops and crop residues to animal feed
- Timing and crop and/or livestock management practices.
- Level of technological development within a given farming systems. This can be assessed through scales of operation, examining level of productivity or output-input ratios, the level of labour saving technologies used.

3.1.1.6 Non-farm enterprises

- Provision of economic services
- Non-farm employment opportunities
- Technical engineering skills
- Agro-processing

3.1.2.0 External factors of influence (components)

The external components (or factors of influence), those are classified as external partly because they are outside the farmers' control. (see figure 3.1). Those external components comprise specific factors of influence. thus:

3.1.2.1 New technologies

- Biological technology improvements for crops and animals
  - elite crop varieties/breeds of animals
  - conventionally bred varieties/or breeds
  - biotechnology – genetically improved varieties or breeds through genetic engineering
- Chemical technological improvements through chemical applications and chemical engineering.
- Physical technology improvements of equipments, tools and irrigation.
- Science and technology
  - applications of S + T to generate new ideas and new technologies
  - adopted imported technologies which are already adapted to local farm, socio-economic environmental and farmer conditions.

3.1.2.2 Institutions component

The institutional factors of the African farming systems are:

- research and development
- training/formal and informal education for farmers and technical service providers
- extension and technical services providers (public and private extension)
- land tenure system
- farmers' organizations
- financial institutions/farm credit
- marketing systems

3.1.2.3 Infrastructure component

- feeder roads
- transport services
- energy
- economic and social services (health, clean water)
- access to markets

3.1.2.4 National policies

- good governance
- input delivery
- resource allocation
- access to credit
- price stabilization
- science and technology

3.1.2.5 National economy/domestic market

- population size and densities (urban and rural populations)
- distribution systems of farm produce
- imported alternative food products
- agro-processing and manufacturing
- intersectoral development

3.1.2.6 External development assistance

- technical external assistance
- bilateral/multilateral agreement
- donors
- international (import and export) trade
- global political and economic issues

3.1.3.0 Natural environmental factors of influence

3.1.3.1 Bio-physical adverse factors of influence

- low potential/narrow genetic base
- diseases
- exhausted/degraded soils
- pests
- weeds
- socio-economic constraints

3.1.3.2 Climate

- rainfall – rainfall pattern, rainfall distribution
- temperatures – average, minimum, maximum
- evapotranspiration – the rate of soil moisture content being lost due to loss of vapour from the soil caused by solar heat/radiation.
- seasonal (wet/dry) calendar
- agro-ecological zones – the combined effects of rainfall, temperatures, vegetation and water bodies

3.1.3.3 Natural physical environment

- topography
- forests
- water bodies
- altitude/latitude
- wetlands

3.2 The factors, dynamics and challenges that interplay and shape realities of the African farming systems

Farming systems can be described as a unique arrangement by which households (in trying to attain their livelihood) manage many (farming) crops, livestock and non-farm enterprises using certain methods/practices in response to the interactions with biophysical, physical, biological, socio-economic and environmental factors ad in accordance with the households goals/objectives, preferences and available resources. Besides there are the agro-climatic and other external factors like technology, institutions, infrastructure and policies which exert their influence on the farming systems. Also the individual household/farm family is part of a larger local community in a given farming systems. All these factors combined influences affect the production methods being used and the output being achieved by the farmers/communities.

The complexities of the African farming systems due to interactions of many interplanted crops or diverge farmers are both within the same farming systems as well as between different farming communities. The needs to analyse, understand and redesign those systems arise out of these complexities. For example two individual farmers within the same system having same crops, patterns and management practices may have different reactions to introduced changes because of their different levels of cash income/capabilities and attitudes. Also different agro-climatic zones require different designs.

The factors under farming systems can be first divided into two categories that is factors which are under the control of the farmers and factors which are beyond the farmers' control like altitude, rainfall, temperatures, bio-physical constraints as well as the external factors (technology, institutions, infrastructure and policies). Thus the major components of a farming systems are 4 components namely: farming enterprises, farm resources, technology, infrastructure, institution, policies and environmental component consisting of infrastructure, institutions, policies and agro-climatic component.

Understanding and identification of problems and opportunities in a given farming system is an interactive and dynamic process. In the past researchers/development workers did not appreciate the constraints/problems in the existing farming systems. Now it is imperative to understand the existing farming system, identify the problems and opportunities and set pricing factors for re-designing and improving the system.

The roles of the farmer/community

All these factors within any given farming systems are being integrated by the farm family in his attempts to achieve his set roles, goals and priorities (see Figure 3.1). When all those factors are integrated together they bring about influence on the farmers' choices of enterprises, technologies and methods production, marketing and utilization. The goals reflect the farm family's desires and what the family is attempting to achieve. The farm family decision making process is further influenced by farmers characteristics such as knowledge, perceptions (beliefs and behaviour) attitudes and goals.

The design team should also focus on farmers' knowledge of alternative management practices, cropping patterns, available technologies, sources of inputs, sources of information and markets. Consideration of farmers's perceptions, beliefs and behaviour greatly influence their production decisions to e.g to seek or not to seek technical advice or financial credit in the adoption of new technologies. In addition, the farmers' attitudes as related to their feelings, emotions and sentiments have also an influence on the farmers' decisions to accept or reject new technologies.

Influence of farming communities

A household/community is a social organization in which members normally eat and live together. Households/communities consist of husbands, wives and children. In Africa usually men are the heads of household who control and make decisions about the use of farm resources. Women may in some instances also be heads of households. Even if they are not heads, women have a recognized important role in agriculture through their labour contributions to the production, management, marketing and ownership of farm resources. Among the African farming communities, there are two scales of farming households. The small scale subsistence farmers who produce just enough to provide their food and clothing plus a little surplus for sale to provide for their purchased foods, salt and medicine. These usually have limited resources.

The large scale commercial farmers who have access to medium/large farm resources and can adequately use available technologies to produce with objective of meeting the market demands. So the socio-economic influence of the farming communities should not be overlooked during the design process.

Diverse crops enterprises

An enterprise is an agricultural activity undertaken to produce an output that contributes to total production or income of the farm family. Crops enterprises being grown by a given farming community depend on the dominant cropping patterns within the respective agro-ecological zone. The most common crops in African farming systems are root crops (yams, cassava, millet and legumes (beans, cowpeas and pigeon peas, cotton). The common fruit trees are: bananas, coffee and other fruit trees).

Livestock enterprises/system

Livestock enterprises – animals raised by the farm family over a period of time as a way of life. Livestock system is a part of farming system where a set of animals are managed along with their complementary components (pastures, disease protection) required for their production and their interactions among the animals plus the biophysical, physical, biological, socio-economic and environmental factors. The most common animals in Africa are cattle, goats, sheep, pigs and rabbits. In most farming systems the animals are kept as a separate rather than an integrated component of the African agricultural production system, missing the opportunities of demand and supply linkages.

Crop-livestock mixed systems

When crops and livestock are being produced by the same households. Usually the crop farmers and livestock farmers, especially cattle keepers have different cultural backgrounds. Both crop farmers and pastoralists may mix crop – livestock. For crop farmers, they normally rear fewer animals than the amount of crops grown. For pastoralists, their major component may be livestock and take cropping as a minor component. In both cases, the interaction between crop and livestock is of great importance but it may not bring about the desired optimal crop-livestock integration.

Non-farm enterprises

The farming households usually engage themselves in non-farm enterprises such as petty trade, handcrafts, construction and provision of social services in order to supplement their farm income. As the agricultural sector develops, the non-farm activities gain more momentum ad lead to major sources of alternative employment opportunities so possibilities for the development of non-farm activities when re-designing the existing farming systems should be exploited at its earliest opportunity. Thus farming communities should be encouraged to look out and venture in those activities as much as possible. But that should persuade us to support rather than abandonment of agricultural development.

Agro-climatic factors

Agro-ecological zones are: Areas with similar agro-climatic (temperature, rainfall, evaporation and wind) conditions but not necessarily contiguous, where a given crop (maize, beans ...) exhibits roughly the same biological expression so that we can obtain for example, similar variety or fertilizer responses within a given environment. Thus we can be able to replicate the GR designs in similar agro-ecological zones everything else being equal.

Rainfall distribution

The amount and distribution of precipitation at a given site in a given period of the year. Rainfall is the most useful climatic variable to monitor. In rainfed-agricultural system, rainfall excess or deficiency can have dramatic effects on both crops and animal production.

Irrigation

Irrigation is not a climatic variable but it prolongs the rainy season for crop growth we can monitor time and duration of flow, methods of water control/management and water quality.

Temperatures

Air temperatures are part of understanding a given farming systems. Understanding the occurrences of critical temperatures such as average, the maximum, minimum, and optimal temperatures for crop growth during the season. Soil temperature may be important in some very hot or temperate regions (with some very low soil temperatures) where some hot/very low soil temperature may affect crop germination.

Evapotranspiration analysis

Evapotranspiration rate is needed to understand the soil moisture content. The the periods of the year when is soil moisture deficit and when there is soil moisture surplus which is badly needed for crop growth at a given site. The evapotranspiration rate which is summing up the inflows (rain water) and outflows (evaporation) to the system can be assessed using long term rainfall data or measuring soil moisture content to get water balance.

Solar radiation

Although solar radiation data is more difficult for a Design team to monitor, it is useful, because solar radiation is critical for photosynthesis and crop development. It helps in modeling of results for selecting new crops to be introduced or transferred to other farming systems.

Technology – Technological factor

Technology is that component which has intrinsic energies or inputs for crop or livestock to grow and produce higher/better yields/results. Biological technology like new crop variety or improved breed of animal which can perform better than the local ones. Chemical technology like fertilizers or herbicides or pesticides when applied to a crop can yield better results. Physical technology-improved weeder, planters etc.

Lever of technology

In a general sense, level of technology is the combination of type of varieties/breeds, and all the management practices used for producing and otherwise managing a given crop, crop mixtures, livestock, crop-livestock interaction and/or other farm enterprise/activity.

Technological factor is one of the most important component in any given farming systems, because it indicates the level of development the system has achieved.

Infrastructure

Infrastructure is the supportive features such as feed roads network, input supply systems, marketing outlets – transport, storage and other post-harvest produce handling facilities, water supplies, electricity, communication facilities and governmental organizations for good governance. The infrastructural facilities support and provide economic and social services to a given farming systems. They greatly aid the subsequent development of that system. Irrigation system is also part of infrastructure and it is deeply and critical factor that can immediately trigger Green Revolution.

Institutional factor

The institutions such as research, extension, financial institutions play an important role in modernizing agriculture. For example rural financial institutions capable of providing farm credit which is vital for the purchase of inputs (improved seed, fertilizers, tools) must be in place for a Green Revolution to happen.

Farm resources

Basically for farm families/households, farm resources are land, labour, capital and management. Land for farming has many characteristics.

- Size of holding – whole farm size
- Cropped land, grazing land
- Fragmentation of the holdings – whether single unit of in separate, isolated pieces
- Ownership – sole owner, joint (husband and wife) ownership communal, long – standing tenancy, short-term tenancy
- Permanent of use – intensive, shifting or nomadic
- Land-lord – tenant relationships – share of crops, division of inputs
- Land fertility – quality – soil depth, texture, presence of toxic subsistence, water logged flat lands, hillside degraded soils, very steep hills may limit process on GR designs
- Terrain – slope, terraced, hillside, valley, bottom valley
- Accessibility – access to transport, market, other services

- Water availability – nearness to water sources, ponds, streams for livestock, crop irrigation or rainfed-farming, dependability of supply.

Labour

Farm family labour includes members of the family capable of working and participating in cooperative efforts.

- Number, age, sex of the members
- Division of labour/effort
- General level of productivity (health, education)
- Division of time between farming and non-farming – occupation, other duties
- Obligation to others, other responsibilities

Capital

The physical and financial assets plus materials that include

- Tools, equipment, buildings, improvements to the land
- Livestock and movable assets capable of being sold to raise capital
- Cash from sales of crops, animals, crafts and other sources of cash
- Access to credit

Management

The skills that can be used in organizing and carrying out farming tasks. The equality of management determines the households efficiency in optimizing/using its land, labour and capital resources to produce crops and livestock.

Bio-physical adverse factors of influence

Most development efforts of the African farming systems are curtailed by the impending biological and physical constraints which in all cases are usually beyond the farmers' control. There are many devastating crops and animal pests and diseases in any given African farming systems which have tended to erode the gains obtained by promising technologies in the past. For example reinderpest, foot and mouth disease have been problem on cattle improvements/developments in East Africa. In the early 1990s, cassava mosaic virus destroyed/devastated all the traditional cassava varieties in Uganda. It was even more dramatic more recently when the agricultural research had barely announced their timely release of four impeccable improved varieties of coffee and five varieties of bananas that were expected to revolutionize those two crops in Uganda, than coffee being hit by coffee wilt disease and the bananas being bad threatened by the banana bacteria wilt disease. Both diseases attack and devastate all varieties of the respective crop. Therefore the presence of biological constraints to a given farming systems prohibit the possibilities of a Green Revolution design as it creates leakages of gains being generated by improvement designs. Other biological constraints are insects and weeds like striga which interfere with plant growth. The problems of low genetic potential and narrow genetic base may affect both plants and animals.

3.3 Preparations and review of procedures leading to GR programme set-up

An African country wishing to embark on designing and causing a Green Revolution in her territory may want to consider the following preparatory stages and procedures.

1. Designate three to four core members of the GR design team to undertake the preparations.

2. Make consultations and interface between key actors among the stakeholders from national and/or international lead institutions. Those actors may include development workers, agricultural researchers and policy makers/political leadership. It is also beneficial to solicit membership from trade, commerce and industrial sectors to bring on board entrepreneurship spirit, to make quick investments where economically viable opportunities arise.

3. The core members of the design team may be given the tasks of undertaking preparatory activities which may include:

   (a) Review of relevant literature. National and international research reports, reports of development project, trade and other economic development reports plus national development vision, policies and strategies.
   (b) Make reconnaissance visits to selected and strategic regions, districts or counties of the country in order to
      (i) collect available climatic and geographical information system
      (ii) collect information of general characteristics of the existing farming systems. For example the dominant crop or livestock enterprises, topography, settlement patterns, major socio-economic/non-farm activities and levels of development.
   (c) Develop a working concept note for subsequent discussions and consultations.
   (d) Mobilization of basic financial and material resources to kick start the Green Revolution design and implementation process. The team should also look into structural facilities, transport, basic tools and allocation of space at a research station, district or regional headquarters.
   (e) Undertake initiation/basic studies in the target areas/benchmark sites:
      - Marketable products and marketing systems
      - Infrastructural set up and facilities available including, roads, transport, energy, socio-economic services, storage facilities including research, extension
      - Institutional set up and available facilities including research, extension
      - National policies on agricultural development
      - Major national sources of food, income and export trade
   (f) Preparation of background information and GR concept note.

3.4 Selection of benchmark/on farm design and testing sites

3.4.1 Pilot Area Characteristics

a) **National Level**

- Agro-ecological zones, district, topography, vegetation, population density, major economic activities, infrastructural/social services and level of development.
- Respondents/households within a similar group will have similar problems.
- There is a high probability that households within a group will be interested in the same potential solutions.

b) **District, County, Sub county**

Topography, land/soil types, land use, farming systems (crop/livestock), cropping system, natural resources (land, soil, forest) management practices, road network, health/social facilities, major economic activities, marketing outlets, rural credit facilities, settlement patterns and levels of development.

c) **Urban Centers**

Major zones, housing structures, population distribution/settlement patterns, economic activities, infrastructural/social services and levels of development.

3.4.2 Criteria For Selection Of On-Farm Design/Testing Sites

- **Geographical spread/location**
  The benchmark is intended to obtain GR designs/recommendations that can be extended to whole target area. Make a quick tour around the district, country to determine the geographical spread. Use a map of target area along with the tour.

- **Representativeness**
  The pilot sites should be representative of the biophysical, socio-economics, agro-ecosystem and any other characteristic of the target research to ensure that the GR design results are applicable to target areas.
- **Accessibility**
  Ability to travel to pilot sites will enhance cooperation between design team and host communities at reduced costs. Accessibility includes infrastructure and transportation facilities.

- **Political Support**
  The design team's assessment of local community leadership and commitment by local officials and farmers is necessary, for good community leadership is helpful in mobilizing cooperation, assuring village mates to reduce their suspicion and increase their participation.

- **Sustainability**
  Benchmark sites should be priority impact areas for development so that positive findings may be supported and implemented.

- **Levels of development**
  Site/village should include traditional/slow villages and progressive villages so as to address all aspects of the issues of rural transformation at grassroots.

3.4.3 Selection Of Participating Households

- **Logistical considerations**
  The GR activities must be allocated of the available human, materials and financial resources. There must be a trade-offs between the criteria of representativeness, and the resource's constraints, to rationalize the use of such scarce country's resources.

- **Sample size** (30-200 HH/participants/community)
  The number of participants is selected according to available resources.

- **Typical/representative households**
  Selected participants must represent both the target area and the average households to allow for applicability and replicability of the design trial results.

