RESEARCH PROGRAM ON Water, Land and Ecosystems

CGIAR

Harnessing Floods to Enhance Livelihoods and Ecosystem Services

HARNESSING FLOODS TO ENHANCE LIVELIHOODS AND ECOSYSTEM SERVICES PROJECT

RESEARCH GUIDE FOR INCLUSIVE DEVELOPMENT

Prepared by the project team

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IWMI International Water Management Institute

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1. Introduction

This Research Guide for Inclusive Development (RGID) discusses three key elements that lay the foundation to successfully conduct a research work, pilot implement the findings and upscale them. These elements are: clearly formulated research questions, scientific and practically relevant methodologies, and the full engagement of right local stakeholders with high motivation and direct interest on the research programme.

The RGID is developed for the CGIAR Research Program on Water Land and Ecosystems project: Harnessing Floods for Enhanced Livelihoods and Ecosystems Services. This research for development project explores how to optimize the use of floods for multiple benefit streams (crop and livestock production, groundwater and domestic water supply, gender equity and ecosystem services) to support livelihoods in different landscapes and socio-economic settings in Sudan and Ethiopia.

Recognizing the importance of floods and Flood-based Farming Systems (FBFS) for local livelihoods and economies, the Ethiopian and Sudanese governments supported by donors such as the International Fund for Agricultural Development (IFAD) invested in the improvement of infrastructure (weirs, intake and canals) and on-farm practices to enhance agricultural productivity. These investments have often been narrowly defined in terms food security and single interventions disregarding gender and other ecosystem service or inter-linkage between watershed and FBFS improvement.

The aim of this research for development project is to add value to ongoing decision making concerning Flood-based Farming Systems (FBFS) development in Ethiopia and Sudan by assessing and valuing the synergies and trade-offs between the different functions and benefits of FBFS under various development scenarios, for different stakeholders and the environment. Annex 1 has more details.

Achieving this very aim is central to the RGID. The process followed to prepare the RGID and the details on its three key elements are discussed in the following sections.

2. Research Guide Preparation: the Approach, Activities and key Outcomes

Working in full partnership with the relevant stakeholders is at the heart of the approach for the formulation of research questions and related methodologies. This is in tune with the central focus of the project on linking academic research with other "agents of change" in development issues including policy makers, donors, private sector, grassroots organizations and the media for inclusive investment and development programmes and highest societal impact.

Three major activities resulted in the preparation of the RGID:

1. Proposal Writing Workshop (WriteShop) organized by WLE, the NILE Basin and East Africa Focal Region in the period 20 to 24 October, 2014. The main outcomes were a large pool of potential project stakeholders (next and end users) as well as three overarching research questions and their respective methodology outline.
2. Stakeholder workshop and preliminary visits to the focal study sites, the Raya Basin in the Tigray Region in Ethiopia and the Gash Agricultural Scheme (GAS) in Sudan. This was organized by the core project implementing partners (Spate Irrigation Network Foundation, Mekelle University, Hydraulic Research Centre, UNESCO-IHE and MetaMeta) in March, April and May, 2015. These workshops resulted in the selection of the stakeholders most crucial for the successful implementation of the research programme and drafted priority research questions.
3. Establishment of research teams: these consist of experts from the core implementing partners and the most crucial stakeholders. They collectively refined the research questions drafted in the stakeholder workshops and developed relevant research methodologies.

The following sections provide further details on these major activities and their deliverables.

3. The start: Proposal Writing Workshop

During the proposal writing workshop (WriteShop), which was successfully organized and facilitated by WLE staff, the varied potential next and end users (stakeholders) of the project outcomes and related outputs were identified. As it can be inferred from Figure 1, multiple direct and indirect pathways were identified to link with and influence various "agents of change" - decision making institutions, donors, civil societies and community organizations as well as research and knowledge centres.

