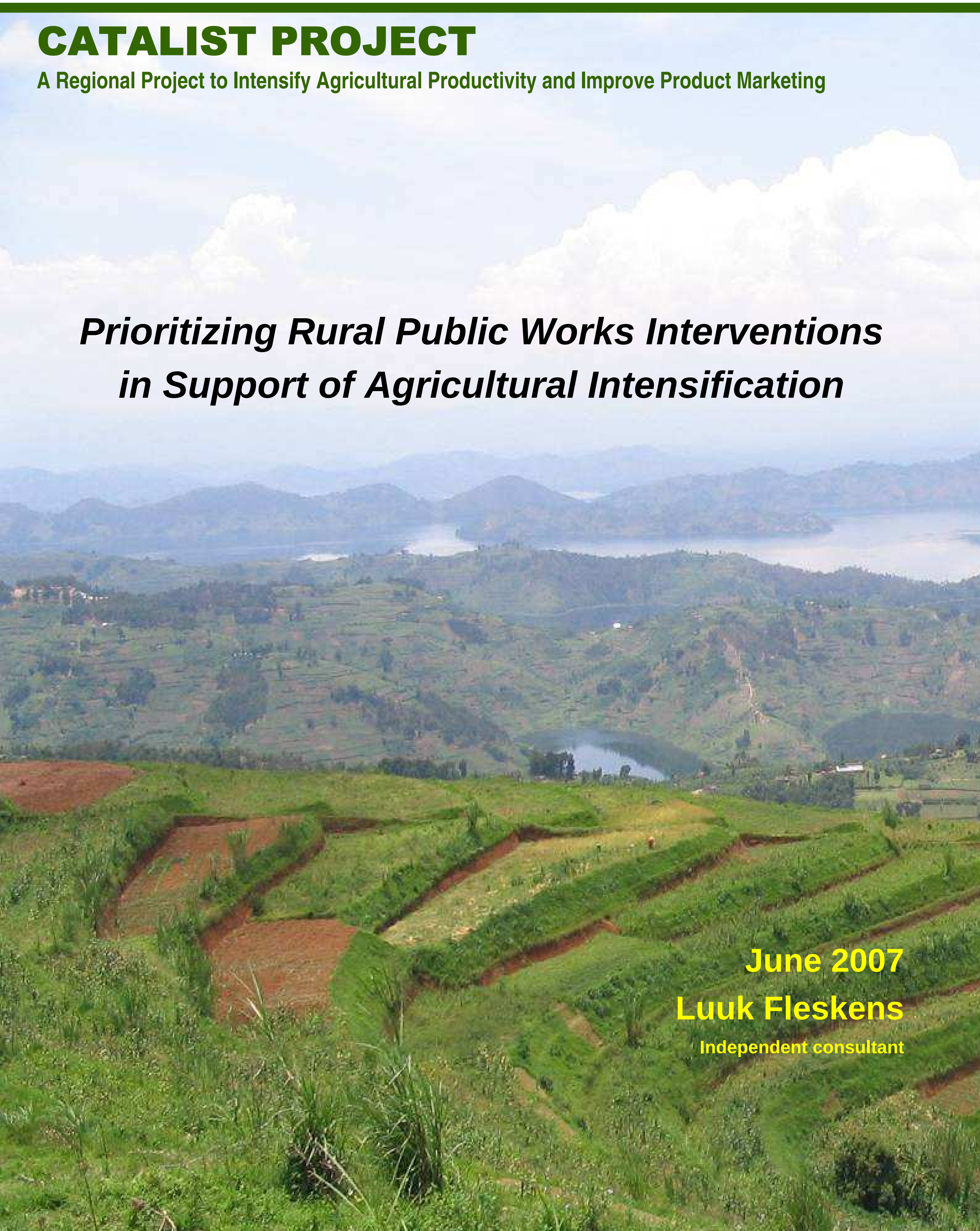
IFDC

HELPAGE

RWANDA

## CATALIST PROJECT

**A Regional Project to Intensify Agricultural Productivity and Improve Product Marketing**



# *Prioritizing Rural Public Works Interventions in Support of Agricultural Intensification*

June 2007


Luuk Fleskens

Independent consultant

# *Prioritizing Rural Public Works Interventions in Support of Agricultural Intensification*[1]

**Luuk Fleskens**

**June 2007**

[1] This is the summary report; it is accompanied by a detailed annex report, to which the reader with specific interests is referred.

## Acknowledgements

The report before you is based on fieldwork conducted in Rwanda and Burundi in February and March 2007. Many persons have contributed to the completion of this work. First of all I would like to thank Dr. Henk Breman, Principal Advisor Agriculture & Environment of the CATALIST project, for initiating this study and stimulating discussions. Prof. dr. Leo Stroosnijder of Wageningen University facilitated the contact with IFDC.

The support of HELPAGE has been crucial in field data collection. Mr. Alexis Byamana, National Coordinator of HELPAGE in Rwanda, has shown tremendous flexibility in organizing field visits to HELPAGE field offices in response to changes of plans on several occasions. Mr. Cyriaque Nzojibwami, Coordinator of HELPAGE's Burundi office demonstrated a keen interest in this study and kindly guided me on a cross-section through Burundi's agricultural zones. Mr. Boniface Nsabimana and Mr. Eric Kambere, Engineers at HELPAGE's Cyangugu office, provided many data of the HIMO-PRP pilot project and showed project achievements from the terrestrial and lacustrine point of view at Lake Kivu. Finally, Mr. Maurice Ndayisaba and Mr. Jean-Marie Sindibona of HELPAGE Ruhengeri provided data and examples of roads and radical terraces respectively, which were carried out under the SIG-HIMO project.

Many thanks to all at CATALIST project office Kigali, notably National Coordinator Innocent Ntyabana, Agronomist Laurence Mukama, Office Manager Marie-Claire Kalihangabo and drivers Beatrice and Jean-Marie. A special word of thanks to COP Geoffrey Livingston for his logistic support and suggestion to concentrate on the analytical study, while offering to hire Christophe Nkenguburundi for data collection in Burundi.

Prior to traveling to Rwanda, Emanuel Rubayiza warmly welcomed me at ILO Geneva, introduced me to ILO's large HIMO tradition and provided a tailor-made bibliography of relevant studies.

Dr. Marijke d'Haese, Mr. Jean-Claude Bidogeza, Dr. Jan de Graaff and Mr. León Nabahungu gave valuable information at the onset of the study. Jean-Claude generously shared his price information database 1997-2006 with me.

Last but not least, colleague consultants Joel Le Turioner and Sylvain Roy commented on preliminary ideas and were excellent company during the stay in Kigali and Bujumbura.

Luuk Fleskens

9 April, 2007

# Table of Contents

# List of tables

# Abbreviations and Acronyms

| | |
|---|---|
| AAA | Agro Action Allemande (Deutsche Welhungerhilfe e.V.) |
| BD | Bulk Density |
| BIT | Bureau International du Travail |
| BU(R) | Burundi |
| CATALIST | Catalyze Accelerated Agricultural Intensification for Social and Environmental Sustainability (IFDC-administered project 2006 – 2011) |
| CBA | Cost-Benefit Analysis |
| CDF | Community Development Fund (under MINALOC, Rwanda) |
| CEC | Cation Exchange Capacity |
| CGIAR | Consultative Group on International Agricultural Research |
| CIDA | Canadian International Development Agency |
| DED | Deutsche Entwicklungs Dienst (German Development Service) |
| DFID | Department for International Development (UK) |
| DRC | Democratic Republic Congo |
| EIIP | Employment Intensive Investment Program (ILO) |
| ESIRU | Establishing a System of Integrated Resource Use (GAA-administered project 2005 – 2007) |
| EUR | European Union Euro (1 EUR = 1.32 US$) |
| FAO | Food and Agricultural Organization of the United Nations |
| FBU | Franc Burundaise (national currency of Burundi 1050 FBU = 1 US$) |
| FRW | Franc Rwandaise (national currency of Rwanda 550 FRW = 1 US$) |
| GAA | Geramn Agro Action (Deutsche Welhungerhilfe e.V.) |
| HELPAGE | Regional NGO, partner in CATALIST |
| HIEQ | Haute Intensité d'Equipement (high equipment intensive) |
| HIMO | Haute Intensité de la Main d'Oeuvre (high labor intensive) |
| ICRAF | World Agroforestry Center (supported by CGIAR) |
| IFAD | International Fund for Agricultural Development of the United Nations |
| IFDC | International Fertilizer Development Center |
| ILO | International Labor Organization |
| IRAP | Integrated Rural Accessibility Planning |
| IRR | Internal Rate of Return |
| ISAR | Institut des Sciences Agronomiques du Rwanda |
| MCA | Multi-Criteria Analysis |
| MINAGRI | Ministry of Agriculture (Rwanda) |
| MINALOC | Ministry of Local Governance, (Rwanda) |
| MINITERE | Ministry of Land (Rwanda) |
| NGO | Non-Governmental Organization |
| NPV | Net Present Value |
| NTFP | Non-Timber Forest Product |
| OM | Organic Matter |
| PD | Person Day |
| PDL-HIMO | National Rwandan program promoting high-labor intensive public works |
| PHBC | pH Buffering Capacity |
| PRP/HIMO | Programme de Reboisement et de Réhabilitation des Pistes Rurales par HIMO (HELPAGE-administered project 2003 – 2006) |
| RDC | Republique Democratique du Congo |
| RW(A) | Rwanda |
| SIG/HIMO | Système Intégré de Gestion des Ressources Naturelles par HIMO (HELPAGE-administered project 2003 – 2006) |
| SOM | Soil Organic Matter |
| SSA | Sub-Saharan Africa |
| SWC | Soil and Water Conservation |
| UN | United Nations |
| V/C | Value/Cost ratio |
| WARDA | Africa Rice Center (supported by CGIAR) |
| WFP | World Food Program of the United Nations |

# 1. Introduction

The CATALIST Project (2006-2011) funded by the Dutch Government and implemented by IFDC is a regional activity in the African Great Lakes region with the aim to contribute to regional peace and security through intensified, sustainable agricultural production and improved product marketing. One of the ways to reach this overarching goal is to improve rural infrastructure that can directly contribute to increased productivity and marketing. This objective is implemented through a subcontract with HELPAGE, a regional NGO specializing in rural public works in support of responsible environmental stewardship.