- **Co-operation**
  The participants should be interested and willing to co-operate. In some cases they may require the ability to participate that is having sufficient resources like land, labour, capital.

- **Gender**
  Women contribute the lion's share to the family means of livelihood than men, yet women's work is not counted as economically productive when no money changes hands. In addition women are denied access to landed property. The design should not overlook gender issues.

- **Resource poor households**
  Resource poor households with their limited/small amount of land, capital and labour which implies poor do not have control over their own destiny. The design team may not target directly the poorest of the poor who are landless. But it may reach them indirectly by creating increased employment in the designed improved farming systems.

Table 3.1: Categorizing of types of households/wealth ranking criteria at Luwero Benchmark site in Uganda (2000)

HH Category	Top	Medium	Small	Poor	Very Poor
Wealth Ranking Criteria Land size Acres	10+	4 - 7	1 - 3	<1	Landless
Level of Income Millions Ush/year	10+	4 - 7	2 - 3	0.1 - 1	Negative or zero
Livestock Cows Small Animals	8+ -	3 - -	1 – 2 few	0 few	0 nil
Type of House	Permanent	Semi-Permanent	Semi-Permanent	Mud, Iron/grass thatched	None

Table 3.1 show the criteria used to classify the farming communities at Luwero Benchmark site, Uganda 2000 by economic status. Here samples of top, medium and small were included in order to enable the GR design practical and effective. See appendix 1.

4.0 PARTICIPATORY PROBLEM IDENTIFICATION, METHODS FOR GR DESIGN AND IMPLEMENTATION

4.1 Community entry process

4.1.1 Why, when and how to involve communities in GR design

(i) Purpose

To get a whole sub county, parish/village community involved in achieving a general consensus and be able to make the group decision about critical issues or broad themes of common interest regarding their agricultural development issues.

(ii) Why/objectives

- It enables both community and GR design team to:
  - Obtain collective views and perceptions about critical issues, critical themes, specific topics, critical questions or problems.
  - Identify a way of getting the community to set their priority constraints and possible interventions leading to Green Revolution designs.

- Learn from the community members the constraints and opportunities and make informed and timely decisions regarding the GR design blocks. project activities.

- Use of participatory methods empowers local communities to express, share, learn, enhance and analyze their knowledge or constraints.
- It gives a broader understanding of the interplay of social, cultural, environmental, natural resources use and management, political factor affecting the farming systems within a given community.
- It makes the community feel a sense of ownership of the subsequent farming systems analyses and design activities.

(iii) When/at what point in GR design stages

- Development workers/researchers want the community to train or identify
- the design team should involve the farming communities at all the stages, so as to:

  - Identify their priority constraints
  - Participate in problem analyses
  - Select the appropriate crop/animal production technologies
  - Determine farmer selection criteria
  - Formulate community action plan of GR dbsigns implementation
  - Participate in on-farm testing of GR designs
  - Determine Implementation Strategies

(iv) How/methods of soliciting community involvement in GR design process

To organize farmer participatory problem identification meeting/exercises

- Do community mobilization in order to enhance chances of community's involvement and active participation
- Identification segments (top, middle and bottom)
- major strengths and weaknesses, potentials and opportunities
- Identify the community channels of communication
- Try to work with the community and avoid being engulfed with smaller interested groups
- Design a clear message to spread around
- Promote community self-help spirit and use local human and material resource
- Determine a method of picking community representatives to the meetings/discussions
- Decide on agenda, fix dates and venues
- Get teams of (mobilisers/community workers) to go around Sub County, parishes/villages sending invitations
- Use community participatory methods all through

4.1.2 Learn and understand the elements/segment of the target community

4.1.2.1 What is a Community?

i) The people living in one place/village/ward/division/parish/sub county/district.

ii) Society – the social way of living together or system whereby people live together in organized/civilized communities e.g. zonal society – national society.

iii) Community consists of many individuals who in turn may fall into one or more groups with different views, perceptions, needs and aspirations. Since every community consists of many groups, community segments with different backgrounds social status, problems/needs, divergent views/interests such as social/cultural/economic/political pressure groups then it will require at least some members to alter their views in order to get general groups consensus.

4.1.2.2 Major elements of a community:

The body of culture is the environment from which the individuals relate to the world around them. A cultural influence the value of judgments of all its members. Judgments are based upon value structures that have evolved out of the experiences of the individuals and the groups concerned. Responding to those values, whether consciously or unconsciously, intervals constantly modify and create the cultural situations within which they live.

4.1.2.3 The social elements

A given community consists of many groups and groups' life style that create the dynamics of social behavior e.g. classes social process of interaction and customs, cultural, traditional and religious beliefs.

4.1.2.4 The psychological elements:

A group (in any community) is constituted of its individual members. Every individual (even from the same family) is unique and different from every other individual. Individuals are, moved in varying degrees by cognitions, emotions and the way they respond to situations in their private as well as public live. The individuals expression of/his degree of behavior and/or performance or action are usually influenced by motivation, need and self concept or self-esteem. We need to understand the perceptions and attitudes of the majority of the individuals within a group.

4.1.2.5 The economic elements:

The total social-economic conditions in the community i.e. availability of social services, food, productive economic activities etc. affect the type of individuals in that community.

4.1.2.6 The geo-political elements:

All communities live within a given physical environment i.e. elements like types of land, space availability or population density, climate, vegetation, ecology agriculture, technological factors – subsistence agriculture, high level technologies for agriculture/mechanization, industrialization, hygienic conditions or general sanitation. So communities need leadership and arbitration systems.

4.1.2.7 Community segments:

Most African rural and/or urban communities are composed of three social-eco-political segments.

a) **(Higher bracket) upper class segment:**
The upper class segment consists of elite rich individuals, big leaders or politicians who pretend to speak for community.

b) **Middle class segment:**
Middle class consists of better-off community members (business people, community, extension workers, teachers, informal leaders and other educated people).

Middle class people usually understand and know the community better than the (big) leaders.

c) **The grassroots segment:**
The grassroots segment consists of the silent majority like farmers, petty traders, men, women, youth, rural people who are usually not consulted for community action.

d) Women and men

e) Marginalized groups (Disabled).

4.1.3 Community Mobilization/animation Process

Mobilization:
Organizing people (community and resources for a purpose)

Community:
People living together in a locality; women, children and youth an organized group of people who share sense of belonging, beliefs, norms and leadership and interact within a defined geographical area.

In order to enhance chances of community's involvement and active participation:

i) Identify the communities characteristics:
- Major themes of interest
- Major strengths and weaknesses
- Potentials and opportunities

Identify the communities, channels of communication and community leaders

- Such as community media
- Village opportunities set up (how social events are announced)
- The community leadership
- Formal leadership sub-village/ward chairperson – Government, executive secretary, councilor's committee members
- Formal leadership – civil leaders, religious leaders, Traditional leaders and influential people

NB: Roles of community leaders are to give advice, mobilize, educate, inform, animate and influence some parts of the community.

ii) Community workers identify yourself with community and state their objectives precisely and clearly – work with the whole community and avoid being engulfed with interested groups

iii) Design a clear message to be spread around

iv) Promote community self-help spirit and use local human and material resources

4.1.4 Community Needs Assessment

1. Basic human needs – the deprivation of a basic need causes a person to seek satisfaction of that need before seeking to satisfy higher level needs. (NB: Human rights are more basic than human needs).

   a) Physiological needs such as thirst, hunger, rest are necessary to maintain life.

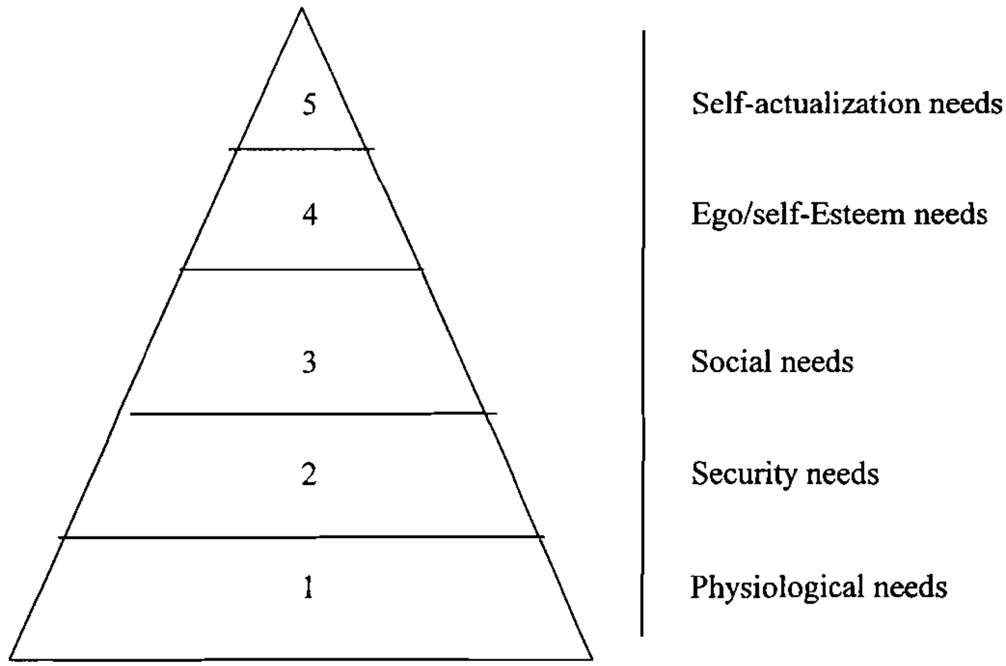
   b) Security needs – are both physical and economic e.g. job tenure, insurance, a home, savings, pension – these needs become dominant – during emergencies like war, disease, injury or natural catastrophes.

   c) Social needs – love, belongingness, acceptance and approval. Social needs involve a desire for affectionate relations with people and a place in a group.

   d) Ego or esteem needs drive people to seek recognition as worthwhile persons. Feeling of confidence, worth, strength, beauty and usefulness.

   e) Self-actualization needs – the need to become the kind of person one desires to be. Satisfaction of this need is expressed in various ways – becoming a good mother, good wife/husband, good teacher etc…

   In order for a person to function effectively, the body's need for homeostasis, i.e. the need for physiological integration, balance predictability and coordination i.e. consistency.



Hierarchy of Basic Human Needs – height

NB: Behavioral consistency has three links: i.e. how one feels, what he/she knows and how he/she acts.

2. Felt and expressed needs

An individual "want" or "desire". A felt need is something believed necessary by the individual concerned.

3. Normative needs

A normative need is when there is a deficiency or gap between a "desirable" standard and the standard that actually exists. E.g. analysis of nutritional standards for low-income families in a given community. One needs also to determine the reason or cause for the gap or need.

4. Comparative needs

Comparing the characteristics of those in receipt of a service with others who are not.

4.2 Participatory data gathering tools and analyses

4.2.1 Purpose of participatory data gathering

In designing a GR, both the design team and the participating communities must have a deep understanding of the interplay and the dynamics between the different technical, socio-economic and environmental factors under the present systems. The identification and analyses of their respective constraints/problems and their subsequent designs must be based on scientifically collected information or data. In many aspects, it is important that the community(ies) itself participates in the information/data gathering/collection and subsequent problem analysis as well as making the appropriate decisions in the design and implementation processes.

4.2.2 Types of participatory data needed and methods of gathering and analysis

(a) Spatial/agro-ecological data analysis
- sketch village/parish (District/Regional) maps
- village/parish sketch map(s) show what and where resources, facilities, infrastructure road network, social services, schools, health clinics, markets and natural resources (like type of land, water, forests) are located.

(b) Agro-ecological zone(s)
Climate, vegetation, population density and settlement patterns. Environmental patterns, farming systems (crop, livestock) patterns.

(c) Transect sketch maps
Spatial arrangements and opportunities. Cross section of main land use zones. It gives data about the main features, resources, uses/activities, problems and various opportunities which is related to a cross section of different zones.

(d) Social data + problems and opportunities
Cultural activities, foods, food preferences
Social constraints and existing social opportunities

(e) <u>Economic</u> data/problems and opportunities
- Major sources of income
  Agricultural crops, livestock, major food crops and non-farm economic activities, products, markets, prices selling and buying
- Identify economic constraints and existing economic opportunities

(f) Technical data/problems and existing opportunities
- soils – soil type – problems and opportunities
- crops – crops grown – cropping systems problems/opportunities
- livestock – type of livestock – problems and opportunities

(g) Seasonal calendar data

A seasonal calendar of a community shows the main activities, problems and existing opportunities throughout the annual and/or agricultural cycle in data or diagrammatic form.

- local seasons (dry, rainfall, wet)
- climate – rainfall, temperatures
- crop sequence, crop rotation
- farming activities (planting, weeding, pruning/thinning, fertilizer application, harvesting, storage and marketing
- crop pests, diseases
- livestock types, livestock activities (births, weaning, grazing fodder, migration, sales
- livestock diseases
- income generating non-farm activities
- labour demands for men, women and children
- prices and price fluctuations
- human diseases
- social events/holidays
- periods of income and major expenditures

4.2.3 Participatory data gathering methods

1. Direct observation

Design Team along with village community visit sites such as farms, markets, transportation (buses, taxis, trains) tops, work sites, homes, health post, places of worship, places of entertainment etc. to make direct observation of important indicators to support and/or cross-check the findings. They use observation checklist, use all senses and divide roles to Design Team and community members to provide multiple viewpoints.
- use measurements like tapes and scales to determine size, weight and volume. Use notebooks, record sheets, diagrams, photographs or collection of samples of objects.

2. Village sketch map

Village community sketch map is used to show where resources, activities, infrastructure, highlight differences in socio-economic levels, problems and opportunities are located. It shows dimensions and scope of issues to be investigated. It also shows information on soils, vegetations, agro-ecological zones, water sources, roads, schools and health facilities.

Design Team and some community members discuss basic information for drawing up the map. They agree on starting point and the route. They take a walk around the village as they discuss, make observations, interview residents on the way and make notes. Finally they sketch the village map.

3. **Transect walk**

Methods – group field exercise, participatory discussions, observation, mapping, squared paper or ruled flipchart and markers.
Purpose – a transect is a diagram showing main land use zones in a given village, gives main features, resources, opportunities and problems being faced at different zones.

Steps –
1. At a meeting venue, community members who are knowledgeable and willing to participate in a walk through village/surroundings, agree on starting point and routes.
2. Discuss the different factors to be drawn in transect (+ Land use-crops, trees, livestock, settlements… + soil types – fertile, gravel, sand, clay, rocky… + problems… + possible solutions… + opportunities).
3. Identify main natural and agricultural features like hills, valleys, flat/plain.
4. Walk the transect.
5. Observe, discuss (problems, opportunities) ask/interview residents on the way.
6. Draw the transect.
7. Group cross-check the transect, identify priority problems and available opportunities.

N.B. Transect walk and village sketch map can be done on same day.

4. **Participatory village Community Meetings**

Purpose: At Community Meetings, Community discuss themes of common interest, collective views and perceptions, identify village/local community problems or constraints, later analyse the problems and prioritize them

Develop Village Agenda
Design Team use information from field reconnaissance visit to facilitate a group of community members (or GR village team) to develop an agenda for village community meeting. They also fix dates, venues and send out the invitation to the whole community.

4.2.3.4 Participatory methods for community village meetings

Methods of Community Meetings – Let village community choose their own chairperson and their own secretary. Conduct of community meetings can take different formats.
Facilitation techniques-focus questions, probing questions, clarifications, but no interruption, no providing answers, no promises.

Formal hearing:
Whereby each individual or group is given a chance to present a testimony for or against the proposed plan. The advantage of formal hearing is that it gives all a chance to express their feelings and ideas. But in the end often the outspoken or strong opinionated people will tend to be taken in the place of a compromise.

Brainstorming:
Here the aim is to encourage new insights, reception of ideas.
In this case:

i) A specific task/topic is suggested.
ii) A key person serves as a facilitator to warm up the atmosphere.
iii) People are encouraged to come up with as many ideas on the task as possible.
iv) Judgment on ideas is differed.
v) More ideas are given a chance in order to get better ideas.
vi) Many ideas are formulated as more people get involved and interested if the environment is free and trusting.

Advocacy and lobbying:
Here interested groups are identified and given the task to work with the whole community to convince them about the proposed plan. The disadvantage of this is when you have several groups with different interests.

Open community meeting/discussions:
Here different groups give their views and express their interests. Then meeting come up with a general consensus.

Focus group discussions: Participatory village meetings can be arranged in such a way that there is a whole village meeting, followed by focus group discussions. Focus group discussions can be set up on basis of adult men, adult women and youths or focus groups arranged for members having similar/common interests/problems.

Task force committee:
A small group representing a community is given specific tasks to be handled in a short period of time by searching out all pertinent information about a specific problem and in consultation with the community.

Meeting Facilitators:

- Use their skills and experience in getting community members actively involved in the discussion, sharing information and their own analysis.
- They make points of clarifications.

Achieving rational group decisions:

- Each individual or community group has different behaviors, characteristics, values and interests.