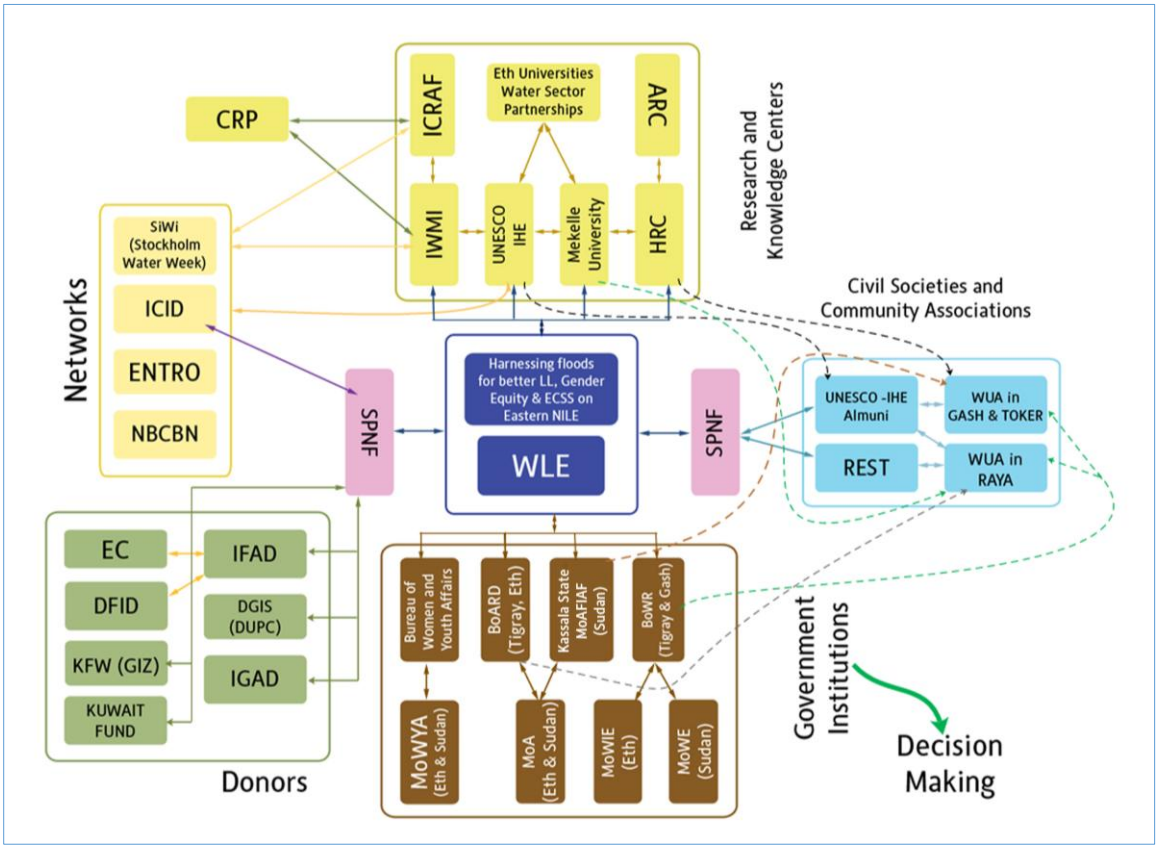

Figure 1: Potential users of project outcomes and related outputs

The Writeshop also resulted in the formulation of three overarching research questions along with an outline of methodologies:

Research question 1:

What is the impact of current investment plans of upstream agricultural development on downstream FBFS and livelihoods, in particular for women?

The methodology to answer this question consists of the following parts:

- description of the baseline situation, developing map images and assessing the hydrologic situation (using tools such as SWAT, HEC-HMS), different uses of floods (expert interviews) and traditional adaptive management strategies in flood based farming by men and women (focus group discussions);
- stakeholder analysis to identify the different beneficiary groups such as upstream, midstream and downstream; men, women, youth;
- livelihood and eco-system services mapping upstream and downstream in the basin, differentiated between men and women;

- participatory mapping of resources and access by different groups, identifying spatial patterns in distribution of benefits;
- economic valuation of benefits derived from these resources by different stakeholder groups, and trade-offs, negotiations and existing conflict resolution mechanisms;
- scenario evaluation exploring current and ongoing investment plans: physical/hydrologic aspects using models such as SWAT, HEC-HMS; socio-economic and gender aspects through focus group discussions and interviews of key experts.

Question 2:
What is the added value of incorporation of gender and ecosystems perspective in investment plans in flood based farming?

The methodology to address these questions consists of a comparison of impacts under baseline and alternative investment scenarios, as follows:

a) Assessment of the baseline situation (separate for men, women and youth), see above.
- Valuation of ecosystems functions with direct and indirect benefit to different stakeholders (using tools such as INVEST, and TEEB conceptual framework for Food and Agriculture)

b) Impact assessment of alternative investment scenarios
- Participatory formulation and evaluation of alternative scenarios that incorporate gender and ecosystems (Focus group discussion) and relate this to specific intervention
- Evaluation of scenarios, including winners and losers and exploring trade-offs and synergies between benefits, costs and their distribution over stakeholder groups (see above) and the environment (using tools such as SWAT, HEC-HMS, Ribasim, INVEST, and focus group discussions in different stakeholder forums at local and policy level).

Question 3:
What is the most 'efficient' use of floods (from different angles) in the study areas - the Raya watershed and valley and Gash basin? And what interventions and set of intervention support this?
- Based on the results of question 1 and 2, Focus group discussions in different forums of the next users.

4. The Follow-up: Stakeholder Workshops

To build up on the successes of the WriteShop, stakeholder workshops combined with field visits to the study sites were conducted in Ethiopia and Sudan that further crystallized the research questions, detailed the methodologies, and identified the most critical stakeholders that must be intensively engaged for successful implementation of the research work, uptake and up-scaling of the findings for greater societal impact at local and national levels.

Sudan: The stakeholder workshop in Sudan was held from 28 to 30 April 2015 in Kassala town, the capital of the Easter Region close to the western border of Eritrea. It is located along the Gash River and its 50,000 ha Agricultural Scheme, the focal study site of this project.

The workshop brought together 31 stakeholders representing policy makers and implementing government institutions mainly the Gash Agricultural Scheme (GAS) Directorate and Gash River Training Unit; Gash river flow dependent farmers and pastoralists, Kassala University and Agricultural Research Corporations. Annex 2 has the full report of the workshop and the complete list of stakeholders.

The two major outcomes were the following:
- Draft priority research questions - these are presented in section 5 in their final more articulated form.
- Four key local partner institutions as discussed below.

From the large pool of stakeholders that attended the workshop, the core project implementing team decided to intensify engagement with the following four local institutions for successful implementation of the research work in Gash and up-scaling the results thereafter to a national level.