The joining of forces of IFDC and HELPAGE in the CATALIST Project was in effect orchestrated by the Dutch Government, which saw important complementarities between two previous proposals for funding submitted separately by each organization and requested that IFDC and HELPAGE enter into a contractual relationship in order to promote synergy, avoid duplication of activities and facilitate oversight and management. Within CATALIST, HELPAGE became an IFDC sub-contractor with its original proposal serving as a menu of options for its interventions. These interventions concern rural labor intensive public works (HIMO: Haute Intensite de la Main d'Oeuvre)[2] in the Albertine Rift Valley: Rwanda, eastern Congo and Burundi. The establishment of a subcontract with HELPAGE in effect altered the objective of the rural works program from employment creation in the context of improved trans-boundary environmental management to employment creation in the context of accelerated agricultural intensification.

The agricultural sector in the Albertine Rift Valley is characterized by its tiny farms on steep slopes with yield levels which have not increased (or even decreased) during the last several decades. Much has been written about the causes and consequences of this stagnation (e.g. Andre and Platteau 1998; Byiringiro and Reardon 1996; Clay 1996; Lewis and Nyamulinda 1996). Among the multitude of factors, the need to intensify agricultural productivity with external inputs is singled out as one of the most important.

The CATALIST project will focus on agricultural product chain development and agricultural productivity increase through increased input use and market development. Agricultural product chains to be supported have been the topic of detailed national studies and will receive due attention in this study[3].

For the case of Rwanda, the following product chains have been identified as priority chains:

- **Maize** [food security; market potential; widespread cultivation; processing industries; favorable national policy; private sector interest; potential for intensification]
- **Wheat** [market chain development; cultural techniques known; adapted to highland; processing industries; cost reduction possible; import substitution; intensification]
- **Potato** [food security; yield improvement; high profitability; market chain development; mix potato flour/wheat; export market; many stakeholders]
- **Livestock** [transversal chain; revenue generation; manure production]

For the Kivu Provinces of Congo DRC, the following priority chains were selected:

- **Cereals (maize and rice)** [import substitution; transport costs; not perishable; food security; enormous demand; valorization sub-products; intensification potential]
- **Livestock** [transversal chain; import substitution; traditional importance; integrated soil fertility management]
- **Wood** [transversal chain; environmental crisis; integrated soil fertility management]

[2] For a brief historical overview and regional experiences with HIMO, see Section 1.2 in the Annex Report
[3] For details see Section 1.3 in the Annex Report

For Burundi, the following priority chains were selected:

- **Potato** [widespread cultivation; rising consumer popularity; cash crop; export potential; intensification possible; research organizations; farmer organizations]
- **Rice** [intensification possible; marshland development; research partnership; processing industry; domestic market]
- **Cassava** [regional staple; intensification possible; resistance against mosaic virus; refugee repatriation
- **Livestock and banana** [transversal chains]

The present study was executed with the aim to verify that proposed HIMO activities and localities are consistent with CATALIST's objective of intensified agricultural productivity, and to increase the chance that temporary employment creation leads in time to more permanent employment. More specifically: i) an economic analysis was made of various labor-intensive rural investments, both without and with external input based agricultural intensification; ii) based on an examination of these analyses and secondary data, the types and locations of HIMO interventions were prioritized; iii) the original HELPAGE proposal was analyzed in its new context; and iv) specific recommendations were made concerning public works sub-projects which have a tangible and significant impact on intensified agricultural productivity.

In order to achieve the above objectives, the consultant has opted to further develop, synthesize and validate a decision-making tool for the prioritization of HIMO activities in the African Great Lakes region. The tool enables the intelligent exploitation of available knowledge in a holistic way, and as such may represent an important added value to present approaches which include believe, intuition and isolated judgments per small sector.

This summary report states the main lines along which the work was elaborated, and presents the main findings and recommendations. For further details, reference will be made to relevant sections in the accompanying annex report.

## 2. Methodology

The menu of HIMO options was divided in two groups: i) infrastructure development (road rehabilitation), leading to better integration of agricultural production regions in markets; and ii) investments in land improvement (terracing, agro-forestry and forestry activities) which enhance agricultural production potential. All of these individual options entered in Cost-Benefit Analysis (CBA), whereby three situations were considered: the without case (A), the case with HIMO intervention but without agricultural intensification (B), and the case with HIMO intervention and agricultural intensification (C). All situations A-C involve benefits and costs, which need to be discounted to capture social time preference: the more distant benefits are, the less attractive they are. Several investment criteria can be calculated, the most important of which are the Net Present Value (NPV – discounted cash flow over years of lifetime of the investment) and the Internal Rate of Return (IRR – defined as the interest rate at which the NPV of an investment is 0). In this study both the NPV and IRR criteria are used. NPV and IRR (IRR) were calculated for the two with investment cases against the without case (i.e. B vs. A and C vs. A)[4].

The CBA calculations were made twice: with financial CBA, analyzing the private benefit for the investor; and with economic CBA, repeating the analysis with effects occurring at the level of the entire (national) society. Financial CBA was carried out as if the direct

[4] See Section 2.1 in the Annex Report

beneficiaries had made the investment themselves (in reality heavily subsidized by the project). This approach was taken from the point of view that successful HIMO projects should be replicable by beneficiaries without project intervention. In the economic CBA, all prices should reflect real costs/benefits for society, i.e. they should be exclusive of subsidies and other trade regulating mechanisms. Moreover, implicit pricing of non-traded costs and benefits should be taken into account. This is where major difficulties may occur, as some effects of investment options may represent important but intangible costs/benefits. One of such effects, the creation of permanent rural employment, will be given consistent attention throughout the study.

In order to evaluate the effects of specific HIMO interventions, a large amount of data is required. Moreover, many assumptions need to be made. As a consequence, the analyses made can not be more accurate than the quality of the input data fed into them. Hence, the development of a decision-making tool that can be adapted once better data are (or become) available provides a particularly welcome element in a prioritization strategy[5]. This tool is based on thoroughly tested impact assessment methodologies with a rather simple architecture and limited data requirements. It consists in coupled spreadsheet models for the separate effects of water-, nutrient-, and acidity-limited agricultural production. The separate models for evaluation of water- and nutrient-limited production have gained global application through FAO and Wageningen University research. These models combined were also already applied to diverse agro-ecological conditions ranging from arid (Tunisia), through semi-arid (Burkina Faso) to humid conditions (Indonesia and Jamaica). In the framework of the present study, this tool was: i) extended to include a larger variety of HIMO options; and ii) adapted to the conditions in the Albertine Rift Valley.

The decision-making tool considers investment and maintenance costs of HIMO interventions and production costs of crops grown (which may vary according to site data and crop rotation)[6]. Seasonal crop production is subsequently simulated in soil water, nutrient and acidity modules (based on site, crop rotation and crop response data), and crop output value assessed (this is based on crop yields and price effects induced by HIMO activities). Discounted cash flows of costs and benefits (over a period of 20 years) enter in a financial CBA to yield financial efficiency of the HIMO investment. Off-site effects (costs and benefits to society that result from the HIMO activity without affecting the investor directly) are subsequently added and an economic CBA is made. Finally, an overview is presented of the intangible costs and benefits not included in the CBA, in any case including the creation of permanent employment.

For CBA, lifetime of the investment options should be equal to be able to compare different alternatives. If equal lifetime cannot be assumed, re-investment of the shorter-lived alternative should be considered for a comparative evaluation of different options. It should be noted that the lifetime of investments assumed in this study (20 years) is only possible with an effective maintenance strategy in place.