- There is need for some members to compromise so that the community together identifies priority constraints and agree on what priority constraints should be done first.
- Community identifies opportunities, strategies and plan GR design and implementation activities.

4.2.3.5 Community Visioning For Development Towards Green Revolution

1. GR Team Reflect on the National vision statement
   National mission statement
   National Research vision and mission statements

2. Get the community to working groups to make:
   a) Natural resources map of their locality (region/parish/village)
   b) Make a list of products being produced in their community and show with diagrams proportions – volume.

   Then set out to understand and get responses to the following questions.

   a) Who are we and what are we trying to do?
   b) How can our farming community be organized to beneficially promote our joint themes?
   c) What can our farming communities do together for greater mutual, social, cultural and/or economic benefits?
   d) How can we make use of our land, swamps, forests to serve/benefit our own present needs and continue to serve/benefit the needs and survival of our children and grandchildren?
   e) What can any one family do to produce enough?

3. Identify and generating community vision values mission statements
   Who are we and what are we trying to do?

   (a) **Vision of society**
   Overall picture of different desires that guides the society

   (b) **Vision of our community organization**
   The image of how we want to be as a future organized community living together

   (c) **Values**
   Your personal vision of how you see the world and what you believe about people.

   (d) **Shared values**
   The values which underpin your work together and your relationship with users and other stakeholders.

   (e) **Organization principles**
   The principles that guide how the Organization functions and how its members conduct themselves

   (f) **Operating principles**
   The principles that guide the individuals in how they approach and implement their organization's work

   (g) **Policy** – written statements of intent about the quality of work you are doing and formal expression of the culture of organization.

(h) <u>Mission</u> – A description of the work the organization does and how the work is aimed at.

Box 4.1: A typology or levels of participation/participatory process

Typology	Characteristics of each type
1. Passive participation	People participate by being told what is going to happen or has already happened. It is a unilateral announcement by an administration or project management without listening to people's responses. The information being shared belongs only to external professionals.
2. Participation in information giving	People participate by answering questions posed by extractive researchers using questionnaire surveys or similar approaches. People do not have the opportunity to influence proceedings, as the findings of the research are neither shared nor checked for accuracy.
3. Participation by consultation	People participate by being consulted, and external people listen to views. These external professionals define both problems and solutions, and may modify these in the light of people's responses. Such a consultative process does not concede any share in decision making, and professionals are under no obligation to take on board people's views.
4. Participation for material incentives	People participate by providing resources for example labour in return for food, cash or other material incentives. Much on-farm research falls in this category, as farmers provide the fields but are not involved in the experimentation or the process of learning. It is very common to see this called participation, yet people have no stake in prolonging activities when the incentive end.
5. Functional participation	People participate by forming groups to meet predetermined objectives related to the project, which can involve the development or promotion of externally initiated social organization. Such involvement does not tend to be at early stages of project cycles or planning, but rather after major decisions have been made. These institutions tend to be dependent on external initiators and facilitators, but may become self-dependent.
6. Interactive participation	People participate in joint analysis, which leads to action plans and the formation of new local institutions or the strengthening of existing ones. It tends to involve interdisciplinary methodologies that seek multiple perspectives and make use of systematic and structured learning processes. These groups take control over local decisions, and so people have a stake in maintaining structures or practices.
7. Self-mobilisation	People participate by taking initiatives independent of external institutions to change systems. They develop contacts with external institutions for resources and technical advice they need, but retain control over how resources are used. Such self-initiated mobilization and collective action may or may not challenge existing inequitable distributions of wealth and power.

N.B. GR team should adopt 6 or 7 level of participation for any given community

4.3 Participatory problem analyses methods

The participatory problem analyses methods can be grouped into three categories namely:

(a) Ranking methods (i) Preference ranking (ii) Pairwise ranking and direct matrix ranking.

(b) Time Diagrams (i) activity analysis (ii) daily routine chart
(iii) seasonal calendar (iv) time trends/historical profile/river of life.

(c) Relationship and decision diagrams (i) Flow diagrams, (ii) Venn diagram (iii) problem tree analysis. The GR team does not need to go through all the problem analysis methods but can select one or two that can identify the leverage factors and entry points (those with negative relationships) depending on their target farming systems.

4.3.1 Preference ranking

Methods – Focus key questions, brainstorming village meeting/discussion, focus group discussion
Decision is reached by voting, or by weighted scores or by eliminating the less important constraints/problems.

Purpose – Preference ranking helps a community to identify the main developmental problems that affect most individual community members.

Steps –

1. What are the major development problems in your community?
   Community lists major development problems on flip charts.
2. What is the worst problem? Next worst problem? Third worst problem? And why?
3. Community develops the criteria for ranking the problems from the worst to least bad! E.g comparing development problems according to (i) category of population being affected (affected groups) (ii) the size (number of individuals) of the affected groups (iii) the weight/relationship of a problem with respect to subsequent problems caused by it. (Route cause).
4. How can the problems be arranged in their order of importance? Why?

4.3.2 Pairwise ranking matrix

Purpose – Pairwise ranking matrix helps community identify their main problems, and enables them to compare the priorities of different focus groups and/or individual members of the community.

Steps

1. What are the major development problems in your community? Community brainstorms and lists major development problems on a flipchart.
2. – What are the main causes of each problem?

- What are the main consequences of each problem?
- Who are the most affected target groups?

  Community analyses the problems considering their main causes, consequences and affected groups.

3. What are the main themes under which all the problems can be divided into sets? E.g. farming problems, marketing and trade, social services etc.
   Community discusses themes and classifies the sets of problems corresponding to the themes.
4. Community members break into three to four groups. Each focus group handles one of the three sets of problems. The group writes problems on cards one by one. Group selects 5 or 6 important problems from each set of problem cards.
5. Group take turns to act as "interviewee".
6. Group selects at random two problem cards, place them in front of interviewee and ask him/her to pick the bigger problem or more favoured and give reasons for the choice. Then note down the response in the appropriate box in the priority ranking matrix and reasons in ranking criteria matrix.
7. Present a different pair of cards to interviewee and repeat the comparison.
8. Repeat step 4 to 7 until all possible combinations have been considered and the matrix has been filled.
9. List the preferences (problem) in the order interviewee has ranked them. After each cell is filled, complete the score column by adding up results.
10. Repeat the pairwise ranking exercise for a number of individuals from the group and tabulate their responses.
11. Then compare the priorities of different individuals.
12. Community in a large group discusses/considers ranking priorities and ranking criteria for each set of problems. Then community chooses over all priority problems, then results priorities, sector by sector or theme by theme along with their ranking criteria.

4.3.3 Direct matrix problems ranking

Methods – case study, focus questions, large group discussions, small focus group discussion, group work, cards, markers, flip chart.

Purpose – matrix ranking gives the ranks of problems beginning from the worst to the least (bad). It also gives the causes, the worst effects or consequences as well as the most affected groups in the community.

Steps:

1. Orientation of the village community meeting.
2. What are the major development problems in your community?
   - What are the causes of each problem?
   - What are the consequences of each problem?
   - Who are the most affected groups in the community?

   Community breaks into three to four focus groups to represent different community interest groups (women, men and youth).

3. Each focus group lists and analyses its own problems in terms of causes, consequences, and affected groups. They may even add extra problems.
4. Which of the causes are most important?
   Which of the consequences are most important?
   Each focus group selects most important causes, consequences and the corresponding problems. Then each focus group writes each problem on yellow card, cause on blue card and consequence on pink card, then writes each affected group on grey card.
5. Community in a large group discusses output of group work. Cards are pinned on flip chart in a matrix form where first column from top down place cards of causes, followed by those of consequences, followed by those of affected groups (i.e. blue, pink, grey cards). Then the yellow problem cards are arranged in top row of the matrix from second column, each yellow card representing a column.
6. Among the blue and pink cards which causes are similar and which consequences are similar? – Among the problems on yellow cards which problems have similar or related causes? – which problems have similar or related consequences? Community combines problems with similar causes and those with similar consequences.
7. Among the causes – which is worst? Then next worst? Etc...
   Among the consequences – which is worst? Then next worst? Etc...
   In each case, community chooses four cards or less from causes, chooses four or less from consequences.
8. Community draws up the Direct Matrix Ranking. On flesh flipchart Pin worst causes, worst consequences cards, then the affected groups in first column. Then pins yellow (problem) cards in top row. Scoring or weighting of problems: Worst cause equals four, next worst equals three, etc..least (bad) equals one. Then worst consequence equals four, next worst consequence equals three etc..least (bad) equals one.
9. Community fills the scores in the cells of the matrix.
10. Adds total score for each problem (vertical totals), then each worst cause, worst consequence, most affected group(s), (i.e. horizontal total scores).
11. Community gives ranks to the problems according to:
    (i) highest total score, (ii) those with worst causes, (iii) those with worst consequences, (iv) those that affect largest proportion of the community, (v) those that hurts the community most, (vi) the overall ranking of the problems and the criteria for ranking.

4.3.4 Time Diagrams of problem analysis
Activity analysis/Daily routine diagram

Purpose – Daily routine diagram helps to collect and analyse information on daily patterns of activities of community members for different groups of people like women, men, old, young, employed, unemployed, educated and uneducated. Group can identify time constraints (shortage) opportunities and how gender roles are divided plus how to improve the use of available labour resources around the community.

Steps:

1. Community members discuss activities carried out by different categories of people in a typical day. E.g. work at home (fetching water, fetching firewood, cooking, washing, cleaning, feeding children) work at farm, etc….
2. Using focus questions, community members can quantify information (using beans or small stones).
3. Members experiment different diagrams e.g. horizontal bar charts or pie charts to visualize the general patterns in analyzing the information.
4. The quantity or size of work load are indicated by drawing thicker or thinner bars. Also by breaking down categories of activities.
5. Community members draw up a daily routine diagram, label it and analyse it in terms of problems and opportunities.

4.3.4.1 Seasonal Calendar

Methods – Notes /explanations, brainstorming, group work, series of diagrams, use of bean seeds.

Purpose – helps to present large quantities of diverse and complex information in a simple diagram, on a seasonal calendar using a common time frame, comparing month by month across sectoral boundaries. It shows main activities, problems, opportunities, and community attitudes towards certain activities. – It helps to identify months of greatest difficulties and impact on people's lives.

Summarized information:
Indigenous seasons, farming activities, labour allocation versus labour demands for men, women, and children, crop pests, and diseases, livestock (births, weaning, sales, migration, fodder), livestock diseases, income generating activities, prices, marketing, human diseases, social events, annual holidays, types and quantity of fuelwood, types of food.

Steps –

1. Community members who are knowledgeable discuss different events and use beans or small stones to quantify information and indicate their relative magnitudes.
2. 2. Draw up a 12 month or 18 months calendar as appropriate, on flipchart or on the ground.
3. Construct the seasonal calendar by tracing quantities of beans or small stones, indicating main activities, months etc…
4. Use focus questions to obtain individual groups responses. The draw up the curves along the heaps of beans on flipchart.
5. Make the appropriate labeling of diagram/curves. Make analyses in terms of problems and opportunities.

4.3.4.2 Time trends/historical profile

Methods – Brainstorming, focus questions, group work, diagrams.

Purpose – It provides summary overview of the key historical events in a community and their importance for the present situation and community perceptions of significant changes over time.

Summarized information – building of infrastructures, introduction of new crops, out breaks of epidemics, droughts, famines, soil fertility loss, land availability, grazing, deforestation, tree planting, changes in land tenure, major social/political events in the community.

Steps –

1. Community members discuss historical problems, events, village elders recall as far back as they can remember or were told by their parents/grand parents.
2. Using focus questions, participants and/or community members visualize the changes by experimenting different diagrams, e.g. bar charts, bar diagrams, number lines, etc…
3. Community selects most appropriate diagrams and draws them on flipcharts and labels them accordingly.
4. Community analyses and notes the problem patterns and the available opportunities.

4.3.5 Relationship and decision diagrams

4.3.5.1 Flow diagrams

Methods - Brainstorming, demonstrations, group work, focus questions

Purpose – Flow diagram shows the causes, effects, sequences and inter-relationships of different problems being faced by a community. E.g. – Relationship between economic, agricultural, factors, or problems. Then each group draws its own flow diagrams. Use arrows to connect boxes.

6. Cross-check the drawn flow diagrams.
7. Community identify the priority problems, based on the root causes, contributing local problems and main problems in each of the sectors represented by flow diagrams.

4.3.5.2 Venn diagrams

Methods – Focus questions, Brainstorming, group work, demonstration, case studies.

Purpose – Venn diagram (named after a man who created it) shows – key problems and how they are interlinked or key institutions and individuals in a community and their relationships and importance e.g. decision making.

Steps

1. Community members discuss and identify main problems/factors/variables in their village.
2. Community identify degree of contact and overlap between different factors/problems, size and relative importance and of overlap.
3. Members draw and/or cut out circles to represent each problem or factor or variable or institution flipchart, use different colours or labels.
4. Place the circles on the ground or pinned on flipchart in their relative positions.
5. Arrange their positions as follows:
   (i) separate circles equals no contact.
   (ii) touching circles equals information passes between e.g. institutions
   (iii) small overlap equals some common variables/share some information.
   (iv) large overlap equals many/share large common (factors) ' information.
   (v) small circle(s) inside large circle equals minor factor included/covered by major factor.
6. Members draw the Venn diagram, first in a pencil, adjust sizes until representation is accurate. Then go over the pencil with a marker, label all the circles.
7. Community prioritize the problems and analyse their relationships.

4.3.5.3 Problem tree analysis

Methods – Focus questions, discussions, group work, cards, flipcharts.

Purpose – Problem tree shows the main problems, their causes, effects or consequences and relationships with other problems in the community. It also helps community to identify root causes of their problems.

Steps –

1. What are the major development problems in your community?
   Community discusses and lists problems on flipchart.
2. What is the worst problem in your community?
   - What are the major causes of the worst problem?
   - What are the major consequences of each of the worst problem?

   Community writes each problem on a card: - worst problem on yellow card, causes on blue cards, consequences on pink cards.
3. Community break into 3 or 4 groups, arranges cards on the ground or pins them on flipchart. Begin with one pink card.
4. Which problem is a consequence of which problem?
5. Community cuts several arrows. Rearranges problem cards and pins the arrows to indicate the direction of cause and effect from problem to problem relationship.
6. Group repeat step 5, discusses and cross-checks to establish the positions of all problem cards and the direction of arrows.

7. Are there any other problems linked to the worst problem direct or indirectly through causes, effects or consequences?
8. Where should the unarrowed problem cards be positioned?
   What is the obtained shape of problem cards?
   - Group describe obtained shape.
9. The group draws the problem boxes and arrows on a flipchart, then describes the obtained shape.
10. Community in large group compares the 3 or 4 focus group output of problem tree analyses, chooses the most important problems on basis of being major:-
    (i) root causes of subsequent problems
    (ii) linkages of a cluster of problems
    (iii) consequences with large negative impacts on the community.
11. Community gives the criteria of prioritizing their problems using problem tree analysis.

4.4 Organization and problem ranking table

1. After problem analyses especially from focus group discussions representing different group interests, the village community needs to reach a general consensus and set up agreed priority problems of the village. The whole village community considers outputs of different groups in terms of problems, causes, consequences, affected groups, and other criteria discussed.
2. As a final output, the community constructs "**O**rganization and **R**anking **P**roblems **T**able". The Table has eight columns (i.e. problem, causes, consequences, affected groups, opportunities, basic criteria, score and final (community) problem rank).
3. The consensus is reached about village priorities (which problem can be addressed first, second, third etc..) in active community participatory process.
4. Development of the community based action plan. Then draws also "Development of Community (natural resources) based Action Plan".
   The community agrees on:-
   (i) development priority problems and their ranks.
   (ii) proposed (natural resources based) possible solutions.
   (iii) If GR improved design is made available
   (iv) what are the resources locally available including opportunities.
   (v) duties, responsibilities for groups, institutions/NGOs, and individuals.
   (vi) external assistance needed.

Then the Green Revolution team(s) received the community participatory analyses results for further field technical assessment and subsequent GR improved farming systems designs.

5.0 FIELD TECHNICAL ASSESSMENT OF PRIME MOVERS, LEVERAGE FACTORS AND ENTRY POINTS TO RE-DESIGN AFRICAN AGRICULTURAL PRODUCTION SYSTEMS

5.1 Field technical data collection

The design team determines the topics of focus and themes to be covered to amplify the results of community participatory problem analysis and systems leverage factors/entry points.