1. *Gash Apex Water Users Association:*
   - led by powerful Chairman and Secretary General who are very well respected by the majority Hadendewa tribe who own over 80% of the cultivable 50 000 ha in GAS.
   - Increasingly emerging as a powerful institution and credible partner of the GAS Directorate in jointly managing the Gash river flows, irrigation structures and field water management systems.
   - It is near impossible to implement field research and have proper access to the farming and agro-pastoralist communities without the blessing and support of the Association and its leadership.
2. *GAS Directorate - a Government Institution:*
   - In charge of the operation and maintenance of the main diversion and distribution structures as well as allocation of Gash flow to the six main irrigation blocks staring from the most upstream Kassala block to the most downstream Hadalia block that channels water to the Gash Die - the inland delta.
   - Without the support of this institution, it is extremely difficult to do effective systems level research that for instance deals with remodelling of the Gash river water allocation to the multiple benefit streams.
3. *Gash Women Association:*
   - This is a still a young evolving association in GAS, but has demonstrated its usefulness to the project by presenting on major gender issues related to groundwater depletion and small-scale vegetable cultivation by women.
   - Given the conservative setting of the Gash community, the Association members will be instrumental in the implementation of the research focusing on gender and socio-economic issues and requires extensive engagement with women.
4. *Kassala State Ministry of Agriculture, Forestry, Irrigation, Animals, Wealth & Fisheries (MoAFIA):*
   - Responsible for allocation of funds to the GAS (GAS) and official decision on research, investment and development projects in the region.
   - Without endorsement of the project by MoAFIA, establishing good working relationship with the above three institutions would be difficult, if not impossible.
   - Could serve as a pathway for up-scaling findings to a national level.

These institutions have actively participated in the stakeholder workshop and openly stated their interest and committed their support to the research programme. The Kassala State Minister opened the workshop and organized a working dinner with the core project team in collaboration with the other three institutions. The Gash Apex Water Users Association and GAS Directorate leadership led the one day field trip throughout the GAS all the way to the most downstream Gash die that vividly demonstrated the urgency of addressing the research questions discussed in section 5.

Ethiopia: the stakeholder workshop was undertaken from 17 to 19 March 2015 with 40 participants that represented donors (IWMI and GIZ), technical experts and decision makers from various departments and faculties of Mekelle University (the president and vice president for research and community services were among the attendees), Tigray Regional State Government Institutions including the deputy heads of the Bureaus of Water Resources and Agriculture and Rural Development, Administer of the Southern Zone and selected district level officials. The full report on the major issues discussed during the workshop and details of the stakeholders who participated is given in Annex 3.

The two concrete deliverables were:

1. Draft priority research questions were formulated - section 5 has the details.
2. The following three crucial stakeholders were selected for full engagement in all aspects and times of the project:
    - The Tigray Region Water Resource Bureau: This has lead responsibility in formulating regional policy with regard to major investments in water and related land development programmes. The Bureau is supportive of the project focus and its objectives and has assigned the Deputy Head to coordinate activities with the core project team.
    - The Bureau of Agriculture and Rural Development. It has a mandate for technical planning and implementation of all agricultural investments in the region including the watershed (bench terrace and deep trench) based upstream development programmes. In fact, this research project in Ethiopia is in part initiated following an explicit demand by the Bureau to assess the downstream impacts of its upstream agricultural development interventions. The Bureau has interest in the project findings and has assigned its deputy head to work closely with the core project team.
    - The Southern Zone Administration. The upstream development programmes are being piloted in the Raya Basin, which is located in the Southern Zone of Tigray. The Administration is responsible for supervising, monitoring and evaluating the upstream development programmes in close consultation with the end users.

As a follow-up to the stakeholder workshop, the core project implementing team together with the Administrator and key agricultural expert of the Southern Zone of Tigray, conduced field visits to the Raya Basin and held discussion with randomly selected women and men end users (Annex 4 has the list of the participants). These activities resulted in the selection of the following two specific sub-catchments and their communities to serve as the focal research sites and local partners (Figure 2 has the land use map and location of the sub-catchments):

1. *Guguf sub-catchment:*
    - Livelihood in the low-lying area is predominantly based on FBFS, which is more than two centuries old. There is a wealth of indigenous knowledge and experiences on hydrology, other technical aspects and flood governance issues the project could take stock of and accordingly make sound recommendations, for instance, to improve FBFS based livelihoods, particularly of women.
    - Pilot site for the bench terrace and deep trench based upstream agricultural development programmes.
2. *Oda sub-catchment:*
    - In the valley, the TIgray Regional Government (TRG) is supporting the development of new breed of FBFS that will make use of innovative hybrid flood diversion systems that combine indigenous and modern knowledge and practices.
    - The immediate upstream of the FBFS is largely bare land and there is no yet watershed management intervention.