# 3. The costs of HIMO investment options

## *3.1. Investment costs*

The HIMO menu of options includes different types of land improvement measures[7] (soil and water conservation measures, forestry activities and marshland development) and

[5] The decision-making tool is described in Section 2.5 in the Annex Report
[6] See Section 2.4 in the Annex Report for an overview of various types of costs and benefits
[7] A list of HIMO investment options with further details is presented in Section 3.1 in the Annex Report.

rehabilitation of roads. Soil and water conservation (SWC) measures include radical (or bench) terraces, progressive terraces (*fanya juu*), hillside ditches (*fanya chini*) and agro-forestry[8,9].

Investment costs of SWC interventions consist for a large part of labor costs. Soil movement requires most labor, hence it is clear that bench terraces have higher establishment costs than progressive terraces or hillside ditches (Table 1). Steep slopes require closer spacing of individual structures; hence investment costs rise with increasing slope gradient. As will become clear later, labor opportunity costs of farmer have a large impact on profitability of terrace construction.

**Table 1: Labor input and total cost of different SWC interventions on the HIMO menu of options**

| HIMO option | Source | Labor input (PD $ha^{-1}$) | Total cost (FRW $ha^{-1}$) |
|---|---|---|---|
| Radical terraces | HELPAGE (SIG/HIMO pilot project) | 1540 | 1,418,834 |
| | MINITERE | 1019 | 1,021,350 |
| Progressive terraces | HELPAGE (PRP/HIMO pilot project) | 500 | 500,000 – 600,000 |
| Hillside ditches | | | |
| Agroforestry | | | 123,300 |
| Agroforestry + Hillside ditches | | | 197,300 |

Woodlots are essentially intended to establish on-farm (fuel-) wood resources as an alternative to forest use. Woodlots can be included in a crop rotation with a cycle of some years (Nyadzi *et al.* 2006). As such this system can be regarded as a special form of agro-forestry. The establishment costs of 1 hectare of woodlots (and those of other forestry activities) consist of tree seedling production in nurseries and on-site plantation[10]. Typical planting densities are (SIG/HIMO data): i) for reforestation: 2500 plants $ha^{-1}$ (a planting grid of 2x2m); ii) for agro-forestry on farms: 240 plants $ha^{-1}$ (5x10m) [11]; iii) along routes: 5m intervals – assuming a planting strip with a 'width' of 0.4 m – 5000 plants $ha^{-1}$).

Road construction by HIMO approaches has worldwide received most attention as roads have since long been regarded as catalyst for development. While in principle any type of road could be constructed with HIMO technology, it is important to assess the comparative advantage of this approach (as opposed to HIEQ) on a case-by-case basis (Emanuel Rubayiza, pers. comm.). In the present study, focus is exclusively on rehabilitation of unpaved rural roads.

Many factors come to play in determining the investment costs of road rehabilitation. It is convenient to make a major distinction between the roadway itself and the structures needed to span waterways and drain water across or underneath the road (in culverts). The number and size of these structures, in turn dictated by the topology of the terrain, will have a large impact on average costs per km. When rehabilitating a road, existing structures should be examined and a decision should be made about the need to replace, repair or maintain them.

[8] Agro-forestry refers to land use practices where perennial trees (or shrubs) are deliberately integrated with crops and animals on the same land unit. This has advantages (tree products) and disadvantages (competition for space, light, water and nutrients). Further details are available in Section 3.1 in the Annex Report.

[9] It is important to realize that these options are not the only ways to control runoff and soil erosion. Other measures include the use of cover crops, mulching, trash lines, deep tillage, ridge and furrows systems, and more holistic approaches such as conservation farming and integrated soil fertility management.

[10] Seedlings can either be purchased in the market when available or nurseries need to be set up by the project. This issue is discussed in Section 3.1 in the Annex Report.

[11] Reported planting densities are possibly non-optimal. For instance, trees, shrubs and grasses on terraces at the Kisaro station (Byumba, Rwanda) have been found to compete with crops for water, nutrients and light, and it was concluded from long-term trials that crops only (no agro-forestry) yielded best economic returns. Section 4.6 presents a methodology for assessing benefits of agro-forestry.

Road construction involves site clearing, widening of the roadway, grubbing and breaking rocks that stand in the way, creation of the longitudinal drainage channels and diversion ditches, shaping of the road body, mining of laterite, spreading of laterite over the road body, and compaction of the laterite layer. Based on experience from the PRP/HIMO project, road rehabilitation costs on average US$ 18,000 $km^{-1}$, although important differences existed between individual roads. In North-Kivu, close to Butembo, 13 km of new road has been constructed through the organization APAV and supported by VECO, to create car, motor and bike access to the Graben (a fertile plain that is almost not exploited), going zigzagging down a very steep slope, for US$ 3,000 $km^{-1}$ (H. Breman, pers. comm.)[12].

### 3.2. Maintenance costs

Maintenance costs of measures implemented on farm land need to be borne by farmers. Thus, it is important that farmers are aware of the importance of maintenance[13]. Good maintenance includes: i) abstinence from adverse practices; ii) training on good management practices; iii) farmer recognition of the benefits of the measure and necessity of maintenance; iv) development of an exit strategy once measures reach the end of their (perceived) economic life; v) actual investment of labor and resources in maintenance.

Actual maintenance requirements are very hard to determine. For preventive maintenance activities, it is difficult to estimate what would happen without it. As a rule of thumb, preventive maintenance should not surpass (discounted) costs incurred by the lack thereof. For repairs, the difficulty lies in predicting where, when and how much of it is needed. Repairs often require urgent action, as the investment might be critically endangered if necessary repairs are not carried out. If the relation between good preventive maintenance and costs of repairs (or worse, loss of the investment) is not clear, there is a high risk of neglect of maintenance. In the present study are considered the costs of: i) regular pruning/cutting of grasses and agro-forestry species to avoid competition for light, water and/or nutrients with crops; ii) maintenance applications of lime. Lime applications of 250 kg $ha^{-1}$ $yr^{-1}$ may suffice to avoid a decrease in soil pH (Beernaert 1999)[14]; iii) regular inspection, preventive maintenance and repairs of physical SWC elements such as bunds, ditches and terrace risers. Following Tenge (2005), maintenance costs for physical structures are estimated at 4% of investment costs; for all other elements 2% is assumed.

Forestry activities can be carried out at private, communal or public land. In the first case, the same observations as for SWC measures apply. For communal and public land, a maintenance strategy should be elaborated and – if necessary – funds reserved. (Potential) problems include excessive cutting/pruning of lake border protection strips, free-rider problems (e.g. access of livestock during the phase of initial tree growth, illegal woodcutting, and non-participation in maintenance activities), and low tree survival rates[15]. PRP/HIMO project estimates include maintenance costs for the first year. Assumed is that these costs (25% of total investment costs) reoccur in the second year, and reduce thereafter to 10% of the maintenance cost in the initial year annually. Costs in the first two years are assumed to represent costs of replanting, while costs in subsequent years are pruning costs. When

[12] The differences being so large, it is recommended that technical construction engineers liaise with VECO to understand where important economizations can be achieved.
[13] Section 3.2 in the Annex Report lists some examples of management issues encountered.
[14] Throughout this report, it is assumed that lime is of a good quality. According to Beernaert (1999) good quality lime is available regionally (see Section 4.6 in the Annex Report for further details).
[15] Section 3.2 in the Annex Report discusses these issues in some more detail.

pruning has a productive purpose, these costs are included as production costs and the value of pruning residues is accounted for as a benefit.

Road maintenance has frequently been mentioned as a factor of primordial importance for safeguarding accessibility – and therefore – development. The lack of road maintenance supposedly contributed to the below-average economic performance in Africa in the past decades (Porter 2002). Lack of road maintenance leads to longer travel time and higher vehicle operating costs and – as a consequence – increasing transport prices. Further deterioration of road condition may lead vehicle owners to avoid the road altogether. After severe degradation of the road, maintenance of the road itself is also not feasible anymore, and road rehabilitation (new major investment) is required.

Burningham and Stankevich (2005) distinguish three types of maintenance: routine (small-scale work to ensure daily passability and prevent premature deterioration), periodic (large-scale organized works requiring technical supervision in order to 'preserve the structural integrity of the road'), and urgent **(**repairs that cannot be foreseen but require immediate action).

Low institutional capacity and organizational problems are a frequent source of failure to maintain roads. It is not always clear who is responsible for road maintenance, so that roads enter a vacuum once the road construction phase is finished[16]. Whatever strategy to road maintenance is taken, a coordinated effort vested with a public agency with sufficient management capacity is crucial. Crucial factor to success is also a sense that not all (stretches of) roads have the same maintenance costs[17].

International figures of costs of routine labor-based rural road maintenance vary from US\$100 to US\$317 km$^{-1}$ year$^{-1}$ (Vaidya and Tusanasorn 2004). With US\$ 218 per km per year, HELPAGE Rwanda estimates are at an intermediate level. Costs for periodic maintenance are higher, but occur at larger intervals. Grading and re-gravelling are two activities that need to be carried out. Although Burning and Stankovich (2005) mention that this is required every 3 years, Vaidya and Tusanasorn (2004) argue that on low volume transport roads, once in 8 years may suffice. An average estimate from international experience for periodic maintenance is US\$ 1500 per km (range US\$ 400 – 2000), or US\$ 250 annuity (Vaidya and Tusanasorn 2004).