5.1.1 Choice of topics and themes

National topics/themes	Village/community's themes
Agriculture	
- Crop or livestock genetic improvement	- Crop farmers or animal keepers
- Soil fertility management	- Maximum land use
- Land use	- Means of livelihood
- Land tenure	- Food security
- Land reforms	- Dual purpose food/cash crop
- Source of planting materials	- Accessibility to farm resources
Health	
- Health services delivery systems	- Accessibility to health services
- Costs, demand and supply of health services	- Affordability of health services
- Curative and preventive measures for management of epidemic disease	- Availability and efficacy of drugs - Protection against epidemic disease(s)
Economics	
- Sources of income	- Alternative sources of income
- Levels of income	- Purchasing power of income
- Broad based taxation	- Tax reliefs/subsidies
- Formal and informal micro-finance	- Availability and accessibility of micro-credit schemes
Natural resources and environmental management focus	
- Land use planning	- Competing uses of natural resources
- Land degradation	- Land tenure systems
- Agro-ecosystem and/or	- Economics and social benefits of natural resources
- Impact of natural resource use	- on climate change
Gender	
- Gender	- Women's roles in the home
Farming systems	
- Agricultural production systems	- Crop enterprises
- Commercial versus subsistence farming	- Cropping systems
- Crop—livestock integration	- Accessibility to farm inputs
- Input delivery systems	- Institutional and policy support services
- Agricultural policies	

5.1.2 Objectives

The design team set up objectives to be covered in the field data collection exercise.
Examples

- To identify major location – specific farming systems constraints to sustainable production/development.
- To determine leverage factors, available development opportunities and/or Green Revolution design elements (or prime movers) and to access the possible entry points for subsequent Green Revolution design process.
- To estimate the technical input-output coefficients that can be used to select appropriate technological interventions that are aimed at increasing the productivity of target farming systems in a sustainable manner. This is to include both crop and livestock productivity (yields) overall whole farm outputs, improved sustainable community's farming systems that can pass the test overtime and farm families economic and social welfare.

After determining the survey/data collection objectives, the design team sets up questions to be answered by the survey data.

- What scope is to be included in the survey?
- What will the survey data/results be used for?
- What variables do we need to include?

In other words, having determined the themes, what are the key variables related to each theme whose data is to be collected?

5.1.3 Primary and secondary data sources

- Primary data source is the agency that makes direct the data collection and compilation and publishes the data for first time e.g. Uganda Statistical Bureau's publication of 1991population census, 1990 Agriculture and Livestock census data.
- Secondary data source is the republication of materials or data extracted from other sources.
- Secondary data source may also include internal or external data records made over time on business or farm operations which are related to the farm enterprises being considered.

5.1.4 Field sampling procedures

Sample surveys

- Surveys are used to collect data/information in order to answer a question or make an informed decision.
- Surveys data are intended to measure one or more characteristics of a population or constraints within an African farming systems. Why sample? It is costly and not practical to

survey the entire population or to survey all details of a farming system. We select a random sample which represents and can be used to estimate the main characteristics of a population or farming system being studied/analysed.

- Advantages of sample surveys versus censuses are:
  - reduced costs
  - greater speed; data can be collected, analysed and summarized guide by then used for the farming design.
  - Greater scope – specific surveys like enterprise sample or whole farm sample can be carried out and be used to complement each other thus providing more scope and flexibility.
- Censuses can be used to provide detailed information/data about the population.

Sampling methods

- Simple random sampling – sampling in such way that every item selected from the population has equal probability (chances) of being picked.

- Quota sampling – In quota sampling the choice of the sample is left to the interviewer who simply has to interview a certain number or quota. There is a some risk of the interviewer tending to be biased.

- Purposive sampling – some experts select units that are thought to be typical and representative units of the target population/farming systems to be analysed.

- Systematic sampling – In systematic sampling at regular intervals, decide on sample size n, the length of the interval k, where $k = \frac{N}{n}$ is an integer. Choose a random starting point.

  That is select the r^{th} unit on the list, then continue to skip down k units and select.

- Cluster sampling

Divide the target area into clusters based on specific location or characteristics of some given factors. E.g. clusters based on level of education, level of income cropping patterns or dominant farm enterprises. Then sample from each cluster.

- Stratified sampling

Stratum (plural strata) is a group of population units. When a population is stratified, it is divided or partitioned into mutually exclusive strata especially when the population in the target area is known to be heterogeneous that is having attributes that are completely different from stratum to stratum. Then samples are taken independently from each stratum thus giving a total sample size n where $n = n_1 + n_2 + n_3 + n_5$.

Multi-stage stratified random sampling

- Multi-stage sampling

Multi-stage sampling is an extension of cluster sampling. It should be recalled that when cluster sampling, we are the cluster means and totals to estimate population mean and total. Similarly, when multi-stage sampling, we use estimates of group mean and total to estimate population mean and total. The application of multi-stage sampling is commonly used when the "target units" can be grouped based on (a) Geographical areas/location or (b) first second, third and fourth level of important characteristics.
For example he may want to take a representative sample of farming communities to analyse the complex farming systems of South Uganda. We can take our sample by going through different stages.

<u>First stage</u> – divide the geographical area of South Uganda into regions namely – (Eastern, Central and South-western).
<u>Second stage</u> – sub-divide each region into administrative districts. Then randomly sample two districts per region.
<u>Third stage</u> – sub-divide each sampled districts into counties and randomly sample one county per sampled district.
<u>Fourth stage</u> – sub-divide each sampled county into sub-counties and randomly sample only two sub-counties.
<u>Fifth stage</u> – sub-divide sampled sub-counties into parishes and randomly select two parishes per sampled sub-county.
<u>Sixth stage</u> – sub- divide sampled parish into villages and randomly sample tow villages per parish.
At the final stage randomly sample three farmers per village. This is called multi-stage random sampling. Multi-stage random sampling allows the survey design team flexibility and possibilities to disaggregate certain otherwise complex characteristics and/or variables of the given farming systems. Also different methods of selection and estimation of variables may be used at each stage.

5.1.5 The types of field data to be collected for technical analysis of farming systems

The types of field data to be collected for technical analysis of the farming systems include (see Fig. 3.1).

<u>Agro-ecological data</u>
- climate – temperature and rainfall, seasonal variations

<u>Physical environment</u> – altitude, topography, vegetation, water sources

<u>Social data</u> – farm family members, number, age, sex, education, occupation

Social cultural environment – culture, norms and customs related to land ownership and use, division of labour within society and family, rights and obligations related to sex, age groups, descent and inheritance systems.

- Social institutions for leadership, for controlling land, social classes based on wealth, power, education or customs.

Economic data

Marketing – access to markets, critical periods needing to obtain credit, animal traction, cooperatives, purchase inputs, sources of labour, wages, commodity and input prices, storage facilities, processing facilities.

Infrastructural data – roads and transport, technology support services, input supply systems, equipment repair services, technical extension services, channels of communication.

Policy data
Policies - govern policies to support technical, economic and social services.
Farm resources
land – land type, levels of soil fertility, land ownership, tenure, farm size, land holding, soil samples for physical and chemical soil laboratory analyses. Terrain and slopes.
Water – water sources and availability – quantity, quality and distance to source.
Labour – family labour available for farm work. Sources of hired labour by sex, age, (education) by farm activity.
Capital – cash savings, cash earnings from crops, livestock, employment, liquid assets, fixed assets (buildings)
- farm tools – small implements, hoes, cutlass
- farm equipments – plough, planter, weeder, harvester, shelter, grinder

Management data

- skills and knowledge of husband, wife, older children
- skills of supervisors (family or hired labour)
- roles and responsibilities of husband, wife, hired manager/supervisor
- Farmers' goals, perception, altitudes, market oriented or not.

Entrepreneurship – those who are doing farming as a business
- number of respondents who have a vision, a goal, objectives and future investment plans of any of their farm enterprises.

Cropping systems

Food and cash crop enterprises, crop varieties, land under crop, production (yields) cropping patterns, crop rotation, intercropping, seed planting rate.

Crop production methods
Labour and methods used for farm activities – ploughing, planting, weeding, crop protection, harvesting.

Cropping calendar
Farm activity by crop by months by type of labour and amount allocated.
Fertilizer applications, rate, time and frequency of application.
Livestock
Type – cows, goats, sheep, rabbits, pigs, poultry
Number, age, birth, milk, sales
Crop-livestock interaction – demand and supply linkages by type of activity and period of time.

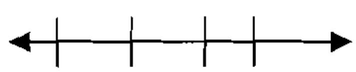
Farm community – joint activities, proportion/size of different segments in the communities.

5.1.6 Design of formal surveys

Scales of measurements:

Nominal scale 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
Numbers are used to classify observations into mutually exclusive categories or classes. This scale is used for measuring qualitative variables such as: very good = 3, good = 2, poor = 1. E.g. type crop technologies: traditional variety = 1, elite/selected variety = 2, genetically improved variety = 3.

Ordinal scale – e.g. scale on number line: mark line segment 0, 0 to 1, 1 to 2, 2 to 3, etc on number line.



0 1 2 3

Numbers on ordinary scale are used as order relationship among the numbers. Here numbers are reserved to observation with continuous measurements which are divisible e.g. magnitude of income received from agriculture.

Interval scale

- equal interval anywhere along the scale represent an equal amount of difference in the characteristics being measured. E.g. measure temperature change on the Celsius scale.
E.g. decrease temperature change from $40^{o}C$ to $32^{o}C$ and $60^{o}C$ to $52^{o}C$ equals $12^{o}C$

Ratio scale

The ration scale is the level of measurement that permits all arithmetic operations

X/Y = 1, 0.1, 0.12, 0.13

Methods of measurements

- Direct observation – the collector observes qualitatives and/or quantitative data variables and records what he/she have perceived.

- Counting - counting is done for discrete variables e.g. cows, persons, objects
- Measurements – using a measuring tape to collect data such as height, length, weight e.g. crop harvested, length of a road, height of a plant, planning stage

Determine question content

- appropriate identification of information/variables
- classification variables in questionnaire
- hypotheses variables/questions
- the ability and likelihood of the respondent to answer the questions e.g. sensitive questions, questions requiring calculations.

Determining question format

- Open-ended questions where the interviewer writes down the response in full.
- Close-ended (multiple choice) questions where the interviewer checks the appropriate response category.
- Dichotomous questions where only two responses are allowed (Yes/No, sell/consume, buy/sell, …).
- Tabular questions where a question is asked after which rows and columns in a table are completed.

Determining the wording of the questions

Every question should:

- focus only on one point and have only one answer.
- be specific – avoid vague words e.g. may, often, frequently..
- use common terms and avoid technical terms.
- be phrased neutrally to avoid biasing the response.
- be phrased so that respondent cannot determine the preferred response.
- specify the relevant time period for consideration
- be numbered to aid the processing of data; for aggregate values start first on individual basis like weekly, plot, or crop enterprise.

5.1.7 Methods field data collection

Direct observation

- measurements – use of tapes, scales, protractors and other devices to directly measure things in the field like plot size, weight of harvest, volume of water etc..

- Recording – notebooks, record sheets, diagrams, photographs collection of samples of objects.
- Sites – markets, transportation (buses, taxis, train, work sites, homes, health post, times before and after public meeting, places of worship, plus hairdresser.
- When observing complex events e.g. weddings, sports, the team should plan and divide roles to provide multiple view points. Different observers can concentrate on different groups of people.

Interviews - information obtained from individual interviews is more personal than from groups interviews and is more likely to reveal conflicts within the community since respondents may feel they can speak out more freely in neighbours absence.

Key informant interview – a key informant is one who has special knowledge on particular topics e.g. trade on transportation, credit farmer on cropping practices. Key informants can provide information about behaviour of others, operations of broader systems – valuable key informants are outsiders who live in the community like teachers, people who have married within the community. They normally have more objective perspective on affairs in the community than the community members themselves.

Focus group discussion – a small group of 6-12 people who are knowledgeable or who are interested in the topics are limited to participate in focus group discussion.

Group interviews – group interviews have the advantage of providing access to large body of knowledge. They provide an immediate cross-check on information as it is received from other group members.

5.1.8 Field data collection methods

<u>**Number of visits**</u>

- single or few visits in the course of field data collection.
- <u>multiple visits</u> – repeated visits to collect the same data points or multiple data points over a period of time e.g. in case of monitoring on-farm trials.

<u>**Surveys**</u>

Formal surveys and informal surveys.

<u>**Informal surveys**</u>

- flexible in decision making – learning is rapid and progressive with flexible methods to explore relevant issues.
- the data collection is dynamic and interactive.
- interviews usually conducted by interdisciplinary team.
- interviews are unstructured and semi-directed.

- informal survey data do not permit statistical analysis because they are taken without a sampling procedure, do not involve obtaining responses to a standard set of questions.
- reliability of the findings depend on the skills and experiences of the research or design team.

Formal survey

Formal survey use questionnaires to provide a systematic, ordered way of obtaining information from respondents and enable precise and statistical analyzable data to be obtained. It is cheaper than direct measurement.

- implement single visit rather than multiple visit surveys.
- emphasize special subject surveys with specific objectives rather than multiple purpose surveys.
- carefully consider how accurately individual variables need to be estimated in order to answer the objectives of the exercise.
- make sure the links between data collection, checking (verification) data entry, processing and analysis for which the data is intended.
- interviewing procedures may be location specific.
- background information relating to objectives and target area should be assembled and digested.
- when a team is working in location first time, the objectives of survey and programme need to be explained to and approved by the community leadership through community meetings.
- in order to get reliable response it is important to get respondent(s) cooperation.

Tips for interviewers to maximize the interaction with the respondents and improve the value/accuracy of information that is obtained are:

Approach - keep a low profile, interview when convenient for the family.

Warm up – be polite, make appointments to discuss the survey, take time to approach survey topics – be prepared to talk about other topics of interest to the respondent – indicate you are there to learn.

Dialogue – be natural and relaxed. Be flexible let the discussion flow, use simple understandable language, respect the local customs/cultures start with simple questions, avoid sensitive questions, obtain information of sensitive questions through indirect questioning, rephrase questions, observe your respondents reactions for they may reveal concerns or reservations, take permission to write answers – Do note take longer than 60 – 90 minutes.

Departure

Bring conversation to an end when topics are discussed or respondent can spare no more time. Thank four respondents and depart respectfully.

5.2 Mathematical model of the African farming systems

African farming systems is very complex in nature. There are many intricate interwoven component/systems, institutions, environmental, physical, biological, economic and social relationship/correlations which characterize the agricultural production set up. For example the magnitude of expected output of a crop enterprise in a given location will vary with soil type, climate, crop variety, quality of labour and management, fertilizers used etc. So before expressing and formulating production relationships in such system. The design team has to set and examine the following guiding questions.

(a) What system of equations is most appropriate/all the dominant factors?
(b) What set of variables are relevant to the model?
(c) What algebraic formulations should be used?
(c) What types of functional production relationship should be expected?
(d) What types of data will be needed?
(e) What kind of production/technical coefficients can be estimated?
(f) How can the most limiting constraints and gaps be identified?
(g) How will leverage factors and entry points be determined?

Specification of the farming systems model

The choice of single or multiple equation models will depend on the major farming systems components and the dynamics within and intra components. For example the production process in one crop or livestock enterprise involves a different set of input-output ratios that may be quite different from enterprise to enterprise.

The design team has to determine the different production, technical and economic relationship involved. Since the African farming systems has many components e.g. crops, livestock and non-farm plus additional influences from external and natural factors (See Figure 3.1) besides the specific enterprise relationship in each component then it requires a systems if equations. In this case each set of relationships can be represented by a set of simultaneous algebraic equations.

Choice of variables

The choice of variables should include as much as possible the underlying mechanics of the production processes in each equation. However in practice the design may have limitations due to inavailability of data or limited due to complicated statistical computations. In which case at least the design should endeavour to include the most important components of the given farming systems.

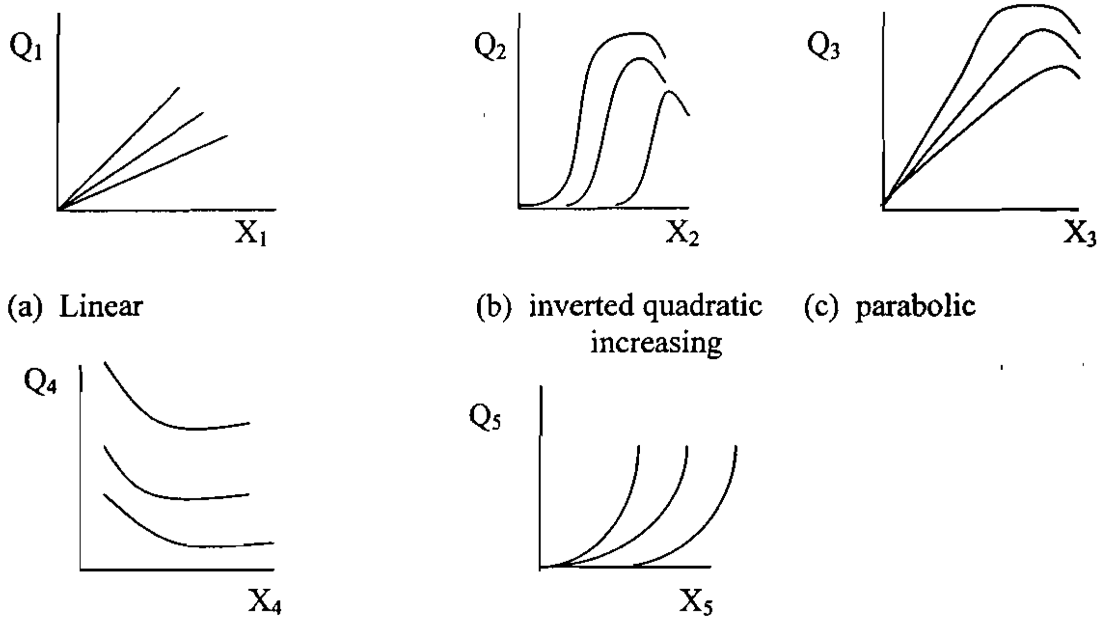
For example. Quantity of crop produced is a function of amount of land, labour, capital, technology and type of management used. Here in one place capital can be represented by one variable combining say cost of fertilizer and seeds. But in other situation one may find that chemical fertilizers and organic fertilizers are being used in combination and /or separately, necessitating use of two variables. Similarly technology in one place may be represented by one variable such as crop variety. On the other hand technology may be represented by more than one variable say to represent biological, chemical and physical separate technologies. Then the team has also to capture the external factor influences like institution, infrastructure, policies and climate.