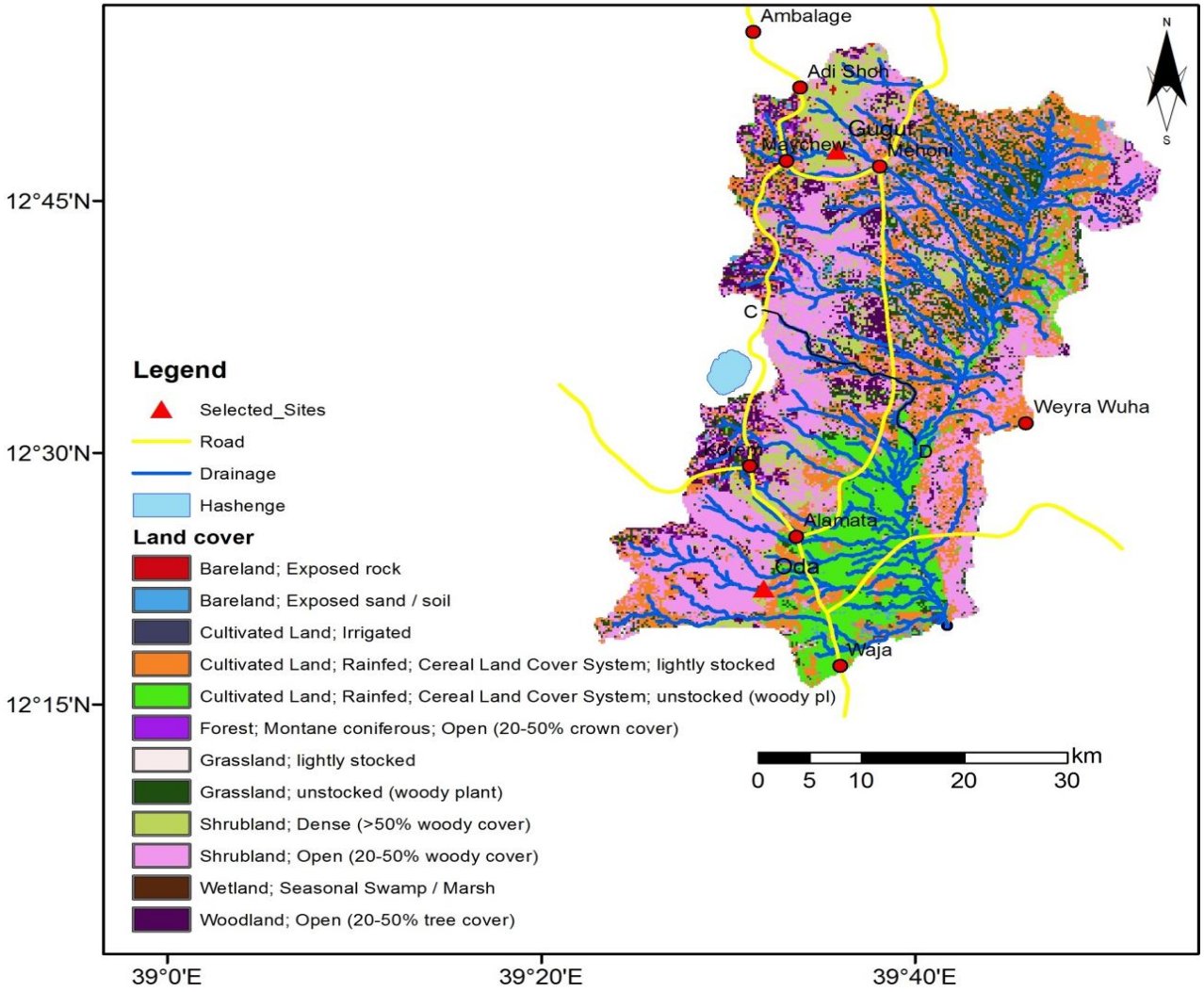

Figure 2. Land use map of the Raya Catchment, Tigray Region, Ethiopia

5. The Last Step: Research Questions and Methodologies

5.1 Sudan Research Programme

The research work in Sudan will be conducted in the Gash river basin. The Gash River rises from Eritrean and Ethiopia Highlands and ends in Gash Die - the so called inland delta in Sudan. It has an estimated catchment area of 21000 km^2 shared among Eritrea, Ethiopia and Sudan (Figure 3). The Gash River is characterized by its seasonality and it flows torrentially between July and October while it becomes dry over the rest of the year. The river, in spite of its highly unreliable and unpredictable flow, remains the only major source of: 1) irrigation for GAS; 2) domestic water supply for Kassala city and its numerous rural and semi-urban surroundings; 3) recharging ground water, which, besides for domestic purposes, is widely used to cultivate fruits and vegetables under men dominated large scale farming and small-scale home gardens operated by women; 4) watering the vast range land and maintaining the biodiversity in Gash Die. In fact, most of the social and economic activities of the area depend on the river. The Gash annual yield is about 1 Billion m^3, which is substantial and could meet all the multiple demands in the Gash Basin if the significant real challenges with regard to the unpredictable nature of the floods, the changes in the river beds and the considerable amount of sediment carried each year by the river, are addressed.

Figure 3: Gash river basin

This research programme attempts to address some of the above outlined challenges. Its focus, as shown in Figure 4, is on four components: water resources allocation, gender issues, ecosystems services, and groundwater modelling. The current and alternative water allocation scenarios will be simulated using RIBASIM model, which will quantitatively determine the amount of floodwater diverted to GAS and the downstream Gash Die. The floodwater that percolates into the groundwater aquifer will be accounted for using MODFLOW model. These simulation results will inform decisions for adopting the best water allocation scenario to optimally meet the multiple and often competing water demands in the Gash basin.

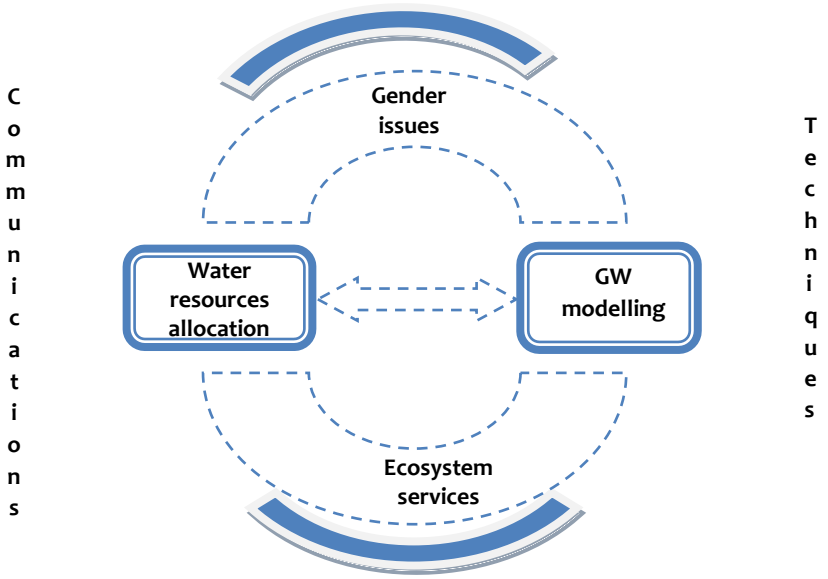

Figure 4: Research Framework for Gash Agricultural Scheme, Sudan

5.1.1 RIBASIM MODEL and Allocation of Gash River floods

The key question that will be addressed using RIBASIM modelling is:

- How should the Gash floodwater be allocated to optimally satisfy the needs of the different benefit streams - agriculture, groundwater recharge, domestic and livestock water supply, and Gash Die ecosystem under current and future water demands and supply?