Data on factors influencing road maintenance costs should be collected to arrive at better assessment of maintenance costs[18]. In the present study, due to lack of this type of information, the following assumptions were made[19]:

- Minimal cost of (routine) maintenance for all roads is 10,000 FRW per km per month (all labor).
- Basic periodic maintenance costs are 825,000 FRW (US\$ 1500) km$^{-1}$, to be carried out once every 8 years. However, on roads with a traffic intensity of more than 50 vehicles per day or roads in mountainous zones, periodic maintenance is necessary

[16] Section 3.2 in the Annex Report includes a description of problems with road maintenance in the PRP/HIMO program, and a discussion of possible solutions.
[17] In the PRP/HIMO program, one stretch of 23 km of the Nyungwe forest road, at an average altitude of 2000 m, precipitation above 2000 mm year$^{-1}$ and unstable soils, has been blocked by 53 landslides in just 3 months (Boniface Nsabimana, pers. comm.), each costing about 100,000 FRW to remove. Although the road verges are thought to stabilize over time, this figure – compared to the other two roads in the program experiencing no landslide problems – may illustrate how different maintenance requirements can be.
[18] See Table 14 in Section 3.2 in the Annex Report for an overview of data requirements.
[19] For Burundi and Congo DRC, the same costs are assumed, converted in local currency. Further details in Section 3.2 in the Annex Report.

every 6 years. On roads which are both relatively high traffic intensity and located in mountainous zones, periodic maintenance is necessary every 4 years. Periodic maintenance costs consist for 60% of labor.

- The case of the Nyungwe road stretch mentioned above is taken to be a 'worst-case scenario' for urgent maintenance cost, with additional initial costs of 76,812 FRW per month per km, declining at an assumed rate of 25% per year. Three levels of urgent maintenance requirements are defined between this extreme and the low of a zero cost. All urgent maintenance costs are assumed to consist for 60% of labor and 40% of equipment costs.

### *3.3. Production costs*

Depending on agro-ecological zone and crops grown, production costs on farm land vary. Furthermore, the three production situations A-C (A. without HIMO intervention, B. with HIMO but without intensification, and C. with HIMO and intensification) influence production costs. In the first place, these differences are caused by a difference in the use of inputs. Secondly, SWC measures may facilitate or complicate cultural operations. Thirdly, planting density and volume of produce may be different, or the cultivation of different crops is made possible thanks to the SWC measure, all of which alter production costs.

Production costs are estimated as follows:

1. For each agro-ecological zone current crop productivity is assessed based on agricultural statistics and supplementary information.
2. For these circumstances, input levels (consumables and labor) are estimated, either from agro-economic surveys, interpolated from levels in other zones, or from levels in other countries with similar conditions.
3. For production situation A. these input levels are assumed to remain unchanged over the entire period of the study (20 years)
4. For production situation B. these input levels are adjusted to reflect changes as described above; in particular labor inputs may change relative to situation A.
5. For production situation C, adjustments of input levels are made to reflect both changes in the use of consumables and labor relative to situation A. In what concerns fertilizer use, recommendations per crop and agro-ecological zone are taken from fertilization trials (Kelly and Murekezi 2000) or interpolated if no data were available.
6. If secondary products are becoming available (e.g. fodder production), associated (labor) costs are considered as well.

Reliable data on production costs is hard to come by, with a virtual absence of labor estimates[20]. Comparing available data from different zones and/or for different crops, it is clear that some are for more intensive production situations than others. By these differences, net revenues tend to vary quite a lot (from US$ 59 to US$ 1,390 $ha^{-1}$ [21], respectively for cassava and banana cultivation in North Kivu). In absence of good labor input estimates it is very hard to calculate accurate net revenues, or labor opportunity costs. Labor input costs

[20] See Section 3.3 in the Annex Report
[21] See note to Table 18 concerning banana; it is hard to conceive a production value larger than US$ 400 $ha^{-1}$.

were taken from a study made in Kisii District, SW Kenya for various crops (and for various types of farms) (Schmidt and Swoboda 1979) [22].

With forestry, the boundary between maintenance and production costs is less clear as with crop production, as the investment is constituted by the trees themselves. To maintain the investment is to maintain the trees. Whether there are production costs involved depends also on the purpose of tree planting. All activities geared toward putting the trees to productive use could be considered production costs. Here, the distinction is made between activities critical to the survival of trees (=maintenance cost) and activities executed to get the highest possible return to forest production (=production cost). Forestry activities for productive purposes on farmland should create benefits in short or medium term, at least for the vast majority of farmers generally facing land shortage. Experiences from Tanzania and Benin were taken as examples to calculate costs and benefits of rotational woodlots (Ramadhani *et al.* 2002). Several activities carried out in the first year (watering, digging micro-catchments for water conservation, weeding, gapping) are to be considered as maintenance costs. However, pruning of trees in the following years is a production cost. In the Tanzanian case, this activity required 8.8 PD $ha^{-1}$ and was carried out in year 2. Pruning yielded firewood worth US$ 23 $ha^{-1}$. There were no costs (nor benefits) in year 3 and 4. Wood cutting after 5 years cost 36.5 PD $ha^{-1}$ and wood chopping an additional 121.9 PD $ha^{-1}$ (the fresh wood yield amounting 153 ton $ha^{-1}$).

Rotational woodlots were also investigated in the coastal savanna of West Africa (Benin) by W.A. Toose et al. (IFDC Africa, H. Breman, pers. comm.). They compared fertilizer response and profitability of mixed maize – *Acacia auriculiformis* systems to continuous maize cropping. They concluded that with good access to maize and wood markets and over a four-year period, the Acacia woodlot system provided considerably higher net revenue (€1212 $ha^{-1}$) than continuous maize production (€814 $ha^{-1}$), with a marginal rate of return of over 1000%. Results indicated the need for P fertilization, both with and without Acacia.

# 4. Factors influencing agricultural production

## *4.1. Agro-ecology* [23]

Crop growth and productivity is governed by a variety of local conditions. Altitude (influencing temperature), precipitation, and soil type are some of the most important factors. Without being exhaustive, this section provides some details of the environment.

The Albertine Rift Valley is a highland region. The lowest point is formed by Lake Tanganyika, at 773 meters above sea level. The highest point is Mount Karisimbi, an extinct volcano of 4,507 meters on the border of Rwanda and Congo DRC. Several agro-ecological classifications have been made for the region. The main distinction is between soils on weathered rocks with high iron content, soils developed on volcanic materials, and alluvial soils. The two latter categories are generally very fertile. Volcanic soils are specifically localized around chains of ancient or active volcanoes, oriented SW-NE North of Lake Kivu. Older basaltic volcanic rock is also present south of Lake Kivu. Vast areas of alluvial soils developed in broad floodplains. These are present to the South-West (the Imbo) and a small band along the NE lake border of Lake Tanganyika, and in the elongated valley of Lake Edward.

[22] Agro-ecological conditions in Kisii District, a high altitude area (1450-2200 m asl) with average annual rainfall of 1800-2000 mm, are roughly comparable to the conditions in the Albertine Rift Valley.
[23] This section presents a rough sketch of agro-ecological conditions of the Albertine Rift Valley. National classifications are presented in Section 4.1. in the Annex Report.

The region is dissected by two mountain ranges, one at either side of the Rift Valley chain of lakes. From South Burundi to Northern Rwanda, the Congo-Nile divide forms the watershed boundary between the Nile and the Congo Rivers. Across the Congolese border, water streams first into Lake Kivu and Lake Tanganyika before with a wide bow reaching the Congo River just behind the Mitumba mountain range. The volcano range acts as a divide in the Rift Valley, with Lake Albert feeding the Albert Nile.

The climate in the Albertine Rift Valley can be characterized as types Aw and Cw in the Köppen system, depending on whether daily temperature during the coldest month surpasses 18°C (Aw). While the effect of temperature modified by altitude is considered as a function of the potential crop production for each agro-ecological zone, precipitation and potential evapotranspiration are required as input for the decision-making tool (and specifically the water balance module). These data were acquired through the New LocClim Local Climate Estimator (Version 1.10)[24], which contains a large database of climate station data.

Throughout the Albertine Rift Valley, climate is bimodal, with the following seasons:

1. Great rainy season, lasting from February to May (Agricultural Season 'B')
2. Great dry season, lasting from June to August (This period is sometimes used for relay cropping in marshland areas – where this is the case it is known as Agricultural Season 'C');
3. Small rainy season, lasting from September to November (Agricultural Season 'A')
4. Small dry season, lasting from December to January

However, important regional differences do occur[25]. In North Kivu the bimodality of precipitation is less pronounced than in other locations (transition zone to the perhumid Congo lowland region). The short dry period is nowhere a real dry spell, but rather a smooth transition period between two rainfall peaks. Modality of the small dry season is highest in Kinigi, N Rwanda and reduces towards SE Burundi, where rainfall patterns are becoming unimodal. Going in S/SW direction, the great dry season becomes more pronounced. Even highland zones in Burundi have a clear dry spell in June-August. Some zones have particularly high spatial rainfall variability. SW Rwanda and W Burundi have an escarpment-like slope where rainfall regimes change sharply over short distances. Decreasing rainfall in eastern direction is a clear trend in the northern region (Rwanda), but less so when going south. Potential evapotranspiration is fairly constant throughout the year in the North-East, but becomes more variable both when going east and south. Moreover, average annual values increase in the same direction. Together with rainfall patterns, this pinpoints at higher risk of drought in these areas. Extreme peaks of monthly rainfall occur in several places (e.g. in April in Kinigi and March in Kinyinya). Such high intensity rainfall could lead to severe erosion problems.