Choice of algebraic formulation

The choice of algebraic form is determined by the type of underlying biological, physical, chemical or economic relationships. For example an economic relationship is often linear in nature e.g. cost and quantity bought relationship. Thus an increase in cost is proportionate to the increase in quantity bought. This relationship is obtained by calculating/estimating the price.

Input-output curves

Biological or physical production surfaces may be represented by a curve whose products Qi produced my be constant, decreasing or increasing as the inputs Xi increases.



(a) Linear

(b) inverted quadratic increasing

(c) parabolic

(d) Isoquant

(e) quadratic

Fig. 5.1: Type of production relationship

<u>Criteria</u> estimation of the slopes

- Input-output ratios
- production elasticities
- marginal physical products
- profit maximization of quantities inputs
- cost minimization of inputs
- returns to investments in variable factor
- allocation of limited capital
- production possibilities
- Arithmetic means
- political coefficients and partial correlations
- +ve or –ve signs of the coefficient
- significance of the coefficients

Production functions

(a) Linear relationship

Quantity produced is a linear function of amount of land, capital, labour and management used.

Qt maize $= f(x_1, x_2, x_3, x_4)$

$= Qt = a + b_1 x_1, + b_a x_2, + b_3 x_3, + b_4 x_4$

To determine constraints and leverage factors

Estimate the linear equation using multiple regression analysis. Determine the size, significance and sign of the bi coefficients.

NB. Significant coefficient bi means that that particular variable is very important. The negative sign means the factor acts as a constraint whereas a positive/negative sign implies that the said factor is complementary.

Multivariate linear regression model

In any agricultural production system there are many factors which interact and/or affect one another. The effects of the interaction between any two factors can be a positive + change or a negative – change. Statistically, this is called a relationship between two factors/variables. For example if we want to determine factors affecting the market demand for bananas in Kampala market in Uganda. We estimate a cooking banana Kampala market demand function. We hypothesis that the quantity of bananas demanded Qbt at time ti, depends on the market price of bananas, also the prices of complementary commodities (beans, groundnuts) and prices of the substitutes (maize flour, cassava, sweet potatoes) and the consumers' level of income.

This is called a demand function which can be estimated by fitting a multiple regression equation price and analysed to estimate for example consumers' income elasticities of bananas. Similarly, a Green Revolution design team wants to determine leverage factors and entry points of a given agricultural production/farming systems. Then the team has to break the system into its components.

(i) crop production systems – considering all the major crops enterprises

(ii) the livestock production systems - considering all animals and their complementary activities.

(iii) the technical, economic and social support systems

(iv) identify the interaction activities between the cropping enterprises/activities and the animal rearing activities.

Let us take an example of a farming system in North Cameroon

By 1990, the farming system in North Cameroon comprised of crops and livestock operated separately. The average farm size of crop farmer is 0.3ha of which 36.2% was planted to cotton, 14% to groundnuts (for food and income), 2% to white sorghum, 25% to red sorghum, 1% to traditional cowpea and millets 5%. Fulbe herdsmen who keep cattle, goats and sheep lived side by side with crop farmers. But the crop farmers kept very few or no animals and the livestock keepers did not bother to grow crops. There were a lot of social conflicts between crop farmers and pastoralists and a lot of competition for land and water resources for both human, crops and animals. Besides North Cameroon has only one rainy season of duration five months in a year when both crop and livestock farmers had to grow their crops, pastures and grasses. During the long dry season the whole region is dry no single grasses or shrubs. The soils become very dry and hard and volunable to manage/breaking being exposed to wind erosion by the roaming animals which can hardly find any dry pieces of grass to eat. In addition, the communities by 1990 were having frequent food shortages during the long 7 months dry season.

We now look at the above farming systems, considering the following objectives

(a) to identify and assess the major constraints in the system
(b) to identify the leverage factors and entry points and
(c) subsequently design an improved farming system that fully integrates the crop and livestock components

We now build the equations by enterprise using the layout in Table 5.1. Then after Collecting the field data we can analyse the above farming systems using either multiple Linear regression or linear programming or both.

Table 5.1: Factors of influence on farmers management of his farming systems in North Cameroon

Farm enterprises	Subsistence priorities			Technology			Resource use			Risks/Hazards							Institutions				Infrastructure		
										Natural				Biological									
Crops	Food staple	Food needs in dry season	Cash income	Biological	Chemical	Physical	Land scarcity	Labour carcity	Capital scarcity	Short rains	Late rains	Drought	Poor soils	Pests	Diseases	Weeds	Research	Extension	Credit	Market	Feeder roads	Transport	Storage
Red sorghum	*	*	*	*	*	*	*	*	*	-ve		-ve	–ve	-ve	-ve	–ve	*	*	*	*			*
White sorghum	*	*		*	*	*	*	*	*	-ve		-ve	–ve	-ve	-ve	–ve	*	*	*	*			*
Cotton			*	*	*	*	*	*	*	-ve		-ve	–ve	-ve	-ve	–ve	*	*	*	*	*	*	
Millet		*		*	*	*	*	*	*	-ve		-ve	–ve	-ve	-ve	–ve	*	*	*	*			*
Cowpeas	*			*	*	*	*	*	*				–ve	-ve	-ve	–ve	*	*	*	*			*
Groundnuts	*	*	*	*	*	*	*	*	*	-ve		-ve	–ve	-ve	-ve	–ve	*	*	*	*		*	*
Livestock																							
Cattle		*	*	*	*		*	*	*	-ve		-ve	–ve	-ve	-ve		*	*	*	*	*	*	
Goats			*	*	*		*	*	*	-ve		-ve	–ve	-ve	-ve		*	*	*	*	*	*	
Non-farm activities		*	*					*	*								*		*	*	*	*	** *

5.3 Analyses of field technical data and identification of leverage factors and entry points

5.3.1 Analysis of agro-ecological data

Having previously collected the necessary (i) community participatory data, (ii) geographical data (iii) field technical, economic and social data. The design team can move fast to analysis stage.

The GR design team has to analyse their collected farming systems data and answer certain key questions about the following factors.

5.3.2 Environmental factors' influence on the farming system

- What environmental factors are there over which the farm household has little control?
- How the farming systems interacts with the environmental factors. What are/is the most limiting environmental factor?
- What possibilities/flexibilities for change exist within the environment?
- What farming strategies are likely to succeed?
- What are farm management factors over which the farm household has reasonable control?
- How to influence local, regional and national decision makers concerning to make necessary changes in policies and support services: For our analyses, the farmers environment factors can be divided into (a) Agro-ecological factors – temperature, rainfall, rainfall pattern, distribution, determination of the length of rainy seasons in days.
  (b) Geographical location by direct observations – terrain, altitude, vegetation.
  (c) Biological environment by observation and key informants – major pests, insects,. birds, rodents.
    - major diseases – endemic epidemics
    - major weeds - wild weeds
  (d) Socio-economic environment/level of site development
    - accessibility by feeder roads to market
    - population settlement pattern/.density
    - major social customs/traditions

In our analyses we shall use example of North Cameroon and/or Central Kigezi in South Western Uganda.

In case of Garoua North Cameroon.

Agro-ecological factors – rainfall, temperature

Table 5.2: Garoua/Cameroon: minimum, maximum temperatures and rainfall data 1989

Temperature month	J	F	M	A	M	J	J	A	S	O	N	D	
Minimum temperature °C	17.7	20	24	25	23	22	22	21	21	22	20	18	-
Mi**x**imum temperature °C	37	38	40.2	39	33	31	32	30	31	35	37	36	-
Rainfall	-	-	-	27	120	160	175	210	210	60	-	-	-
Total annual rainfall													962mm
Defacto duration of growing season						X	X	X	X				-
Month/soil moisture surplus days					5	30	31	30	10				106 days

Table 5.3: Major traditional crops grown in North Cameroon 1989

Crop	Millet	Cotton	Croundnuts	White sorghum	Red Sorghum	Cowpea
(a) Percentage farm under crop	5	36.2%	14%	2%	25%	1%
(b) Percentage of farmers growing the crop		78.3%	73%	7%	85%	9%
(c) Number of days to crop maturity		125	160	180	180	130
(d) Design team entry points days to maturity of improved crop varieties	90	120	130	120	120	70

Table 5.4: Traditional seasonal calendar

-	April 15 - May 15	-	dry early planting of sorghum
-	May 15 - May 30	-	dry early planting of groundnuts
		-	dry early planting of cotton
		-	dry early planting of cowpea
	June 1 – June 15	-	wet late planting of sorghum
		-	wet late planting of groundnuts

5.3.3 Results of agro-ecological data analysis

According to our analysis of agro-ecological data of North Cameroon 1989, we have the following results.

(i) The monthly minimum temperatures throughout the year ranges between 17.7 °C in January to 25 °C in April. The monthly maximum temperatures throughout the year range between 36 °C in December during Hamathan to 40 °C in March at the heart of the six months (November to April) long dry season. See table 5.2.

(ii) The rainfall distribution, with on set in April and cut off in October with a peak in August (210mm) and a total annual rainfall of 962mm (see Table 5.2)

(iii) Analysis of evapotranspiration considering the differences between precipitation (rainfall and evaporation due solar radiation/temperatures shows number of days when there is moisture surplus per month are 5 days in May, 30 days in June, 31 days in July, 30 days in August and 10 days in September. Thus giving a total 106 days. See Figure 5.1

(iv) Results in Table 5.3 shows the major traditional crops grown in North Cameroon of particular interest is the number of days to maturity for cotton being 125 days, groundnuts 160 days, white and red sorghum 180 days and traditional cowpeas 130 days from planting to maturity. Comparing number of days to maturity of the crops and the number of days in a year when there is soil moisture surplus at Garoua one can say that those traditional crops can no longer fit within the location growing rainy season.

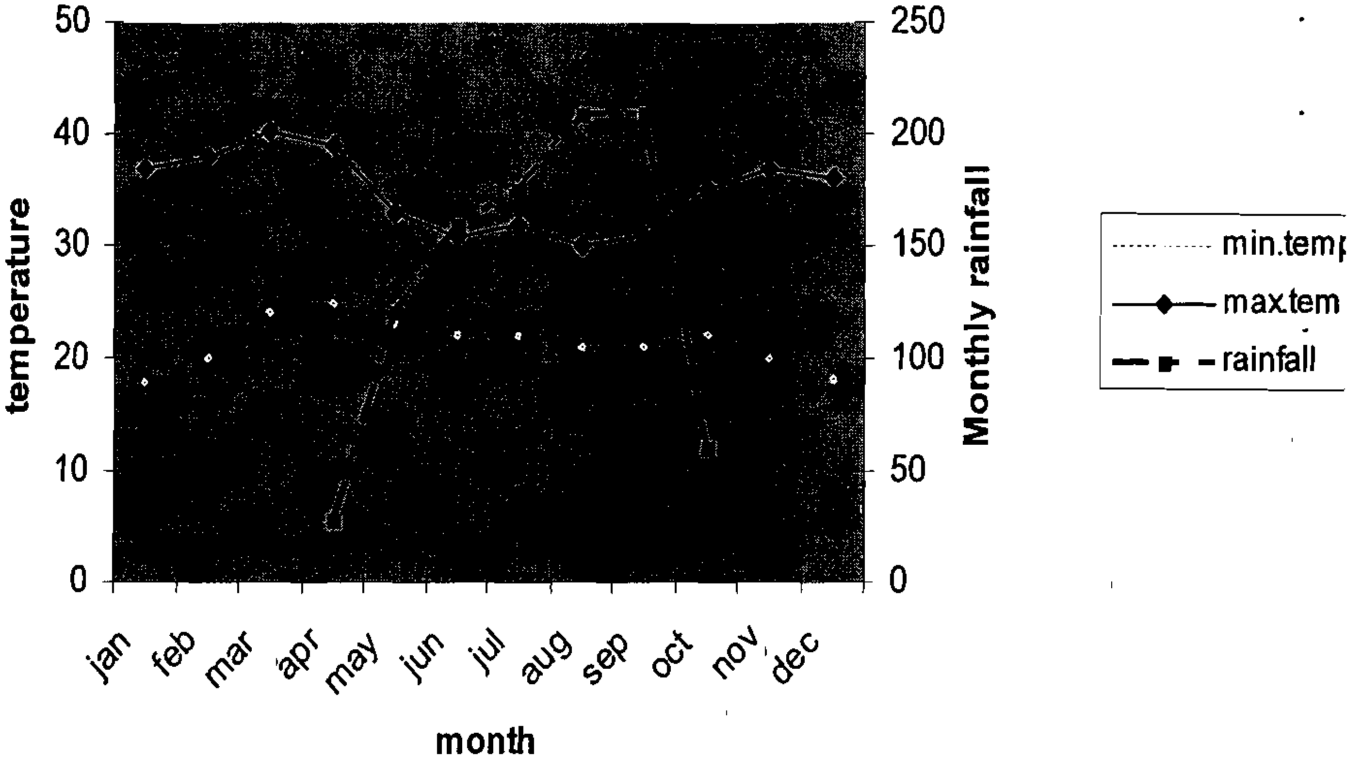


Fig 5.1 Comparision for seasonal Rainfall and Temperature at Garoua (mean of 34 years (1950 -1984)

5.3.4 Analysis of traditional seasonal calendar of farmers in North Cameroon

The analysis of seasonal calendar of farmers in North Cameroon in 1989 showed that traditionally most of the farmers had to dry plant in May at the on set of the rains but actually before the crop growing season which have identified in Figure 5.1. Then a few farmers were doing their late wet planting of sorghum and groundnuts in June at the on set of the growing season. That seasonal calendar in Table 5.4 was found to have major constraints.

(i) Farmers in attempting to catch up to fit in all their plantings of longer duration crops by dry planting which in many cases led to poor germination and poor crop standards in the field partly because of soil insects, or because of dieback of early germinated seedlings scotched by prolonged dry spells that punctuated the intermittent/isolated showers of rains in late May.

(ii) For farmers whose dry planted crops failed to take off, they would have no more seeds to replant or even to supplement their food supplies they had lost all their available seeds ended up much worse off.

(iii) For farmers whose fields germinated fairly, they faced with the constraint of timely weeding for all crop fields having been planted before the rains were very weedy by mid June demanding a lot of labour making the farmers unable to cope with the weeding.

5.3.5 Analysis of crop-livestock biological and economic data of a given farming systems

The analysis of a farming systems data is normally done at different stages/or levels. The stages of field technical data analysis may include:

Stage 1. Single variables data analysis

We have discussed in section 5 – type of data variable to be collected such as crop yield, price of sales, size of land planted to a crop, number animals (cows) owned by a farmer. Single variables data can be analysed estimating descriptive statistics. Arithmetic mean mode, variance, standard error, critical values of mean yields are for example given in Table 5.3.

Stage 2. Analysis of crop or livestock enterprise

In this case all the variables related to a given crop, livestock or non-farm enterprise are analysed as a set. Either each individual variable separately or jointly. Examples of joint analyses are: single variable linear regression $Q = a + Xb + E$ where the variables being analysed are Q = quantity of maize being harvested, X quantity of chemical fertilizers being applied per unit land. The estimated b gives us a technical coefficient of maize output to fertilizer input ratio sign of the technical coefficient b is a prior expected to be positive. Then the greatest magnitude of b is expected to be +1.

Stage 3. Analysis of crop or livestock enterprise using multiple linear regression analysis

In multiple regression analysis many variables are fitted in one equation or in many simultaneous equations and jointly analysed together. E.g. Q quantity of maize harvested is a function of x_1 fertilizers applied, x_2 land planted, x_3 labour used, the type of maize x_4 variety planted.

The specification of multiple line regression equation becomes
$Q = a + b_1x_1 + b_2 x_2 + b_3x_3 + b_4 x_4 + E$
The estimated coefficients of $b_1, b_2, \ldots b_4$ will suggest which variable in that equation is giving an expected high, which one with negative sign which the design team can consider as a leverage factor and entry point respectively.