The schematic representation for the RIBASIM Model is given in Figure 5. It shows the Gash floodwater inflow (Q_{in}), the collective uptake by all six irrigation blocks of GAS (Q_{GAS}), the outflow to Gash Die (Q_{die}), abstraction by the domestic ($Q_{domestic}$) and groundwater (Q_{die}) sectors. Should other major floodwater uses be identified during the field research period; these will be included in the simulations.

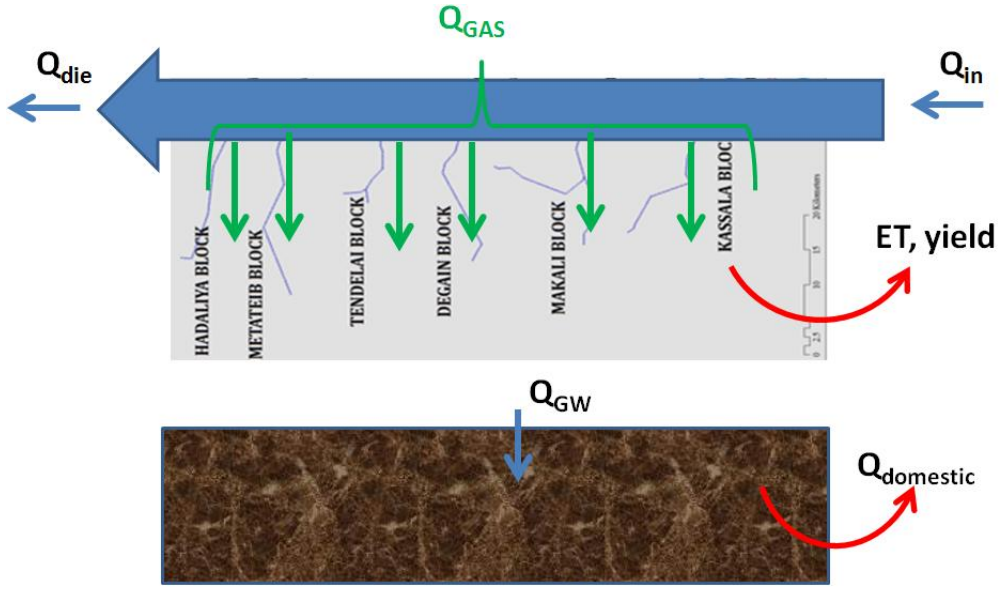

Fig. 5: Gash waters modelling by RIBASIM

Different datasets are needed to build the RIBASIM model:

1. Hydro-meteorological data series, viz: precipitation, evaporation rates of Kassala meteorological station for the period 1915-2015. In addition to Gash River discharges at ElGeera hydrological station for the period (1915-2015).
2. Existing and future water demand and supply:
    - Irrigation demand/supply from Gash River.
    - Groundwater abstraction for irrigation on 10-day or monthly basis.
    - Groundwater abstraction for public water supply and vegetable and fruit production on 10-day or monthly basis.
3. Cropping patterns, cropped areas.

5.1.2 MODFLOW and Groundwater Modelling

Here, the key question the MODFLOW model will quantitatively answer is:

- What will be the groundwater table drawdown under different Gash floodwater allocation scenarios to GAS, Domestic and Livestock water supplies, Gash Die and other major uses?

MODFLOW is well established widely used groundwater model. To properly build it for the Gash Basin, however, the following data are required:

- Hydro-geological structure: top elevation, bottom elevation, and extent.
- Aquifer properties: transmissivity, storage coefficient, effective porosity and related parameters.

- Boundary Conditions.
- Recharge data.
- Discharge rate - ground water use for domestic, vegetable and fruit production on 10 day or monthly basis

The data for both RIBASIM and MODFLOW models are available.

The follow-up questions to the Groundwater simulation results are:

- How will the men and women vegetable and fruit producers be affected by the different levels of groundwater table drawdown?
- Should there be significant negative impact, how can it be mitigated? What are the set of alternative groundwater management practices that could be recommended?

These two questions will be qualitatively addressed through expert interviews and focus group discussions segregated for men and women.

5.1.3 Gender and ecosystem services

The key questions within this research them are the following:

- What, if any, are the missed opportunities (benefits) in past investment programmes including the large over 40 million IFAD investment programme due to lack of integrating ecosystem services and gender perspectives?
- What, if any, will be the concrete added values of incorporating gender needs and ecosystem services in future investment programmes?

The methodology to be followed will include interviews and focus group discussions with varied stakeholder's including women and men, upstream and downstream, farmers and pastoralists as well as WUA leaders and relevant government officials.

The interviews and discussion will be guided with clearly articulated questions such as:

- What are the specific needs, priorities and constraints of women that should be addressed if they are to benefit from investment programmes in GAS?
- Were these priorities, needs and constraints not taken into account in the design and implementation of past (including IFAD) investment programmmes? If yes? Why? What are the major missed opportunities as a result?
- How do you think these needs, priorities and constraints could be incorporated in future investment and development programmes? What would be then the main expected benefits and costs?
- Are there any opportunities being missed due to inadequate representation of women in the GAS WUAs? If yes, could you list the top five?
- Often Gash River brings large floods that are difficult to handle within the irrigated fields. Do you think it is a beneficial investment to:
    - Guide the large floods to Gash Die and spread it there to grow grass for cattle and fill the reservoirs for domestic and livestock water supply?
    - Enlarge the recharge basins in upper Gash, harness these large floods and increase the groundwater supply for domestic and livestock water supply, increased production of vegetables and fruits?
- If these are useful investments, why were they neglected in previous investments including the recent one funded by IFAD?
- Etc..