Acrisols are the most commonly found soils in Rwanda. The physical quality of these soils is good, but their chemical fertility is low, as is biological activity. Mineralization rate is also slow. In the more weathered acid zone also Humic Ferralsols occur. Acid highland soils maybe gradually improved by amendment of organic matter (so-called anthropic soils near houses in intensely cultivated areas). Ferralsols have excellent drainage, but this constitutes a high risk for leaching after terrace construction, especially when not intensified.

[24] New LocClim Local Climate Estimator is developed by Jürgen Grieser (2006) and supported by FAO. The software is downloadable from ftp://ext-ftp.fao.org/SD/Data/Agromet/New_LocClim/

[25] This paragraph describes trends inferred from data from 13 climate stations, Figure 8 in the Annex Report.

The Nile-Congo crest has deep soils (>1 m) with 35 – 60% clay, mostly classified as acrisols. In the Byumba highlands, soils are 50 – 100 cm deep, contain 35 – 60% clay and include mainly leptosols and humiferous ferralsols. Volcanic soils (andosols) are characterized by black topsoil. While very fertile, they are notorious for phosphorus fixation problems and high water erosion risk. They have a high water holding capacity. The Central plateau (Rwanda) is also covered by acrisols, but they are generally less weathered (pH 5 – 5.5), with low to medium content of exchangeable bases, and less problems of Al-toxicity. To the west, soils are mainly cambisols (with considerable erosion) and fluvisols. Soils on the shores of Lake Kivu are shallow (0 – 50 cm) and contain 20 – 60 % clay. The eastern part of Rwanda has a large variety of soils: ferralsols, fluvisols, leptosols, cambisols.

### *4.2. Runoff and soil erosion*

Soil erosion has often been stated to constitute a major risk associated with intense cultivation of the frequently steep slopes in the Albertine Rift Valley. While soil conservation practices have increased (up to the beginning of the 1990's), soil erosion has augmented more as a result of increasing utilization of marginal lands driven by population growth (Lewis and Nyamulinda 1996). In the 1991 agro-economic survey, on average 1.4% of holdings owned land treated with radical terraces, 21.6% reported having planted hedgerows (on average 56m/ha), 47.8% anti-erosion ditches (161m/ha) and 60.3% grass strips (205m/ha) (Clay 1996). The use of these measures decreased from 76% of land covered in 1991 to 65% in 2000 (Kelly *et al.* 2001)[26]. In Burundi soil conservation has received less attention. About 70% of cultivated lands in Rwanda are located on steep slopes (>18%). About half of the country is believed to suffer moderate to severe erosion (Lewis and Nyamulinda 1996).

Table 2 synthesizes results from a large quantity of erosion plot studies, and gives an overview of the amount of erosion that can occur under various crops and management practices. Apart from hedgerows and grass-strips also mulching of banana, cassava and coffee is an efficient soil erosion control method, which moreover is actually an improved land husbandry practice not requiring investment costs.

**Table 2: Synthesis of erosion and run-off values collected on run-off plots in Rwanda and Burundi**

| Plant cover | Treatment | Erosion (t ha$^{-1}$ yr$^{-1}$) | Runoff (% rainfall) |
|---|---|---|---|
| Bare soil | tilled parallel with the slope | 300 to 550 | 10 to 40% |
| Manioc or potato, maize/bean or pea-sorghum, as companion crops | traditional hoe tillage | 50 to 150 (300) | 10 to 37% |
| Crops + idem + 200 trees/ha | litter 50 kg/tree/yr | 30 to 50 (111) | 5 to 7 % |
| Idem + trees + hedges every 5 to 10 m | Biomass | year 1: 7 to 16 | 10 to 15% |
| | 3 to 6 kg/m²/yr | year 4: 1 to 3 | 1 to 3% |
| Idem + trees + hedges | ± covered ridges every 5 m | 1 to 4 | 0.1 to 2% |
| Banana plantation | open, mulch removed (10 t/ha/yr) or | 20 to 60 | 5 to 10% (45) |
| | complete, mulch spread out or in lines | 1 to 5 | 0 to 2% |
| Coffee plantation or manioc | thick mulch (20 t/ha/yr) | 0 to 1 | 0.1 to 10% |
| *Pinus* forest, pasture, old fallow | (5-15 t/yr of litter) | 0 to 1 | 1 to 10% |

Source: Roose and Ndayizigiyé (1996)

In order to include soil erosion problems in the assessment of yields, the Universal Soil Loss Equation (USLE) can be applied. The USLE considers erosivity of rainfall, erodibility of

[26] Preliminary data of a national farm survey in 2005 mention 64% of parcels treated: 5.1% radical terraces, 38.6% hillside ditches and 20.4% other measures (MINAGRI, unpublished data).

soils, slope length and steepness, soil cover and management practices[27]. HIMO activities may help conserve the soil either by affecting slope parameters (terracing), soil cover (different crops or plant densities, use of mulch) and management practices. Erosion as expressed in the USLE result, i.e. ton of soil loss per ha, is not a useable indicator to assess the effect on agricultural production. While one could, in extreme cases, imagine that soil loss exceeding the rate of soil formation leads to direct consequences of diminishing rooting depth (and soil volume for the crops to explore), the approach further taken here is to:

- assess the effect of soil nutrients taken away (see Section 4.4)
- assess the effect of water runoff; water which does hence not infiltrate and cannot be consumed by the crops on the field (see paragraph below and Section 4.3)
- assess the economic cost of sediment lost (i.e. downstream sedimentation, Chapter 6)

The above-described approach to estimate erosion does not include an estimate of runoff. Table 2 gives an idea of the amount of extra water that enters in the soil water balance. Runoff is in the decision making tool included as a percentage of monthly rainfall, with a distinction between high rainfall (e.g. > 60 mm month$^{-1}$) and low rainfall, with corresponding difference in surface runoff estimates (e.g. 30% in high rainfall months and 15% in low rainfall months).

### *4.3. Soil water availability*

This section briefly explains how soil water availability is assessed in the water balance module of the decision-making tool[28]. The spreadsheet model described draws heavily from de Graaff (1996). It works with a time step of one month[29]. The soil water balance addresses precipitation, runoff (water lost for infiltration in the soil through overland flow), evapotranspiration, and deep drainage (water lost for plant production by percolation below the rootzone). The balance between these fluxes is the net amount of water stored or lost from the soil profile. Precipitation and potential (reference) evapotranspiration are considered as a function of location (as explained in Section 4.1). Surface runoff is the defined as the portion of rainfall that does not enter the soil but is lost right away. As was shown in the previous section, runoff is defined as a percentage of monthly rainfall. The transpiration requirement of agro-forestry species is given priority above (annual) crops, because they are already well-established when the annual crop still needs to develop its root system, and will as a consequence have a head start in assuring water supply[30]. Eventually, the calculated ratio between actual and potential evapotranspiration determines the effect of water-stress on crop yield (Doorenbos and Kassam 1979).

### *4.4. Soil nutrient availability*

Apart from yield reduction due to water-stress, also nutrient stress may impact on yields. Although a causal relationship cannot be assumed, many authors point at a general trend of declining productivity in the region. Some authors attribute this generally negative trend to soil nutrient mining (Henao and Baanante 1999). Rwanda and Burundi have one of the most negative balances on a country-level of whole SSA). The situation in Kivu might be just as bad, but no disaggregated data are available. However, findings of other scientists warn to exert caution to the above indirect link between productivity and soil mining. Yields have

[27] Details on how this is done are presented in Section 4.2 in the Annex Report.
[28] For a complete description, please refer to Section 4.3 in the Annex Report.
[29] This time step is adequate for the purpose here defined to assess differences between production situations.
[30] Assumptions of water requirements of agro-forestry species are included in Section 4.3 in the Annex Report.

been found to increase with rising population density. Mazzucato and Niemeyer (2000) showed that nutrient depletion as suggested by e.g. Henao and Baanante (1999) can not be validated in the field. De Ridder et al. and Breman et al. (H. Breman, pers. comm.) showed that this can be explained by the transport of nutrients from range-, bush- and wasteland to crop land: general nutrient depletion thus does not easily concern the cropland![31]

The use of fertilizer in the region is extremely low, even for African standards. Thereby, the option of organic manuring is limited. Even if every rural family had a cow[32] (Rwanda government policy objective), which excretes 11 kg N year$^{-1}$ (of which 20% will be lost), this would not be sufficient to offset the negative balance on the average farm area of 0.83 ha per household. More problematic still is the feed supply for the cows. Assuming the cow needs a feed intake containing 25 kg N year$^{-1}$, and a grassland productivity of 30 kg N year$^{-1}$, the 1.4 million cows would require an area equivalent to almost halve the country to feed on! This could of course be reduced if the cattle are fed with agricultural residues and waste, but this would render the cropland balance even more negative.