The analysis of economic and many of the farming systems variables/factors are done in a similar manner.

Table 5.5: Critical values of measurements of selected parameters in a given African farming systems

Variable/factor being measured/estimated	Selected parameters	Methods of measurement	Critical/recommended lowest value
Crops 1. Cereals – maize, rice, wheat	- yield/hectare - resistance to/pests common diseases - growth days to/maturity, variety	Weight of clean grains - green leaves days after planting latest technology	Min. 6 tons/hectare Least spots Max. 140 days Desirable characteristics
2. Legumes – beans, cowpeas, soyabeans	- yield/hectare - resistance to/pests common diseases - growth days to/maturity, variety	Weight of clean grains - green leaves days after planting latest technology	Min. 2tons/ha Max. 130 days Desirable characteristics
3. Root crops – sweet potatoes, irish potatoes cassava, yams	- yield/hectare - resistance pests/ diseases - growth - days maturity, variety - do -	Weight of tubers - green leaves days after planting latest technology - do -	Min. 30 tons/hectare Least spots 120 –160 days Desirable characteristics 40 tons/hectare Least spots 360-720 days
4. Fruits – banana, East African highland cooking, East African juice cavandish	- yield/hectare - resistant to pests/ diseases - growth - days to maturity - height of plant	Weight of bunches - green leaves days after planting	20-60t/ha least spots 450-600 days 130-180cm
Livestock 5. Cows Zebu exotic male, female	- live weight - resistance to diseases - growth rate milk yield birth rate breed	Weight of live animal - health weight gained liters/animal/day latest technology	90-800kg/animal healthy highest 5-25 liters
6. Goats - Agigola exotic	- do -		

Table 5.6: Critical values of measurements of selected soil parameters in a given African farming systems

Variable/Factor being measured/estimated	Selected soil Parameters	Critical values
Black top soils		
Acidity	PH	min. 5.5
fertility		
organic matter composition	OM%	min. 3.6
soil nutrigen	N%	min. 0.29
Available soil phosphorous	PPPM parts per Million	min. 10.00

6.0 THE PROCESS OF AFRICAN GREEN REVOLUTION DESIGN

6.1 Posing recapitulation, and/or searching questions for factors, variables, interactions/GR design blocks

At this point let us quickly recapitulate the highlights of the previous discussions. In order to ensure that the design team has a good understanding of target farming systems to be re-designed, jot down the responses to the questions below.

(a) How was the community participatory problem analyses
- What are the 4 major constraints?
- What are the communities/farmers top priorities?
- What are the farmers social, economic, biological, physical and/or environmental circumstances that may has significant influence on the target farming systems?

(b) From the field technical data analyses

- What are the most important/highly significant crop, livestock and/or non-farm enterprises? And why?
- For each of the most important enterprises what are the factors or variables whose relationships has negative signs suggesting they have adverse effects?
- What are the highly significant factors/variables in each enterprise?
- What are the 4 top most significant factors/variables in the target farming systems?

(c) Are there any dynamic interactions
  (i) between major components crop/livestock?
  (ii) between any two or more enterprises?
  (iii) between factors or variables within an enterprise?

(d) Is the farming community already tuned up to demand, receive and/or participate in the process of re-designing and implementing the GR pilot on-farm trials/tests?

(e) What are the possible potential technological, social, economic and/or institutional interventions that can be used to address constraints detected in the target farming systems?

The responses to these and other questions make the pool of GR pilot designing blocks. After going through the processes of understanding the target farming systems, we can now look at fitting the GR blocks together in the following sections.

6.2 Matching prioritized constraints and technical measurements to actual field situations

In chapter four, we discussed various methods of community participatory analyses and prioritizing say to top 4 farming systems constraints. Then in chapter five, we discussed various approaches/methods of collecting and analysis field technical data. Then identifying say three factors for each of the most important farm enterprises.

Table 6.1: Community participatory problem analysis in Central Kigezi South Western Uganda

Priority problem	Root causes	Effects/consequences
1. Lack of capital for improved farming as a business	- lack of reliable source of income - low crop yields - inability to make savings	- inadequate farm produce - shortage of food/hunger - inability to engage in effective farming
2. Lack of effective market for farm produce	- lack of market information - many growing same crop/lack of local demand - Poor feeder roads network - inadequate regional and external export market research	- discourages people who tend to give up farming - inability to maintain improved farming methods - discourages development causing stagnation, backwardness - degenerates into low quality of farm produce
3. Exhausted soils/degraded land	- soil erosion - continuous cultivation of same crop in same field -destruction of terraces on hill slopes - non use of organic and inorganic fertilizers	- non-productive → low yield → low farm produce → shortage of food → poor nutrition → hunger – outbreak of diseases - idleness in rural areas

Source: Ngambeki et al 2001, Report on how to improve household income through modernization of agriculture in Kigezi. Ministry of Finance, Uganda.

Results of prioritized problems/constraints from participatory analysis of the farming systems in Central Kigezi are presented in Table 6.1. Then the results of the field technical data analysis are presented in Table 6.2.

First we can compare those results, secondly after comparing the two sets of results, we match the two sets of results with what is on the ground in the field under the target farming systems in this case of Central Kigezi.

Table 6.2: Multiple regression analysis of factors affecting farm productivity in Central Kigezi farming systems

Dependent variable: Annual farm cash income

Independent variables/factor	B coefficients	T statistics
Education level (yrs)	47.70	6.293***
Cows	8.187	1.634**
Terracing	106.805	1.442**
Age of farmer (yrs)	2.517	1.132*
Farm size (acres)	1.981	0.964
Climatic change	-186.088	-2.470**
Soil erosion	-111.853	-1.097*
Constant	-26.056	-1.64*

Key: *** Significant at 1 percent
** Significant at 5 percent
* Significant at 10 percent

Source: Ngambeki, D.S. et al. Sustainable Farming in a fragile mountain Ecosystem: The case of Central Kigezi

The results of the multiple regression analysis in Table 6.2 suggest that Education level (which represents skills, creativity, initiative, capacity for farm management and confidence) and terracing (which may also represent proper land management/soil conservation) are the major (most significant) factors that may contribute positively to the improvement of the farming systems in Central Kigezi. The positive and level of significance of the variable cow (which represents livestock) in the regression analysis suggest the importance of mix (crop-livestock) farming. The negative signs and levels of significance of variables (factors) climatic change and soil erosion, suggest that those factors negatively affect the farming system of Central Kigezi by reducing its productivity.

Let us now match with the variables (factors) in Table 6.3 with what is on the ground in the field of Central Kigezi. Below is a brief of what can be seen on the field.

In Kigezi, South western Uganda, mountain ranges rise 1,500 to 2,500 metres above sea level. Normally such mountains would be expected to play an important role in modulating climate and supply of water. Indeed in 1940s and 1950s, Kigezi was well known for its successful/beautiful scenery of mountain agriculture based on hillside terracing. The temperatures were low between 10°C and 22°C and Kigezi was then known as the Switz land of Africa. By then most of Kigezi was characterized by mountain ranges with steep fluted hillsides and u-shaped valleys, some of which were wet with papyrus swamps and others dry. Traditionally people used to live on the base of the slopes, cultivate the hillsides and used the hill tops and valleys for grazing. By 1940s in Kigezi, the soils along the hill slopes, hollows and along the foot slopes were deep, with good soil structure and a PH of 6.7. By 1990s, this had changed completely. The terraces were abandoned. The soils on the mountain slopes are now in a very poor state. The soil PH ranges from 3 to 5.5 and greatly deficient in major soil nutrients and below critical values of organic matter OM% 5.5, soil nitrogen N% 0.3, and available phosphorus Av.pppm 9.0 (Ngambeki et al 2001). Most mountain ranges are bare, creating serious shortages of fuel wood and poles. Excessive soil erosion, sheet soil erosion and landslides are common. Consequently, drainage of the wetlands has been threatened and has been converted for agricultural activities.

So there are sufficient indications suggesting that the selected variables (factors) in Table 6.3 do match with what obtains in the field within the farming systems of Central Kigezi.
We can observe the leverage factors to be education, cows/livestock and terracing.

Table 6.3: A comparison of factors/variables that have significant influence and/or interactions within the farming systems of Central Kigezi

Community participatory priorities	Field Technical data analysis	Level of significance	Sign of b.
1. Lack of capital for improved farming as a business	1, education	very highly	+ve
2. Lack of effective market for farm produce	3, cows (livestock)	highly	+ve
3. Exhausted soils/degraded land	2, climate change 4, terracing 5, soil erosion	highly highly high	-ve +ve -ve

But after attempting the first design we need several follow ups so as to obtain an improved design which completely transforms into an improved systems.

6.3 Use of planning/designing diagrams, matrices and linear programming applications to design GR model

In re-designing the target farming systems we first aim at the following reality perspectives:

(i) reducing and/or removing the effects of the major constraints
(ii) removing the inefficiencies within the sectors, enterprises and/or activities
(iii) introducing in new and improved technologies
(iv) strengthening the linkages between activities, between enterprises and between sectors in the context of the national economy.
(v) enhancing the achievements of national policies, goals, and objectives.

As indicated in chapter 3 of this manual, an African farming system has many components and is complex. When we take agricultural sector as part of the national economy on the production (supply) side, the main production variables or scarce resources of soil/land, water, labour and capital are shared on competitive basis by many enterprises (products) on the same farm. In addition, there are many farmers in the same district, and many districts in the same region and many regions in the same national economy all competing for the same production resources. On the market demand side – where product substitution is always possible.

So, as we re-design we are introducing new levels of resources utilization and resulting in higher levels of produced/supplied products and requiring high levels of market demand to purchase/absorb the increased surplus. On the production (supply) side we have two levels of decision problems. That is at the national policy (macro) level, in terms of alternative allocation of public resources towards specific ends of the policy.

Here the policy maker tries to decide how best for example to allocate funds in the face of more than one objective. But there is also the uncertainty about how farmers, communities, pastoralists and others will respond to the contemplated policy change. We therefore need to inbuild the questions/alternatives of how farmers will respond to/adopt introduced improved technologies (/new products) and how they fair to manage the new improved farming systems.

Secondly in order to set an operational agricultural model to designate regions and representative farms, in terms of their resource endowments like land, irrigation facilities, family labour, livestock, annual and perennial crops, tools, working capital and access to any other resources.

Thirdly, we need to define the production technologies available by category/farm size/type/type of community.

Fourth, we define the existing enterprises.

Fifth, we define the various activities at the representative farm.

Common activities of an agricultural sector model are:
<u>Crops subsector</u>: activities are: producing crops (maize, rice, beans ...), marketing or selling, purchasing for home consumption, buying inputs, importing inputs and/or technologies, exporting produced products.
<u>Livestock subsector</u>. Activities are rearing (cow, goat, sheep, poultry etc...) buying, grazing, selling.

Let us now actually re-design the target farming systems at regional level (i.e. consider one region only, rather than considering many regions at national level). We begin by specifying a linear programming model of a representative traditional farm whose characteristics are described in chapters 3, 4 and 5. We shall call this model the base model. If we want crops subsector and animal subsector separately we shall crops base model, animals base model. If we want crop-animals mixed we shall have mix (crop-animal) base model. Secondly, the new technological levels and introduced alternative enterprises and/or opportunities are sequentially added to the respective base model. We can also take separate representative farms for the different farm sizes/scales of production.

Base models algebraic form.
Let the crop activities be defined as x_i, $i = 1, \ldots n$
Let the livestock activities be y_j, $j = 1, \ldots . n$

Then in the base model, the purpose is to find a traditional farm defined by a set of activities x_i, $i = 1, \ldots n$ which has the largest possible gross margins (equation 1), without violating any of the fixed resource restrictions (equation 2) nor involving any negative activity levels (equation 3). See Fig. 6.1 for schematic present

$$\text{Max } 2 = \sum_{i=1}^{n} c_i x_i \qquad (1)$$

Subject to

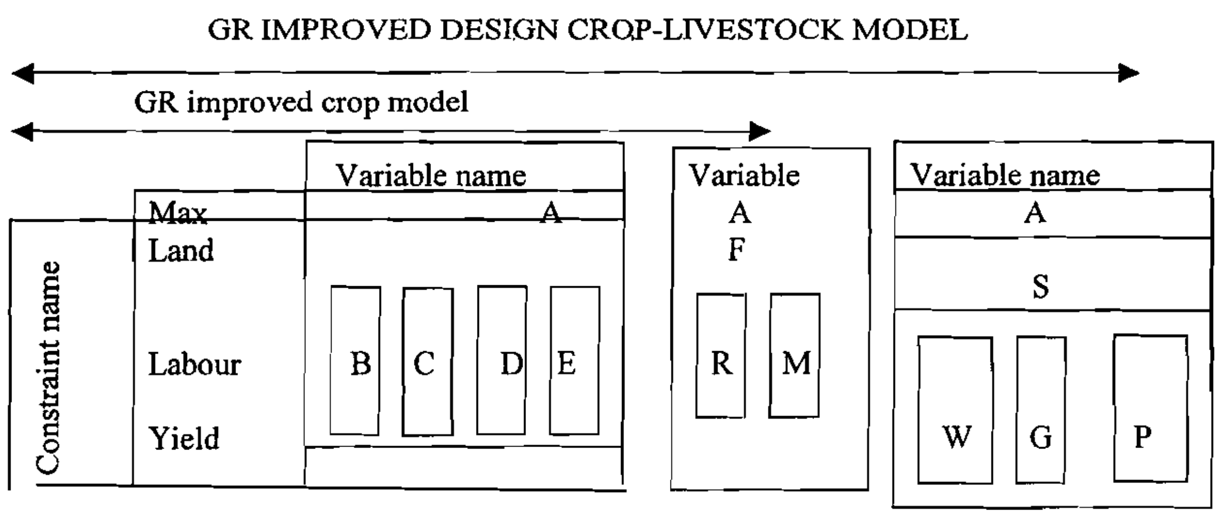
$$\sum_{i=1}^{n} A x_i \leq b_j, \text{ all } j = 1 \text{ to } m \text{ and } i = 1 \text{ to } n \qquad (2)$$

$$x_i \geq 0 \text{ all } i = 1 \text{ to } n \qquad (3)$$
$$b_j \geq 0 \text{ all } j = 1 \text{ to } m$$

For obtaining the GR improved farming systems design, we use the matrix formulation. Thus
GR design $= F^1 [B] + S^1 [S]$ .... (4)
Where B = matrix of crop production parameters
F^1 = matrix of parameters of improved crop technologies
S = matrix of livestock production parameters
S^1 = matrix of improved livestock technologies

The computation of both the base model parameters and the transformation matrix parameters F^1 or S^1 we apply regular mathematical computation procedures, linear regression, linear programming and/or the application of matrices as appropriate.

Figure 6.1. Schematic of Base and GR improved crop models



Key: A = objective function D = minimum grain/food subsistence
B = crop production activities E = resource endowments
C = labour hiring activities F = introduced improved crop technologies
R = improved technologies of rice S = Livestock technologies
M = improved technologies of maize W = Cows P = pigs
BN = beans improved technologies G = Goats

NB. Buying and selling activities may also be added

The purpose of the GR improved model is to find an improved farming system which has a set of activities combining the base and improved technologies to get a gross margin 40% higher than the best gross margin if one, two or three of the most limiting constraints are somehow relaxed in the base model.

Similar, a GR improved model can be found which combines, crop base model, livestock base model, crop improved and livestock improved to give say 60% increases over the maximum/best gross margin when the most limiting two or three constraints are relaxed in the base models.

6.4 Designs of systems components

After specification of base and GR improved models, then their respective activities are incorporated. Then computations can be done to obtain optimal linearly programmed designs. The design team can now draw up the best design and compare their resource requirements, expected outs, with the base model along with the available opportunities and allowable resources.
The activities of promising designs can be further combined with those of additional levels of technology checking consistence and sustainability until robust GR components GR designs are obtained.

Figure 6.2 shows livestock-crop integration model as a pilot Green Revolution design of North Cameroon 1986-90 with taking a livestock-crop base model and introducing in 9 new components to obtain GR pilot crop-livestock design which has been tested with farmers participation.