These and related open ended questions will be organized, categorised, coded, analysed and interpreted with HyperRESEARCH software package and related statistical tools.

5.2 Ethiopia Research Programme

For the reasons outlined in section 4, the research work in Ethiopia will be piloted in Guguf and Oda sub-catchments (Figure 2) of the Raya Basin, which is located in the South-east part of the Tigray Regional State (TRG). The Raya Basin has two distinct agro-ecological zones: 1) the low-lying area (the valley) with an altitude of less than 1000 m.a.s.l and an average annual rainfall estimated at below 350 mm; and 2) the upland area at above 1500 m.a.s.l enjoying mean annual rainfall that ranges from 600 to 775 mm.

FBFS is widely practiced in the Raya Valley. Currently there is 80 000 ha under FBFS and its potential is estimated at 200 000 ha. The Upper Raya catchment has been selected by the TRG for pilot testing its bench-terrace based agricultural development.

The major research issues and the expected outcomes are explained in Figure 6.

The central question is:

- What is the impact of current and alternative investment programmes in the Raya Upper Catchment on:
  - The downstream FBFS livelihoods, particularly women.
  - Ecosystem services of the upper catchment (particularly the balance between retention and export of flood flow, sediment and nutrients) and the socio-economic status of the inhabitants, particularly women.

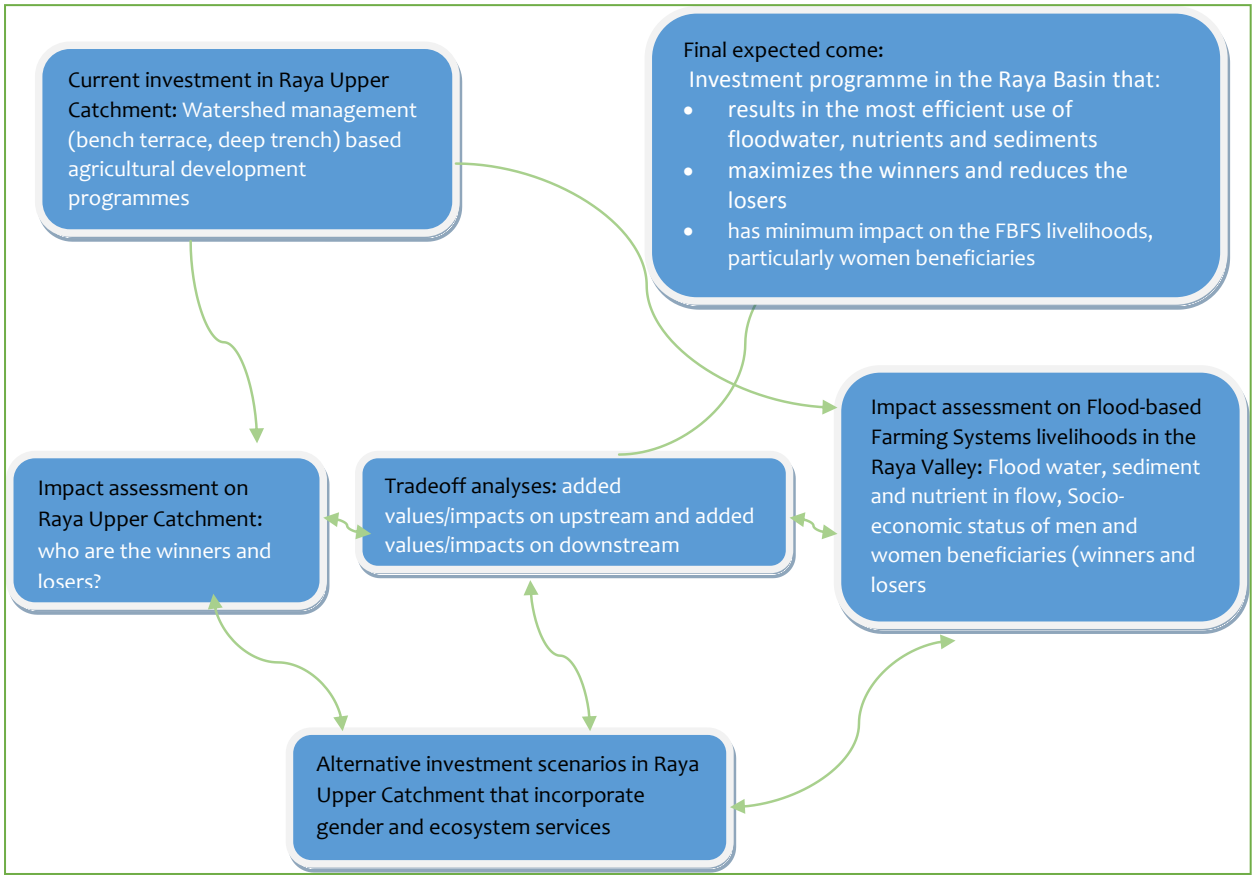

Figure 6: Research framework and major issues for Raya Basin, Tigray Regional State, Ethiopia

To answer the central question four specific themes are identified:

- Ecosystem services valuation
- Hydrology and land use
- Gender and livelihood impacts
- Watershed, microclimate and ecosystem services

The specific questions within each of these research themes along with the relevant methodologies are discussed in the following sections.

5.2.1 Ecosystem Services Valuation

The three key questions covered under this theme are:

1. What are the ecosystem services and tradeoffs of current and future watershed and agricultural development investments in the Raya Basin?
2. What are most cost-effective and gender prioritizing watershed development investment portfolios that can be recommended to decision makers?

InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) model will be used to address the first question. The specific ecosystem services to be analyzed are the amount of sediment and nutrient (P&N) retained within the upper catchment and the quantities exported downstream to the FBFS. These ecosystem services will be quantified at different investment levels for the current and future scenarios.

The input parameters for the model include land use/land cover, topography (DEM), precipitation, LULC coefficients, plant available water content, potential evapotranpiration, soil erosivity and erodibility indices. These data will be obtained from multiple sources including field survey, satellite image or land sat; FAO soil data base (will be supported with ground verification). Official government documents will provide the actual budget of the current watershed and agricultural development programmes; this will serve as the basis for estimating the budget for the alternative future investments.

The second question will be answered with the help of Resource Investment Optimization System (RIOS) model. Through focus group discussions and stakeholder forums segregated for women and men, different investment activities considered to be cost effective and meet the specific needs of women will be identified. The stakeholders will also advice the preferred locations for these investments within the watershed. The other input data are as descried for inVEST. These data will be analysed by the model and the output is Investment Portfolio Advisor Report at different budget lines and scenarios.

5.2.2 Hydrology and Land Use

The central question of this research theme is: what is the amount of floodwater flow to the low-lying FBFS under:

- The current land use of the two selected sub-catchments: a) Oda sub-catchment with largely bare land in the upstream and newly implemented FBFS downstream; b) Guguf sub-catchment, which inhabits centuries old FBFS in the lowland and bench terrace supported agriculture intensive upland.
- Alternative land use of the sub-catchments - this will be inferred from the TRG upstream investment and agricultural development intervention plans.

HEC-HMS (Hydrologic Engineering Centre's Hydrological Modelling System) tops the list of the Hydrological models most suitable for addressing the above question because of its ability to simulate extreme flood and rainfall events, which are common phenomenon in the Raya Basin. HEC-HMS is the successor to and replacement for HEC-1 program and provides additional

capabilities as it can model both individual (single) rainfall events as well as long and continuous sequences of the precipitation data.

To provide reliable answers, as is the case with other models, HEC-HMS needs to be properly calibrated and validated. This requires the following input data.

Hydrological data

Event runoff will be measured at the selected outlet of the two catchments using Mini-Divers. Suitable gauging stations will be identified and the cross section will be reshaped. Cross sectional and longitudinal profiles will be obtained using Total Station. Flow velocity will be measured with a current meter calibrated float and theoretical rating curve will be established based on area-velocity method. The flow data from the mini-divers will be compensated for atmospheric pressure.

Meteorological data

As orographic rainfall dominates the study area, suitable rain gauges should be located in the upper most and outlet part of the watershed. The existing meteorological stations will be identified and checked if their spatial and temporal coverage is representative of the rainfall pattern in the watershed. Moreover, two additional automatic rain gauges (tipping bucket) have been installed in each catchment; one at the upper most part and the other around the outlet.

Land use and land cover data

Detailed Land use land cover map will be produced for two selected time intervals from IKNOS satellite images. Sufficient ground truthing and accuracy assessment will be conducted to validate the supervised classification results.

Hydrological Soil Group

The hydrological soil group will be prepared using sieve and hydrometric analysis for soil samples taken at representative sampling points. The samples will be collected following a transect line and the hydrological soil group map to be prepared using ArcGis following the morphological approach.

Soil loss

The soil loss will be estimated using Revised Universal Soil Loss Equation (RUSLE) for the two catchments. The suspended sediment load will be sampled using automatic sediment sampler for selected event responses.

With the above input data, HEC-HMS provides simulated discharge (runoff). This will be compared with the corresponding event runoff and the efficiency of the model will be evaluated using the statistical methods RMSE and NSE. RUSLE estimated suspended sediment will be validated with the sediment measured using the automatic sampler.

5.2.3 Gender and livelihood impacts

Here, the main research questions are:

1. Who are the winners and losers of the different investment scenarios discussed in earlier sections?
2. What is the difference in costs and benefits for men and women?

These questions will be answered by employing the following specific PRA (Participatory Rural Appraisal) techniques:

- *Participatory mapping:* This is a spatial analyses technique useful to define type and position of the investments, to have information about command areas and the target groups served.

- *Field walks (survey):* to have close inspection of the different watershed management and agricultural development interventions and to organize discussion in situ with target groups and other relevant stakeholders about the functioning of the interventions.
- *Expert interviews:* This refers to interviews with varied stakeholders in the study area including men and women beneficiaries, government officials that are knowledgeable about the interventions.
- *Focus group discussion:* This discussion will be conducted with selected groups of 10 to 12 persons segregated for men and women beneficiaries.

The group discussions and individual interviews will be conducted based on a set of well articulated and clear guiding questions. They include, but are not limited to:

- What are the livelihood priorities of the men and women target groups? Do the different investment scenarios meet these priorities? How are they meeting them?
- If, how and why are livelihoods changing? Which changes are due to the investments? Which changes are short-term 'coping' strategies, and which are long-term 'adaptive' strategies (adapting to either new opportunities or constraints)?
- What are the possible diverse, positive and negative, short-term and long-term ways in which the investments affect the livelihoods of women and men target groups?
- How do the livelihood strategies of men and women affect the way they participate in, or are affected by, the investments?
- How can intervention activities be adapted in order to enhance positive livelihood impacts on the target groups while maintaining their main objective - in this case converting the steep hill side in the study area into productive agricultural land?
- What are the costs to men and women due to the unintended negative impacts of the investments and the various measures they have to implement to mitigate such impacts?

The men and women who will participate in the group discussions and individual interviews will be randomly sampled from the official population records of the specific study sites, the Oda and Guguf sub-catchments.