Analyzing whether such synergy is possible is the objective of the nutrient balance module of the decision-making tool. This module is based on the approach of Stoorvogel and Smaling (1990) using a spreadsheet model as proposed by de Graaff (1996). The general agricultural nutrient balance distinguishes 5 nutrient influxes and 5 nutrient outfluxes:

| | | | |
|---|---|---|---|
| IN1 | = Chemical fertilizer | OUT1 | = Harvested products |
| IN2 | = Organic manure | OUT2 | = Removed crop residues |
| IN3 | = Atmospheric deposition | OUT3 | = Leaching |
| IN4 | = Biological N-fixation | OUT4 | = Gaseous losses |
| IN5 | = Sedimentation | OUT5 | = Erosion |

While a nutrient balance could be prepared for many nutrients (although most commonly N, P and K are considered), in the present study the focus is on N. There are two reasons for this limitation: i) nitrogen is the most limiting nutrient on the majority of fields; and ii) data availability to assess profitability of other nutrients is severely lacking (no or very few trials have been carried out solely using other nutrients, so that the effect cannot be attributed to specifically to the nutrient of interest)[33,34].

With negative nutrient balances a gradual rundown of the N stock occurs. Fallowing may, through limitation of erosion and biological N-fixation, replenish the N stock, but this is a slow process. The generally perceived better performance after fallowing is mainly related to a *de facto* input of organic manure through rapid mineralization of plant residues. Although this is not standard accounted for in the module, it is solved by calculating the stock N build up over the period of fallowing and supplying 50% of the difference as IN2 instead of gradual release through mineralization.

[31] This issue is discussed in more detail in Section 4.4 in the Annex Report.
[32] Assumed is that Rwandan cattle is equivalent to a tropical livestock unit (TLU), 250 kg live weight.
[33] To certain extent, this is also true for N, which was almost always applied together with manure or compost, and where NPK or DAP were used, there may have been interference from P and K as well. Thus, indirectly, some attention is given to these elements as well.
[34] This limitation should by no means be interpreted as if other nutrients are not important. Occasionally, reference will be made to other nutrients, and the recommendations include some aspects that clearly need CATALIST's attention.

### 4.5. Soil acidity

Strongly weathered soils throughout the tropics are generally characterized by low pH values. There is important concern that terracing might increase problems of soil acidification (H. Breman, pers. comm.) as can be witnessed by 4,000 recently constructed radical terraces not being put to use in SW Rwanda (Sylvain Roy, pers. comm.). This section reviews how soil acidity affects crop yields, how it can be managed, and whether this can be captured in a simple model.

What is the problem? As Wenzl *et al.* (2003) put it nicely: "In acid soils, exchange sites vacated by cations leached out of the soil profile are occupied by Al ions solubilized from decomposing primary minerals. The result of this natural acidification process is a complex syndrome of Al (and sometimes Mn) toxicity, deficiencies in Ca, Mg, and Mo, and a frequently low availability of P as a result of chemical fixation." Cations are lost during cultivation. Soil acidity primarily impacts on crop yield by Al toxicity. Aluminum decreases plant root elongation resulting in a poor root system and hence decreased uptake of water and nutrients, particularly for Al-sensitive crops. Al-toxicity starts below a pH-value of 5.4 (Beernaert, 1999).

The regional problem of acid soils is related to altitude, parent material and land management history. In the volcanic zone of NW Rwanda, soil pH is about 5.8. In the eastern part of the country, with much lower annual rainfall, pH values are ~7.2 (at Kibungo). However, the highlands of Gikongoro and Byumba have a prevalence of pH values <5. About 600,000 ha of acid soils are cultivated in Rwanda, mainly west of the axis Kigali-Butare (Beernaert 1999)[35].

Soil acidity is not a static soil property. Soil pH is a variable parameter subject to seasonal variation (for instance as a function of soil water content). However, long-term trends of acidification are commonly reported when soils are cultivated. An important source of acidity formation is a cation:anion uptake ratio by crops greater than unity. This ratio varies from crop to crop, and also depends on the source of N for plant nutrition. If plant material decomposes where it grew, there is no net change in soil acidity. However, removal of agricultural produce breaks the cycle, by exporting alkalinity (Randall *et al.* 2006). Application of acid-forming N fertilizers such as $NH_4$, $NO_3$, $(NH_4)SO_4$ and $NH_2$-CO-$NH_2$ may aggravate soil acidity problems (He *et al.* 1998). Soil acidification by nitrogen fertilization is the effect of $H^+$ ion release through nitrification of $NH_4^+$ and the subsequent leaching of $NO_3^-$.

Soil acidity can be corrected by liming. However, as (very) acid soils besides presenting toxic effects of $Al^{3+}$, $Mn^{2+}$ and $H^+$ are usually also in an advanced stage of weathering[36], increasing the pH in the soil to reduce the presence of those toxic elements in the soil solution may not lead to yield increases. A direct effect of liming alone can be expected in the following cases:

1. Al-toxicity in the subsoil is so strong that it effectively reduces the actual crop rooting depth. In this case, immobilization of $Al^{3+}$ ions may help roots to develop to deeper soil layers and explore a greater soil volume.
2. Current yield levels are not affected by nutrient limitation. This could be the case in less strongly weathered soils, and when crops or cultivars sensitive to the toxic effects associated with low pH are grown.

[35] More details are provided in Section 4.5 in the Annex Report.
[36] In 10% of the acid zone in Rwanda K is a limiting nutrient (exchangeable K < 0.3 cmol(+)/ kg soil) (Beernaert, 1999).

A simple module has been created to evaluate the effect of soil pH on crop yields, based on a model described by De Klein *et al.* (1997)[37].

Rwanda disposes of limestone and dolomitic resources, in Ruhengeri and Lake Kivu regions respectively. Limestone contains 40% CaO and is directly applicable as soil amendment without problems; dolomitic resources contain 30% CaO and 20% MgO, and should only be applied mixed with 70-80% lime travertine to avoid Ca/Mg imbalances (Beernaert 1999). According to this author, in treating acid soils it is better to split lime applications over several years. In this way, the effectiveness can be higher, the risk of disturbances of soil life is minimized, and farmers may spread the investment involved.

After treatment, an annual maintenance dose of 0.25 t $ha^{-1}$ $y^{-1}$ is recommended. Erosion control is indispensable, as there is a low response to lime / fertilizers on sloping fields. All doses reported presume good quality lime is used.

As an alternative to attempt to treat acid soils, one could also match these soils with crops that are acid tolerant (they can cope with high Al-toxicity levels): pineapple, coffee, tea, rubber, cassava. Leguminous crops like cowpea and pigeon pea are also more tolerant than beans or soybeans.

While liming has a positive effect on reducing soil acidity, SOM management has also been advocated (Zhang *et al.* 2007)[38].

### *4.6. Agro-forestry*

As agro-forestry is promoted as a HIMO option, it is important to review effects of the introduction of tree and/or shrub species in the farm field. A vast literature exists on the topic, which can not be discussed here. However, quite some agro-forestry research is documented within the region. A selection of the main findings of these researches will be given.

In agro-forestry systems, one of the principal issues is that different species have different capabilities in capturing resources, especially if one of the components is an annual and the other a perennial (Ong *et al.* 1991). The following types of competition may occur in hedge-barrier systems (Kiepe 1995): above-ground competition for light; below-ground competition for water; below-ground competition for nutrients; and competition for space.

In the decision-making tool, agro-forestry is integrated in the soil water balance and soil nutrient modules, as well as in a separate agro-forestry module[39].

First, in the agro-forestry module a percentage of the cropped area is assumed to be affected by competition from the roots of agro-forestry trees (this percentage should be estimated)[40].

Competition for water is assumed to affect the water balance of the entire cropped area proportional to the importance of the extension of the zone of influence. Whereas water stress is assessed on an area-basis, nutrient competition is assessed on a biomass production basis.

---

[37] For details about this module, refer to Section 4.5 in the Annex Report.
[38] For further discussion, see Section 4.5 in the Annex Report.
[39] For further details, see Section 4.6 in the Annex Report.
[40] Competition for light is not taken into account; it is assumed that crops are of primary importance and effective pruning of agro-forestry trees takes place.

# 5. Factors influencing agricultural output value

## *5.1. Farmer objectives*

Smallholder cropping choice is a delicate mixing of crops for cash (potatoes, beer bananas, coffee), calories (cooking bananas, sweet potatoes, cassava) and proteins (beans, peas, and, to lesser extent, cereals) (Clay *et al.* 1995).