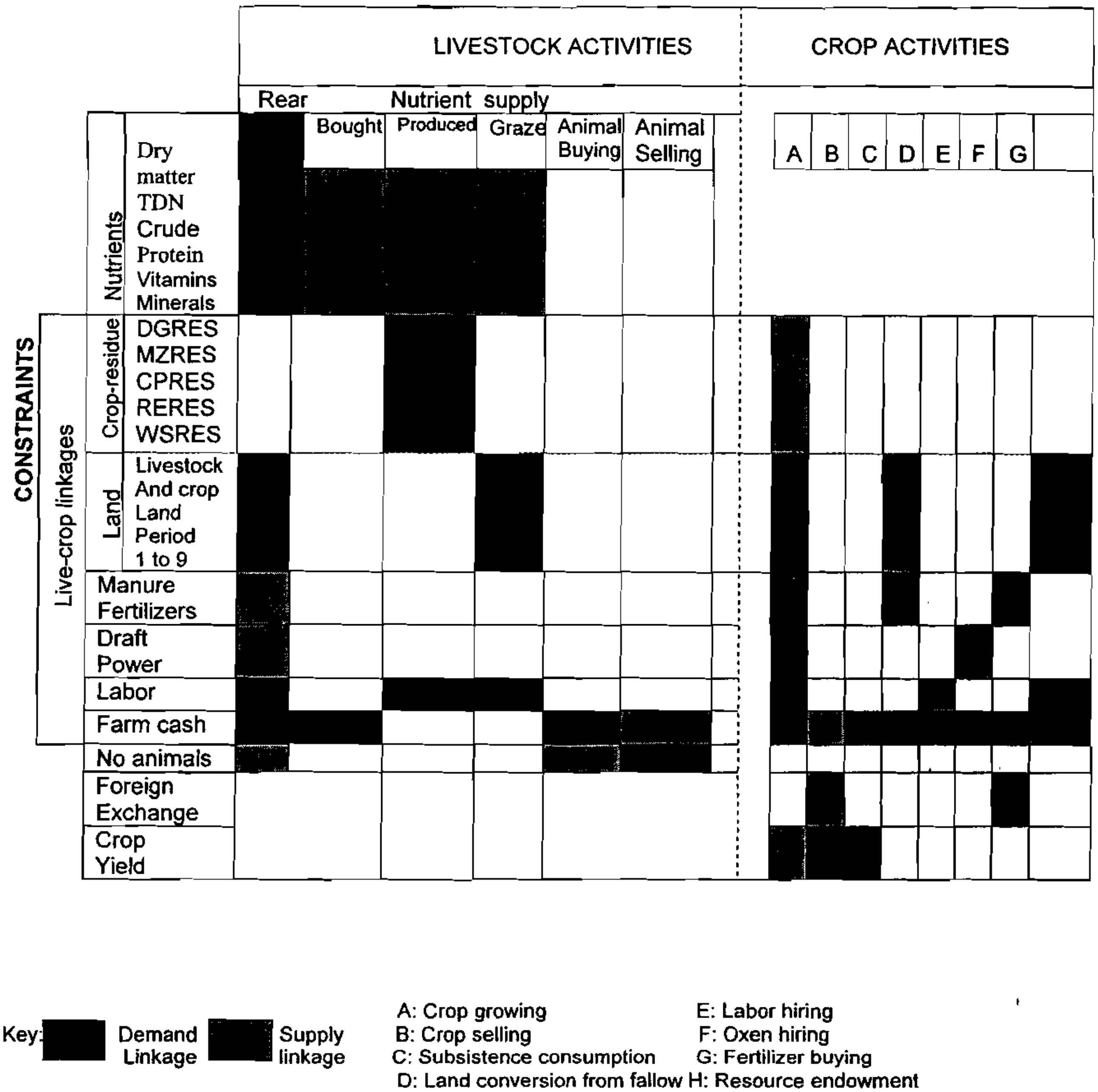


Fig.6.2. Livestock-crop integration model .A green revolution design of North Cameroon.1986-1990 DGRES: dry groundnut residues; MZRES: maize Stover; CPRES: cowpea residues; RERES: red sorghum Stover.

<u>GR designed components.</u>

1. Maize and cowpeas, introduced crops improved varieties.
2. Red sorghum, groundnuts, millet, muskwari cotton are retained traditional crops.
3. Improved varieties of white sorghum, groundnuts, cotton.
4. Integrated crop-livestock.
5. Introduced linkages and complementariness.
6. Re-designed seasonal calendar of farming activities to ease labor demand bottlenecks.
7. Traditional white sorghum and traditional cowpeas dropped.
8. Introduced dry planting of maize and sorghum.
9. Introduced concepts of stagger plantings.

6.5 Conducting on-farm/field trials at a pilot GR benchmark site

6.5.1 Rationale

Purpose of on-farm trials?
(a) to test the performance of a given intervention.
(b) to alleviate major constraints in the agricultural development process.
(c) to initiate/introduce Green Revolution prime design blocks of technology and appropriate commodities and complementary technologies.

On-farm trials are experiments conducted on farmers' fields so that new technologies can be adapted to the specific physical and socio-economic environment and resource constraints of small scale farmers in a given locality. The need for conducting on-farm trials arises out of the fact that the yields obtained at experiment stations are almost always higher than yields observed on the farmers' fields. The yield gap is mainly due to:

(a) non-adaptability of certain crop varieties
(b) crop diseases and pests
(c) differences between crop management used at research stations vis-à-vis that of farmers' traditional cultural practices.
(d) crop competition for farm resources
(e) non-transferable technological, ecological and environmental differences, between research station and farmers' fields.
(f) farmers' inability or unwillingness to provide ideal inputs/environment to the new varieties because farmers place high priority to increased income (profitability) rather than increased yield parse. That is the marginal returns from using a new technology must be large enough to cover all costs incurred in materials, equipment and other inputs needed for the adoption of new technology in the shortest time possible i.e. increases be 40% and above.
(g) it must be seen to alleviate a major constraint in the agricultural development process.

6.5.2 Types of trials

There are two major types of trials; multi-locational trials and technology adaptation trials (fine tuning, technology verification, or demonstration trials).

6.5.3 Multi-locational trials

Multi-locational trials are usually scattered over different regions. The designer may conduct the trials in order to test the newly developed technologies under different agro-ecological conditions. Multi-locational trials may or may not be conducted in collaboration with farmers. The important test factors in multi-locational trials are elevation and topography, including high plateaus, mountains, hills, and low plains. Also considered are agro-ecological zones covering climate or weather conditions, cumulative rainfall, distribution or rainfall pattern, temperature (hot, moderate, cool or cold), relative humidity, and the length/duration of the rainy season.

6.5.4 Technology adaptation and/or verification trials

Technology adaptation trials are conducted in order to reveal the most promising new technologies under farmers' field conditions. Testing the performance and adaptability of the new technologies to farmers' conditions is done to obtain feed back so that the designers can adjust these new technologies. These trials must be conducted on farmers fields in collaboration with farmers. They are called on-farm trials.

6.5.5 On-farm trials

Strictly speaking there are three types of on-farm trials. Each type of trial can have several modes according to its specific objectives, although treatments should not exceed six different factors. On-farm trials must be conducted in collaboration with farmers if the overall objective of conducting these trials is to be achieved.

GR designed but jointly farmer and extension agent implemented

- (a) adaptation/fine tuning tests
- (b) farmer extension/researcher interaction on management
- (c) superimposed trials

Farmer and extension designed and farmer managed

- (a) verification tests
- (b) investigation or confirmatory tests
- (c) demonstration or adoption promotion tests of GR designs

6.5.6 Setting up on-farm trials

The first step in developing on-farm trial programmes is to review general information about the site where these programmes are to be established. Information on agro-ecological zones, soils and climate data, types of production systems and farm size, major production constraints, existing transportation, credit services, and inputs available will aid in the design of these trials. Background information is especially important for site and farmer selection.

Hypotheses formulation is also important for program development. Hypotheses must be based on the knowledge of the existing farming system, be statistically testable, and once verified, be able to improve the efficiency of the system by a large percentage increase.

6.5.7 Selection of sites and cooperating farmers

On-farm trials are normally designed to generate recommendations that can be extended to a larger number of farmers under same or similar conditions. Therefore, the sites for the trials should be representative of the biophysical and socio-economic conditions associated with that farming system. It is important before sites are selected, that a quick tour around the district, county, or sub-county should be made.

Criteria for selecting sites

1. The land type should be representative of the dominant farming system and/or cropping patterns.
2. The necessary infrastructure should be available, including accessibility to transportation facilities.
3. The area should be priority impact area for development, so that positive findings will be supported and implemented by both farming communities and the government support.
4. The area should be large enough for the full experiments and/or the necessary replications, which are usually distributed over many farms.
5. Specific objectives of the type of on-farm trials may also influence site selection.

Selection of cooperating farmers

Target group of farmers

The farming population may be divided into target groups. Farm families in a group to be influenced will have similar farming activities, equipment, social customs, access to support services, marketing opportunities, technology, resource endowments and off-farm occupations.

Thus target groups can be based on:

1. predominant production system, crops or cropping patterns.
2. similarities in crops and livestock.
3. farm size and income levels (small, medium, or large scale farmers).
4. national priorities/goals and other political considerations e.g. food security or export diversification, agricultural development or GR design model.

6.5.8 Methods of selecting farmers

There are many methods of selecting farmers for on-farm trial activities. These include simple random sampling, cluster sampling, stratified sampling, multi-stage random sampling and purposive sampling. The important point is for the design team and/or the agents to use a method that suits the objectives of a particular trial in selecting the representative farmers. One practical way of selecting farmers is to hold a village meeting, then compile a list of the target group of farmers from which one can select randomly or otherwise the names of participating farmers.

Farmer selection can also be influenced by other criteria such as (i) accessibility to market (ii) accessibility to input delivery and other support systems (iii) willingness and ability to cooperate (iv) land type (v) assistance from village heads/chiefs and extension agents who are usually more knowledgeable about the local farming community or selected GR design criteria.

6.5.9 Management, supervision, and monitoring of trials

For meaningful evaluation, design team and extension agents should make frequent supervision and monitoring visits to the sites and interact with farmers on various aspects of the trials. Management of farmer managed trials should be left in the hands of the farmers. Farmers should be fully aware of their responsibilities for conducting the trials. Design team and extension agents should discuss the trial management plans with farmers long before the planting season begins. Farmers should not be encouraged to plant the trial plots at different times than their own fields. Farmers should understand the trial objectives in order to appreciate the importance of applying their normal management decisions to the trials. That way the tested/verification trial can become part and parcel of the resultant GR designed improved farming systems.

6.6 Assessments and adjustments of systems designs

When or after testing the GR improved systems in on-farm field trials, field data is collected, processed, analysed and again subjected to linear programming models.

Similar formulations, analyses and computations that were done 5.3, 6.3 and 6.4. This is to enable the GR design team to come up with the appropriate adjustments.

6.7 Impact assessment of technological intervention

6.7.1 Methods and sources of data used to assess impact: data sources

- baseline survey
- single cross-section data at end of pilot testing
- views of local experts plus government

<u>How</u> (a) with and without (b) before and after

6.7.2 Social assessment:

Who are the beneficiaries and what is the impact of GR activities on their system/lives?

<u>Target group responses</u>

(i) Full adopters with good application of new techniques who are satisfied with the results as they perceived them.
(ii) Adopters of selected parts of the recommendation packages that require little change to existing practices.
(iii) Those who claim to have been adopters but have actually not changed anything.
(iv) Those who have rejected the techniques because of their dissatisfaction with results.
(iv) Those who have not adopted though given the opportunity.
(v) Those who had no access to the GR team services and recommendations.
(vi) Those who have adopted from their neighbours.

6.7.3 What variables to measure for impact/technical assessment

1. The rate of change of output
2. Increased output
3. Economic returns
4. Impact changes

6.7.4 Economic assessment of impact

Economic returns
- Crude indicators
(i) physical period of mutual investment
(ii) % rate of return of interest on investment
- Economic indicators
(iii) net present value
(iv) benefit-cost ratio
(v) internal rate of return on investment
- Impact indicators
(vi) level of income
(vii) standard of living

7.0 SCALING UP AFRICAN GREEN REVOLUTION DESIGNS WITHIN A COUNTRY, A REGION AND/OR OTHER REGIONS OF AFRICA

7.1 Formation and coordination of GR teams focusing on common national priority development programs

The Green Revolution design team(s) at pilot site(s) within a given country require complementary inputs from their counterparts in (i) technology generation, dissemination and extension teams (ii) institutional/policy formulation and analysis teams (iii) provision of infrastructural/social/economic support services technical teams and key stakeholders representing the business/investment interests in commodity marketing from the private sector, to scale up their GR activities. The formation and coordination of those key GR teams is necessary to consolidate the tested GR designs in on-farm trials at pilot sites and scale them out to other parts of that country. It is recommended that all the experts/teams in agricultural research, extension, rural development and those in related sectors (public and private sector) be coordinated and focused to the common goal of promotion of science and technology priority programmes for modernization of agriculture and rural transformation.

7.2 Scaling up through formation of regional partnerships and focused associations

In order for the African Green Revolution to happen, it is recommended that countries that share the same agro-ecological zones to formulate and coordinate the science and technology policies and/or programs. Moreover some of the countries may not have sufficient resources to invest and create the critical mass necessary to trigger Green Revolution Initiative. In such cases, a group of neighbouring countries could form partnerships and GR networks and/or strengthening the existing regional associations for Agricultural Research and Development.

There exists already regional collaborative associations for Agricultural research in various regions of Africa. But those Regional African Associations are formed on basis of good intentions and principles of exchange research results. However they hardly share a common master plan that could be jointly implemented. For example within ASARECA (Association for Strengthening Agricultural Research in Eastern and Central Africa) different countries set their national research priorities using varying agendas without references to the goals or programs that unite them in the regional association. Table 7.1 represents National Agricultural Research priorities of some countries of (ASARECA) Eastern and Central Africa.

Currently the ASARECA priority crop research programs are maize, sorghum, cassava, rice, wheat, bananas, irish potatoes, groundnuts, beans, coffee and cotton. Then the priority livestock research programmes are dairy cattle, beef cattle, sheep and goats. Other priority programs of ASARECA are soils, water, forestry and socio-economics. Comparing the national priorities in 7.1 and the above list of ASARECA priority programmes. For example the priority crops research cover a very wide area making it difficult for member countries to harmonize their national and regional priorities. Table 7.2 shows the number of agricultural research scientists in some countries of Eastern and Central Africa. Table 7.2 suggests that some African countries have very few Ph.D. researchers to create a critical mass for causing a Green Revolution. Indeed one of the aims of having a regional collaborative association is to reduce the costly and time consuming duplications of research efforts across the region. At this point, it is advisable that priority GR design programmes/activities be tailored to the facts on the ground including the specific challenges characterized by existing farming systems within their respective agro-ecological zones.

It is therefore recommended that the GR national priorities be linked to regional programmes and versa vica so as to create a critical mass by sharing and benefiting from the scarce services/facilities within a given African region. Other regional research associations in Africa are CORAF, INSAH and SACCAR.

Table 7.1: National Agricultural Research priorities of some selected countries of Eastern and Central Africa

Item	Country						
Country	Kenya	Uganda	Tanzania	Ethiopia	Rwanda	Malawi	Zambia
Year of plan	1994	1990	1990	1995	1993	1990	1995
Priority goals	Increased food, exports, employment, income technology	Increased food, income exports, raw materials	- zonal/national goals - improved efficiency and effectiveness	Increased food, income foreign exchange, exports, technology	Food security, exports	Food, Cost effectiveness	Increased food, income, employment
6 Priority crops	Maize, wheat, sorghum, millet, pulses, horticultural	Bananas, millet, cassava, sweet potatoes, beans, coffee, cotton	Coffee, cotton, tea, rice	Teff, maize, wheat, sorghum, barley, enset, coffee	Beans, soyabeans, sorghum, maize, wheat, rice	Maize, roots + tubers, wheat, groundnuts, rice, cotton	Sorghum, millet, cassava, sweet potatoes, legumes, oil seeds
Livestock	Dairy cattle, goats, sheep, animal nutrition, vet services	Cattle, animal nutrition, fisheries	Meat, and milk production, livestock diseases	Dairy, meat draught	Cattle, small ruminants	livestock	Livestock development and improvement
Systems	Farming systems, integrated crop-livestock, horticultural	Cropping systems	Farming systems, agroforestry	Monoculture	Agroforestry	Agroforestry	Farming systems
Natural resources	Soil/water management	Soil/water, forestry	Soil/water management	Soil/water	Reforestation protection of natural forest	Soils	Soil/water management

Source: Agricultural Research Plans in S. Africa. ISNAR 1997

Table 7.2: Number of agricultural research scientists in some countries of Eastern and Central Africa

Country	Year	PhD	BSc	Others technical	Total
Burundi	1989	2	46	38	86
Djibouti	1993	-	5	3	8
Eritrea	1994	-	8	9	17
Ethiopia	1993	82	293	1538	1913
Kenya	1993	107	182	386	675
Madagascar	1991	20	38	111	169
Sudan	1993	315	833	448	1596
Tanzania	1990	34	136	157	327
Uganda	1993	61	76	194	331
Zaire	1992	70	226	48	344