5.2.4. Microclimate, Watershed Management and Ecosystem Services

Climate science has a large interest in 'average weather'. There is an obsession with predicting larger climate trends: regional long-term patterns of rainfall, temperature peaks and averages. How this pans out locally in time and space in less understood.

Microclimates are the wonderful local interplays between factors such as soil temperature, air temperature, wind directions, soil moisture and air humidity – affected by day-night effects and seasonal effects. Understanding the microclimate is an essential part of managing an ecosystem, but it has so far remained below the radar screen of researchers, policy makers, development institutions and other agents of change.

The research and scientific knowledge gap is huge and there are so many unanswered questing linking watershed management, ecosystem services and microclimate. This project will make solid foundation to our understanding of key microclimate interactions through case study based research guided by the following key questions:

- How significant is the impact of the intensive re-greening, watershed management interventions as well as agricultural activities on the microclimate (temperature, dew and frost formation, rainfall pattern) of the Guguf sub-catchment in the Raya Basin?

- How has this change in microclimate affected the various provisioning and regulating ecosystem services that are usually overlooked: 1) increase in biodiversity of the natural vegetation with considerable value as additional sources of income to local communities, 2) revitalization of grass and bush land for livestock, 3) groundwater recharge and the birth of springs, 4) reducing the occurrence of damaging flood events?

These questions will be largely addressed qualitatively; several of the PRA techniques explained in the earlier section will be employed to capture the perceptions of the Guguf local communities as well as the government and non government institutions actively implementing the watershed management practices.

The findings are expected to provide some evidenced based knowledge to the microclimate interactions within a landscape (Figure 7) and the manner in which they affect and are affected by watershed management interventions and how these consequences translate into the different ecosystem services.

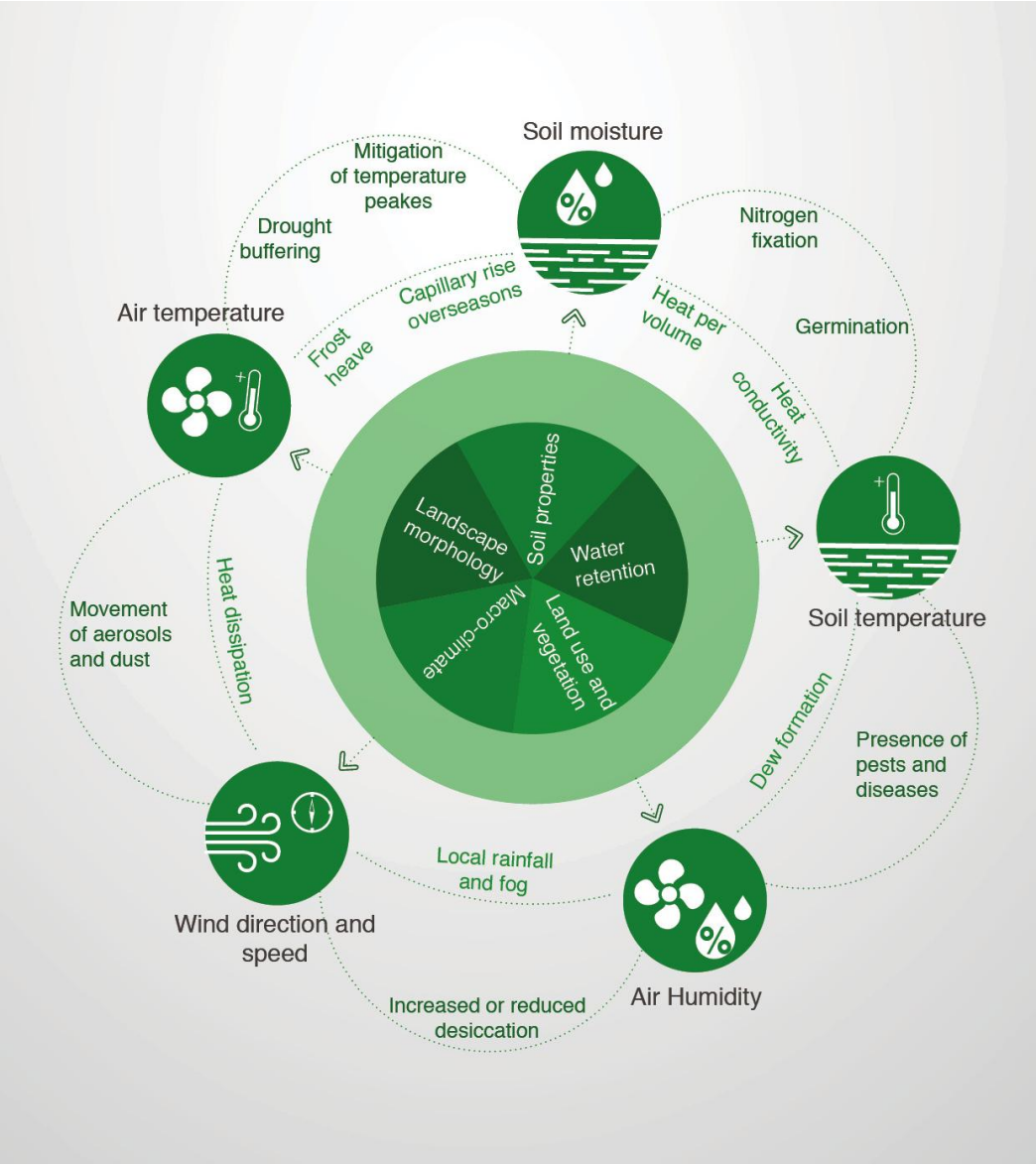

Figure 7: Microclimate interactions