Not all farmers pursue the same mix. Of major importance are the farm household's relative distribution of (and marginal values for) the production factors land, labor and capital. Most commonly, farm households in the region have a lack of land. In Rwanda the average cultivable area per household is 0.74 ha (2002). However, in Gisenyi it is only 0.49 ha, in Ruhengeri 0.53 ha and in Cyangugu 0.60 ha. These provinces have population densities approaching 1,000 inhabitants $km^{-2}$ [41]. Regional differences at district level would probably present even more problematic regions. The most densely populated provinces (i.e. Gisenyi, Ruhengeri and Cyangugu) all have a very uneven geographical spreading of the population. The same could be said for Umutara province, which is for the vast part a low-density area.

Apart from regional differences, within-region differences are important. The land distribution issue in a context of increasing population and declining productivity leads to a stratification of how people value land, labor and capital. Overall, land availability per household declined over 1990-2000. This change (in % of original area) has possibly been larger for the relatively well-off (McKay and Loveridge 2005). However, the further decline of the area owned by the poorest people is much more critical. Sales of crops have decreased for all quartiles of the farm households, but most strongly for the poorer 75% of the population. Moreover, off-farm labor opportunities do not seem to have improved, except for the least poor.

Social criteria have been left out of the current analysis. In the light of studies such as those by (Andre and Platteau 1998) and (Byiringiro and Reardon 1996), it is clear that rural households can be divided in several classes with different (land) assets and opportunity costs of labor[42].

## *5.2. Prices of agricultural inputs and outputs*

Prices of agricultural inputs and outputs are crucial factors to the profitability of farming. A price database of almost 10 years (January 1997 – August 2006) with data from more than 50 markets in Rwanda (at least 30 at any point in time) was analyzed for different trends. Price developments were also available from FAO Burundi. Although constituting a less exhaustive database than the one for Rwanda, it was possible to identify some trends[43].

The prices of agricultural inputs, and more specifically the differential between input and output prices has a strong impact on the profitability of farming. It is one of CATALIST's principal aims to make agricultural inputs both more readily available and more affordable. Rwanda and Burundi being landlocked countries at more than 1500 km from the nearest seaport, and the Kivu provinces of Congo DRC being even more isolated because of inexistent national infrastructure, prices of fertilizers and other agricultural inputs are high. Although much can be gained from various project interventions in the agricultural input sector, agricultural intensification is aided by the fact that prices of fertilizers have risen less

[41] These data are discussed in the light of other sources in Section 5.1 in the Annex Report.
[42] Andre and Platteau in their influential study even established a link between growing disparities between social groups and the chances of becoming a victim during the atrocities in 1994.
[43] Price trends for selected commodities for both countries are discussed in Section 5.1 in the Annex Report.

than output prices[44]. As a consequence, the value/cost ratio of fertilizer application has on average been greatly improved since 1999 (Laurence Mukamana, pers. comm.). The largest single increase can be attributed to fertilization of potatoes in the volcanic zone (AEZ 5C). On average, cost effectiveness of fertilization of rice (not shown) and sweet potato increased most. Nearly all V/C ratios are larger than 2, so that fertilization can be (strongly) recommended.

Economic prices can be different from financial prices. One of the reasons is existence of import taxes on certain goods and products. Having joined the Common Market for Eastern and Southern Africa (COMESA) in 2004 and participating in its Free Trade Area, Rwanda and Burundi have abolished any taxation on products manufactured within the member states[45].

### *5.3. Accessibility of rural areas*

The development of input and output markets can, and according to many should, accompany direct agricultural development. This section reviews how roads constructed or rehabilitated by HIMO technology can contribute to increasing agricultural output value. It takes a broad perspective on this question based on aspects that have been reported from other areas. In line with this broad perspective, various effects of road construction and rehabilitation are discussed; some only indirectly related to development of input and output markets. A cross-cutting issue in many studies cited is poverty reduction. While the purpose of road rehabilitation in the CATALIST project has been more narrowly defined, the experiences with poverty reduction certainly are of interest. Furthermore, HIMO approaches are often compared with HIEQ approaches. Although not of primary importance, as HIEQ is not considered as an approach, this comparison provides some additional information on the effects of HIMO works.

In a study on sustainable land use and distance to the market in Benin, Gandonou (2006) concludes: “the empirical results confirm that higher use of mineral fertilizers necessitates good roads. The effect of road access on the use of physical soil conservation technologies is positive, although not precisely estimated. Food crop output improves under good roads. But the effect appears low in economic sense. The study shows that marginal product of labor in food production is higher when road access is easy, allowing some labor to be freed and eventually redeployed on other crops/activities. The empirical data have indeed confirmed that the cultivation of commercial crops and non-farm employment expand under good roads. The study alerts that rural roads deserve more attention in development research and interventions in poor regions than before.”

Citing studies from the 1980’s, Keddeman (1998) concludes that there is widespread consensus that HIMO works contribute to mitigate short-term food insecurity and loss of income of the rural poor. Targeting of beneficiaries of employment opportunities is a function of wage levels paid, with chances for poor people increasing when wage levels are low. Involvement of the poor is further also influenced by the amount of work available, with comparatively low amounts leading to selection of relatives and friends of the local elite in Sri Lanka (Stolte, 1988, cited in Keddeman, 1998). Income comparisons of non-participating and participating households have demonstrated higher levels of non-participants in Lesotho (50% higher), demonstrating the self-targeting effect of the rural poor, but lower levels (–20 %) in Burundi as a consequence of work payments. Opportunity costs of unskilled labor have

[44] A trend also notable on the world market
[45] Currently comprised of Burundi, Djibouti, Kenya, Madagascar, Malawi, Mauritius, Rwanda, Sudan, Zambia and Zimbabwe

been estimated at 10% (Nepal), 33% (Mauritius), 50% (Lesotho, Tanzania and Zimbabwe), 60% (Ethiopia), 75% (Cambodia) and near 100% (Thailand) of wage levels paid for participation in HIMO projects. Concentration of work in off-season was the reason for low alternative employment possibilities in Nepal.

Value of time savings is unlikely to be high due to high unemployment. In Lesotho access to banking services, building materials shops, agricultural inputs and butcheries were most frequently mentioned when beneficiaries of a road construction were asked about the impact of the road (Keddeman 1998).

Loveridge (1991) concludes that paving of roads between cities in Rwanda has led to increased market integration for dry beans. However, market integration has contributed to the peculiar situation that most regions of the country are not self-sufficient in beans and the majority of rural households (83%) are net purchasers. Transport costs to remote regions (Cyangugu) could add 40% to the price (October 1986). On the other hand, farmers in Kibungo, a zone of surplus bean production, experienced a price about 20% lower for the same reason.

According to Porter (2002), transport costs on bad roads may be double (Ghana) or more (Zambia) compared to well-accessible ones, due to higher vehicle maintenance costs. Off-road inhabitants in rural areas in Ghana mention access to health-care as the most urgent problem, followed by access to traders and markets.

A new tool for prioritization materialized in the 1990's, which became known as Integrated Rural Accessibility Planning (IRAP). It is build on the insight gained since the 1980's that rural transport is mainly undertaken by foot (head load), and that road construction (or improvement) not necessarily leads to rural development. Instead, in this context, improving **accessibility** of services sought by rural populations was found to be the objective, with rural roads constituting one of several means to achieve that objective. IRAP as a planning tool was developed in Malawi (Dingen 2000) and The Philippines (Donnges *et al.* 2006)[46].

The decision-making tool includes a transport module to evaluate the effect of increased accessibility. The transport module allows distinguishing up to 12 road sections. This is for example intended to determine as accurately as possible the area that will benefit from the road. Per section a section width can be defined to either side of the road to arrive at the total area that benefits from the road. Section width may vary according to several factors. First, a general willingness to use the road for marketing purposes will be limited. This willingness will in practice vary, e.g. as a function of topography. Another reason for adjusting a section width may be that the road is adjacent to unusable land (i.e. a National Park). Also vicinity to alternative roads may be a factor.

From the beginning and end point of the road stretch, distance to an (external) market may be defined. If the market is located at either end, a distance of 0 km should be entered. Up to three internal markets can be defined.

For each road section area, the percentage of the population that is dependent on agriculture can be defined. The transport module subsequently calculates the total agricultural population served by each road section and sums them up for the entire road.

The decision-making tool further allows specifying for each road section whether it is currently passable for different types of transport, and the contribution of each type of transport can be calculated taking into account the average velocity of different modes of transport as well as average transport capacity. By specifying time and/or price of transport

[46] IRAP is further discussed in Section 5.3 in the Annex Report.

for different situations (i.e. a case without road improvement and a case with road improvement), differences in transport costs can be assessed. Such differences can subsequently motivate farmers to change (increase or decrease) their market involvement in agricultural inputs and outputs.

While it is possible to use the above method in the decision-making tool, it was found to be too demanding in data requirements (e.g. location of markets, current and (estimates of) future transport fluxes). Instead, the area with improved access conditions, and resident (agricultural) population were estimated. The entire area was subsequently assumed to benefit (or suffer) from altered prices. In evaluating the profitability of road improvements, the effect of agricultural intensification (if present) on yields is assessed with two prices: the price in the case without improvement for produce consumed by the farm family, and the price in the case with improvement for produce marketed. Produce marketed is determined by a variable base percentage specified per crop, and potential extra marketing of the quantity of produce that surpasses farm household energy requirements.