Source: World Bank technical report numbers of 290-1995

Table 7.3: African countries with efforts in plant biotechnology

Country	Area of research/biotechnology applications
Burkina Faso	- Biological nitrogen fixation, production of legume inoculants, fermented foods, medicinal plants
Burundi	- Tissue culture of medicinal plants, yams, potatoes, bananas and cassava, - supply of disease free in vitro plants
Cameroon	- Tissue culture of cocoa trees, rubber trees, coffee, cocoyams, - In vitro propagation of tea, cotton, bananas, pineapples and oil palm
Congo DRC	- Tissue culture of medicinal plants, In vitro propagation of rice, maize, potatoes, soyabeans, and trees
Congo Rep.	- In vitro culture of Spanish, - bioprospecting of nitrogen – fixing species
Cote d'Ivoire	- In vitro production of coconut palm and yams, - Virus – free micro-propagation of eggplant, - production of rhizobia-based biofertilizers
Egypt	- Genetic engineering of maize, potatoes and tomatoes
Ethiopia	- Tissue culture of teff, - micro-propagation of forest trees
Ghana	- Micro-propagation of yams, cocoa, plantain, cassava, banana and pineapple polymerase chain reaction facility for virus diagnostics
Gabon	- Production of virus-free banana and plantain and cassava
Kenya	- Production of disease-free plants, micro-propagation of citrus, pyrethrum, bananas, potatoes, strawberries, sugarcane, sweet potatoes; micro-propagation of ornamentals and forest trees. Transformation of beans, tobacco, tomato, sweet potatoes with proteinase inhibitor gene
Kenya	- Decay-reducing technology for long-term storage of potato and sweet potatoes
Kenya	- Market-assisted selection of maize for drought tolerance and insect resistance, - Well-established microbial resource centers providing microbial fertilizers in East Africa
Madagascar	- Tissue culture of disease-free rice, maize, and medicinal plants, production of - biofertilizers for groundnuts and bambara nuts
Malawi	- Micro propagation of tea, trees and bananas
Morocco	- micro-propagation of trees and date palms, - Development of disease-free and stress-tolerant plants, - Molecular biology of cereals and datepalms, - Molecular markers, field test of transgenic tomato
Nigeria	- Micro propagation of yams, ginger, cassava, and banana - Long-term conservation of yam, cassava, banana, and medicinal plants; embryo rescue for yam; - Transformation and regeneration of yam, cowpea, cassava and banana; genetic engineering of cowpea for virus and insect resistance; marker-assisted, selection of maize and cassava; DNA finger printing of yam, - Cassava, bananas, and pests and microbial pathogens; - Genome linkage maps for yams, cowpea, cassava and bananas; - Human resource development through group training, fellowships and networking
Rwanda	- Production of biofertilizers based on rhizobials and azolla; tissue culture of medicinal plants; - Micro-propagation of disease-free potato, banana and cassava
Senegal	- Microbial resource centers serving West Africa in microbial-plant interaction. In vitro propagation of ana tree, gum tree, sesbania, and Senegal gum in cooperation with several international agencies

Table 7.3: continued

Country	Area of research/Biotechnology applications
South Africa	- Genetic engineering of maize, wheat, barley, sorghum, millet, soyabean, hycins, sunflowers, potato, tomato, cassava, cucurbito, sweet potato, ornamental bulbs; fruits (peaches, apples, bananas, apricoto, strawberries, table grapes); - Molecular marker applications, - diagnostics for pathogen detection; - Cultivar identification (potatoes, sweet potatoes, ornamentals, cereals, cassava) - Marker-assisted selection in maize and tomato, - Markers for disease resistance in wheat, and forestry crops - Production of disease-free plants (potato, sweet potato, cassava, dry beans, bananas, ornamental bulbs - Micro-propagation of coffee, banana, potato, ovacado, blueberry, strawberry, rose roots stocks, apple root stocks, ornamental bulbs and endangered species, - In vitro gene bank collections (cassava, potatoes, sweet potatoes and ornamentals
Tunisia	- Abiotic stress tolerance and disease resistance, - Genetic engineering; - Tissue culture of citrus, date palms, prunns root stocks, DNA markers for disease resistance
Uganda	- Micro-propagation of coffee, banana, citrus, cassava, granadella, pineapple, sweet potato and potato; - In vitro screening for disease resistance in banana - Production of disease-free banana, potatoes, and sweet potatoes
Zimbabwe	- Genetic engineering of maize, sorghum, and tobacco - Micro-propagation of coffee, potato, cassava, tobacco, sweet potatoes and ornamental plants - Marker-assisted selection
Zambia	- Micro-propagation of trees, cassava, potato, banana - Hosting Nordic-funded gene bank for the Southern Africa Development Community

Source: Brink, Woolward and Dasilva 1998
- Also Harnessing technology for development ECA 2000

7.3 Means and ways of scaling up GR designs in a Country or Regions of Africa

One of the requirements of GR strategy is that each participating African country has to mobilize human, financial and material resources to invest in GR related activities to create a critical mass backed by long-term Government commitment to policy/priority of sustainable modernization of agriculture and rural transformation. Any neighbouring or regional grouping countries need to agree to the concepts of partnerships and networking when applied to stakeholders (public + private sector investors) internally within one country and externally between neighbouring countries, International Research centers and International Donor Agencies.

Secondary to share the existing resources/facilities and a network on the critical activities, there is a need to:

- characterize the existing farming systems and identify the major constraints, potentials and opportunities within the respective agro-ecological zones

- identify the capacities of existing international and national research centers that can serve as sources of advanced technology.
- Identify for example the existing capacities/facilities for research and training of biotechnology (see Table 7.3 African countries with efforts in plant biotechnology). NB. It should be noted that according to information in Table 7.3, not all the respective African countries have the same capacities of biotechnology facilities in order to complement each other. They need to form regional collaborative associations and undertaking network activities
- Identify commodities for which the zone or country or region has comparative advantage – that is which can be produced at the least minimum cost per unit and be exportable to generate the maximum returns.
- Organize and facilitate stakeholders for national or regional planning meetings to discuss priorities of GR, partnerships and to harmonize priority of science and technology policies/programs (national governments, political and technocrat representatives, private sector (Business/NGO), research, extension, international research centers, and donors).
- Set partnership modalities.
- Identify and agree on germplasm and biotechnology exchanges and making applications of biotechnology.
- Identify national/regional strategic research and on-farm testing centers.
- Establish germplasm banks that are characterized for their usefulness by national/regional research programs.
- Develop a plan of action for networking activities.
- Divide and agree on roles/responsibilities, and reciprocity of activities/products and services.
- Lobby for national governments and donor communities for human, material and financial support.
  - make networks for sharing activities, exchange of information, germplasm thus making efficient use of scarce resources available in the region.
  - appoint technical and business coordination teams to link very well all the stakeholders (public and private sectors). Besides technology, the public sector across the region must provide policy framework plus institutional and infrastructural support services. Then the private sector should be mobilized to provide necessary investments when opportunities arise during the GR design process. Then entrepreneurs input is needed to market the produced products at their earliest opportunity.

7.4 General Conclusions

The major objective of this Green Revolution design manual was to guide and help to enhance the capacity of African countries to design and implement their own pilot Green Revolution in their respective priority regions.

The specific objectives were:

(i) to identify the core building blocks and the methods for the design of the African Green Revolution.

(ii) to identify the prime movers (technology, institution, infrastructural and policy (TIIP) and the entry points, and leverage factors that must go into such design and how?

(iii) to propose a strategy for African countries to design and cause a Green Revolution to happen in Africa starting with their respective pilot areas.

In conclusion

1. This manual describes a typical African farming systems and gives tips on how a country's GR design team can go about interagling the interwoven parts /strings of their farming systems.
2. The manual gives the basic GR design principles.
3. The team has at its disposal a series of community participatory methods from problems identification, problems participatory analysis and consequently while tuning up and priming their farming communities to receive and demand GR improved farming systems designs.
4. This manual describes field technical assessments and how to estimate and obtain the most significant/important variables and effect to obtain the leverage factors from the analyses of field technical data.
5. Finally the manual gives tips on how practically to go about putting components of GR improved farming systems, test them in on-farm trials and making subsequent adjustments and appropriate impact assessment.

8.0 REFERENCES

1. ECA 2003, Report of the Workshop on Identification and Assessment of African Green Revolution Indicators and design, Kampala December 8-12 , 2003.

2. Carl Eicher 2003. Flashback, Fifty years of Donor Aid to African Agriculture. Paper presented at Inweat IFPRI, NEPAD, CTA Conference on Successes in African agriculture. Pretoria, S. Africa, 1-3 December, 2003.
3. Ngambeki, D.S. et al 2001. How to improve household income and eradicate poverty through modernization of agriculture in Kigezi region. Ministry of Finance, Government of Uganda.
4. Ngambeki, D.S. 2003. Principles for Designing own Green Revolution in Africa. African Green Revolution Initiative. Paper presented to ECA Workshop on Identification and assessment of GR indicators, December 2003.
5. Ngambeki, D.S. et al 1995. Shifts in Banana productions in Uganda. Makerere Publication.
6. Ngambeki, D.S. et al 1989. SAFGRAD/Cameroon: Farming Systems Report of North Cameroon.
7. Ngambeki, D.S.; R.R. Deuson and P.V. Preckel 1992. Integrating Livestock into farming systems in Northern Cameroon. Agricultural Systems 38: 319-338.
8. Ngambeki, D.S. et al. 1999. Sustainable Farming in a fragile mountain ecosystem. The case of Central Kigezi, Uganda.

In Eco-agriculture Initiatives in Eastern and Southern Africa. University of Guelph 1999 Edited by J.F. Devlin and Zettel.

Annex 1: A summary of a Report of pilot Green Revolution Design of a banana based farming systems at Luwero Benchmark site in Central Uganda 1996 – 2003.

1.0 Background

Uganda is the second largest producer of bananas at (12 million M.T) to India which produces 16 million M.T. In Uganda, banana is dual purpose crop (for food and income) providing for over 70% of the rural population. It occupies 36% of the agricultural land followed by cassava, millet and maize which occupy 20%, 12% and 5% respectively. During the 1930s and 1940s, traditionally, the most important banana producing areas were districts in the Central and Eastern Uganda which were producing 50% and 44% respectively as compared to western which was only producing 6%.

However by 1991, there was not team of researchers in Uganda conducting research on bananas. In 1993/4 a banana research team which had been put up together by the National Agricultural Research system, conducted a diagnostic survey in the banana producing districts of Central, Eastern and Western Uganda. Using the results of the diagnostic survey the banana producing districts of Uganda were divided into three zones.

(a) Zone one being the districts of Bushenyi/Mbarara/Ntungamo in South Western Uganda where banana production was still at its optimum – optimum production level produces 70% of the banana in Uganda.

(b) Zone two being the districts of Masaka, Rakai and Sembabule in South Uganda where banana production had yielded by 10% to 20% - the intermediate level of production which produces 20% of the banana in Uganda.

(c) Zone three being the districts of Central and Eastern Uganda where banana production had severely declined by 50-70% - producing less than 10% of bananas in Uganda.

In each banana production (level) zone, a typical representative benchmark site was selected for subsequent banana based farming systems on-farm research.

(i) Ntungamo Benchmark site represents optimum production level in zone (a).
(ii) Masaka (Kisekka) Benchmark site represents intermediate production level in zone (b).
(iii) Luwero (Bamunanika) Benchmark site represents severely declined production level in zone (c).

In 1996, a research team started its work on Luwero Benchmark site.

The initial community participatory problem identification and priority setting showed that the communities' constraints/problems were:

(1) Food shortages for majority of farmers in 25% of the days in a year.

(2) Frequent crop failure.
(3) Declining soil fertility.
(4) Frequent prolonged dry spells (drought)

Communities major priorities

- Food
- Income
- Reliable crop that withstand their climatic and field conditions

In 1997 the research team started on a baseline survey, in 1998 established 12 on-farm trials which led to the re-designing of the original farming systems and subsequent on-farm tests of integrated and improved designs whose summary is presented below.

2.1 Results of existing traditional farming systems from baseline surveys at Luwero Benchmark site

(a) Annual crops (land under crop)

Cassava	14%	Maize	5%
Sweet potatoes	12%	Beans	5%

(b) Perennial crops (land under crop)

Kayinja unmanaged fields	14%
Coffee (200 trees)	37%

(c) Livestock

Zero cows, one goat/sheep-poultry

2.2 Constraints/percent affected farmers

- declining soil fertility	52%	- subsistence farming	80%
- pests and diseases	44%	- frequent prolonged dry spells/drought	44%
- poor crop management	70%	- frequent food shortages (1meal/day)	85%
- scarce planting materials	18%	- rampant coffee wilt disease	85%

3.0 Determining leverage factors and entry points

3.1 Farmers' goals/priorities

- Food - Basic social needs
- Income - Risks, and management

3.2 Technical interventions

- A dual purpose crop as source of food and income
- Banana production and utilization technologies

4.0 Designed and improved agricultural production system tested in on-farm trials at Luwero Benchmark site

4.1 Promoted and adopted banana technologies

Biological components:

- introduced resistant and high yielding multipurpose exotic banana cultivars Kabana 1,2,3,4,5 Fhia 25 which provide (food, juice, dessert, waragi).
- selected elite East African highland cooking cultivars: Mpologoma, Kibuzi, Nakitembe, Kisansa

Complementary technologies:

- clean planting materials in clean fields to avoid nematode/weevils.
- soil and water management (mulch, manure, fertilizers, trenches)
- integrated pest management methods:
    - sanitation to reduce pests; nematodes and weevils
    - enhanced plant nutrition to reduce sigtoka disease
    - Bio rationals – ash, urine, pepper to reduce pests and add nutrients

4.2 Redesign improved farming system

- revived improved banana production
- adjustment of annual crops cassava, maize, sweet potatoes, beans reduced by 50% of land under crop.
- revived livestock-integrated crop—livestock: cows, goats, poultry
- improved crop livestock management forwards and backwards linkages (cows manure, banana peels-animal feed)
- engaged in farming as a business using farmers own resources

4.3 Strengthened institutions linkages

- increased trade and market outlets
- increased communication with neighbouring communities
- improved transport services – bicycles, motor bikes, taxis and graded feeder roads by soliciting support from District Local Government
- improved social relationship – family and neighbours – increased family/social friendship
- increased access to education/health facilities – private schools and health units

4.4 Promotion of participatory development communication

- farmer to farmer extension – given out suckers of improved cultivars
- trained farmer trainers – 16 farmer trainers

- improved organization of farmer groups – 42 new farmer groups formed
- pooling and joint use of savings and farm tools
- farmer joint marketing efforts/venture and increased bargaining power
- increased frequency of exchange visits both with neighbours and distant district communities

4.5 Social economic benefits and rural transformation

- improved livelihood of farm families
- obtain food security; family meals increased from one to three meals per day
- improved farm cash income to 300,000 Ush per family/year
- socio-economic status of individual farm households and farming communities transformed from small to medium
- improved housing – transformed from mud to brick/iron sheet roofed houses, plastered walls and floors
- increased household properties/utensils – plates, radios, TV, clothes, school fees, medicine
- increased access to clean water
- 40% women actively involved in management has transformed the social way of life.

4.6 Dissemination of banana technologies in Bamunanika/Luwero

Year	1998	2000	2002	2003	2004
Planted trials	12	200	-	-	-
Adopters	-	-	500	10,000	20% of Bamunanika population – 7 subcounties
Sucker distribution	-	-	19,313	25,551	40,000

The impact assessment of designs tested at the Benchmark site suggest that by 2004 the number of adopters had increased to 20% of the population in Bamunanika subcounty and to 35% of the subcounties in Luwero District.

Annex 2: Names and roles of team members

Uganda Green Revolution Design Team(s)

Team Name	Profession	Role	Membership	Site	Status	Partners
1. Ngambeki D.S	Agricultural Economist	Designer/mobiliser	FT	1. Bamunanika	3	NGO-VEDCO CARITAS
Tushemereirwe W.	Pathologist	Coordinator	FT			D/Extension
Kangire A.	Pathologist	Coffee/Banana	PT		2	Donors DFID/IDRC
Nankinga C.	Entomologist	Animator		2. Masaka		
Kiwanuka Z.	Technician	Field Work	FT			
Nsubuga Erastus	Agro techno.	Entrepreneur	PT	3. Katikamu	1	
Kibirige Ssebunya	Breeder/MP	Political Support	PT			
2. Ngambeki D.S	Agricultural Economist	Designer/mobilizer	FT	4. Kabale	2	NGO/Africare ARDC Kabale
Mutabazi S.	Agro-Extension	Field Work	FT			UCDA
Zake J.	Soil Scientist	Field Work	FT			D/Extension
Kagonyera M.	Vet/MP	Political Support	PT			Ministry of Finance
3. Sekamate	Pathologist	Field Work	FT	5. Kasese		D/Extension
Ngambeki	Agricultural Economist	Designer	PT			CDA

Key: FT = Full Time
PT = Part Time

MP = Member of Parliament
UCDA = Uganda Coffee Development Authority
CDA = Cotton Development Authority

Status: 1 – Identified
2 – Re-designed
3 – Technological Intervention

Annex 3: Community's land use plan

	Environment Protection	Fertility crops Cereals	Fertility crops roots	Fertility crops legumes	Perennial tree crops	Grazing	Wildlife	Forest reserve
Land Type	slope/valley							
Fertility Agri Level								
Very fertile		*	*					
Medium fertile		*		*				
Low fertile				*		*		
Marginal					*	*		
Forestry	*						*	*
Steep mountain	*						*	
Plain marginal						*	*	
Bottom valley Fertile						*		
Bottom valley Wetland	*							*