# 6. Prioritizing HIMO interventions

## *6.1. Making strategic choices*

In Chapters 4 and 5 the agro-ecological and socio-economic determinants of agricultural productivity and particularly the contribution HIMO activities can make to it were discussed. To increase agricultural productivity there are two options to depart from: i) concentrate on crops with potential for intensification (CATALIST's perspective); or ii) concentrate on crops which currently give a good return.

These two options are interrelated: if after intensification returns to a crop are below levels currently existing for alternative crops, chances for success are limited. However, increasing input levels in a currently profitable crop that does not lead to increased productivity is also deemed to fail. This section briefly introduces the current financial profitability of crops to have a reference point for subsequent analyses of HIMO activities. It does so based on model simulations of the current cropping situation (with current defined as Situation A – the without case – with minimal soil erosion, but with full accounting for nutrient depletion). Four agro-ecological zones were chosen for a brief characterization (the Rwandese zones 4B – Butare, 4C – Kigali, 5B – Byumba and 5C – Ruhengeri); for these zones best data were available (Table 3)[47].

**Table 3: Financial profitability of the three most profitable crops for different agro-ecological zones**

| Type of return to most profitable crops | Agro-Ecological Zone | | | |
|---|---|---|---|---|
| | 4B | 4C | 5B | 5C |
| | Banana# | Sweet potato | Sweet potato | Potato |
| Return to land (FRW $ha^{-1}$) | 525,000 | 357,000 | 570,000 | 360,000 |
| Return to labor (FRW $PD^{-1}$) | 4,875 | 2,285 | 3,350 | 1,143 |
| | Sweet potato | Banana# | Banana# | Sweet potato |
| Return to land (FRW $ha^{-1}$) | 399,000 | 260,000 | 398,000 | 244,000 |
| Return to labor (FRW $PD^{-1}$) | 2,495 | 2,665 | 3,815 | 1,720 |
| | Cassava | Peas | Beans | Banana# |
| Return to land (FRW $ha^{-1}$) | 100,000 | 8,000 | 154,000 | 139,000 |
| Return to labor (FRW $PD^{-1}$) | 880 | 525 | 1,015 | 1,660 |

Note: #Profitability of banana is still underestimated as the model can handle rotations up to 4 years – the first two years banana is not yet fully productive.
Source: model simulations based on data from various sources.

47 For a discussion of these results, see Section 6.1 in the Annex Report.

### 6.2. Financial evaluation of HIMO interventions

Table 4 summarizes the results of analyses of the financial profitability of the different HIMO interventions. Below some observations are made for each intervention individually[48].

**Radical terraces** reduce erosion, lead to changes in water availability and nutrients, and reduce production costs due to better workability of terraced fields. Moreover, by these effects the response to intensification (i.e. fertilizer application) may be far greater. Apart from the investment, terraces present also additional costs in the form of maintenance requirements including liming to avoid soil acidification, and loss of effective available land area, although the risers of the terraces could be planted to grasses, and the edges of the terraces could be used for planting agro-forestry trees[49]. However, while these areas as such can generate some benefits, these are not comparable to cropping. Only when agriculture on the terrace area can be substantially intensified, radical terraces can have a positive NPV.

**Progressive terraces** are cheaper to construct than radical terraces and equally effective in curbing soil erosion and runoff. Soil lost (by erosion or downslope movement by tillage) will gradually accumulate on the downslope section of the terrace. By these characteristics progressive terraces may not facilitate cultural operations as much as radical terraces, at least initially. Furthermore, seed and fertilizer may still be washed down prior to actual terrace formation. The soil acreage lost for cropping is slightly higher. The only major difference is that the return to the investment is much higher.

Where progressive terraces are not profitable or where erosion is not a major problem, **hillside ditches** could prove to be a viable alternative. At about a third of the investment cost, erosion can be controlled[50]. A disadvantage is that the slope is only very slowly modified, so workability is not substantially improved[51,52]. An advantage is the lower loss of cultivable area compared to progressive terraces. At an IRR of 17% (B) and 16% (C) this investment is profitable. However, the returns to labor and land remain below standards. Both improved situations still degrade substantially. The fact that situation B is evaluated slightly better than situation C may illustrate that intensification under these conditions is not sustainable. Hillside ditches (and in fact also progressive terraces) are not appropriate under all conditions[53].

A wide variety of **agro-forestry** interventions is possible, all than not in combination with other (erosion control) interventions. The profitability of hedgerows in AEZ 2A (Rwanda) is low, and a closer examination explains why: without intensification (situation B), crop yields are decimated as a result of the loss of area to hedgerows and competition (for soil nutrients). The competition for space and nutrients is masked by fertilizer application in the intensified situation (C). When combined with hillside ditches, situation B results in slightly worse performance, mainly due to the fact that the area loss is more substantial in order to accommodate for the ditches as well. The better control of soil erosion can not offset this disadvantage. Situation C does not result in a better profitability of the investment. In contrast, in AEZ 4E agro-forestry with intensification is a very profitable enterprise.

---

[48] A full description of the results for each HIMO intervention is available in Section 6.2 in the Annex Report.
[49] Whether this is economically efficient will be evaluated.
[50] Provided that contour plowing is practiced (or other SWC measures such as mulching, minimal tillage, etc.)
[51] As an example, model estimates show that progressive terraces reduce field slope from 30 to 9% after 20 years, hillside ditches (with hedgerows) reduce the same slope to 20%.
[52] Not everybody agrees that workability improves by flattening of a slope. An agronomist at Butembo insisted that slopes are pleasant for working the soil: much less back pain! (H. Breman, pers. comm.).
[53] See further details in Section 6.2 in the Annex Report.

To assess financial profitability of forestry, i.e. from a farmer perspective, **rotational woodlots** are the most appropriate activity. As they claim the farmer's resources, notably land, the without case should constitute conventional cropping practice. An important problem constitutes the determination of the optimal harvesting date[54]. The profitability of rotational woodlots was evaluated for AEZ 5A. When woodlots are implemented, during the first two years crops can be grown in between the young trees. However, as tree density is high, yields are severely reduced. In fact, cropping is not profitable, and profitability of the woodlots would be much higher (IRR of 242%) without intercropping. Although yields become much higher under intensified management, it is still better not to intercrop. Low prices of wood do not lead to the disqualification of woodlots as HIMO activities. In AEZ 5C, because of higher wood prices and more favorable agro-ecological conditions, intercropping with young trees is advantageous and financial profitability is high.

**Road rehabilitation;** a number of roads was assessed[55]:

- **Kinigi – Gahuna2** (15 km, Rwanda). This currently impassable road is in densely populated area in AEZ 5C, for the major part following the contour of the border of the Volcanoes National Park. According to the consultant's estimates, a zone of 3300 ha of agricultural land and with near 40,000 inhabitants will experience better accessibility. Intensification thus leads to very interesting results, with a NPV of 27 times the investment (IRR of 479%). Without intensification, the effect of price increase does not lead to a positive NPV at a discount rate of 10% (IRR of 7%).
- **Nyabitsinde – Mutovu2** (46.8 km, Rwanda). This road consists of several stretches in variable condition, at two points approaching towards the main road between Ruhengeri and Gisenyi. The road crosses entirely through densely populated volcanic highland (AEZ 5C), following the contour of the border of the Volcanoes National Park until continuing to the Congo DRC border in the East. This road opens access to an area of 13,360 ha, inhabited by 120,000 people. Yields are very responsive to intensification. Intensification leads to very interesting results, with a NPV of over 50 times the investment (IRR of 915%). Without intensification, the effect of price increase is still considerable with an IRR of 22%.
- **Kibumba – Mudende** (18 km, North-Kivu – DRC). This road starts at Kibumba on the road between Goma and Rutshuro and ends at the border with Rwanda (Mutovu). Despite the trans-border character of this road (together with Nyabatsinde – Mutovu road in Rwanda), no important impetus is expected for cross-border traffic, as the agro-ecological conditions are similar and international traffic is already served by the Gisenyi – Goma border post. Being a very fertile zone, improved access could however give a strong incentive for agricultural intensification.
- **Mparamirundi – Muvumo** (47 km, Burundi). This road starts at the road Muramvya – Butare at 1700 m altitude, to rise to 2400 m altitude at the Kibira National Park and to slightly descend again to 2200 m before reaching the Rwandese border at Muvumo. This road is currently not passable. Its rehabilitation increases access to an agricultural area of about 20,000 ha in Northern Burundi, inhabited by an estimated 160,000 people. It crosses two agro-ecological zones: Buyenzi and Mugamba. The financial profitability is very high when combined with agricultural intensification.

[54] Section 6.2 in the Annex Report explains how the optimal harvesting date can be determined.
[55] Important notes on these results are included in Section 6.3.

- **Mabayi – Ruhororo** (12 km, Burundi). This road section runs parallel to the eastern border of the northern patch of the Kibira National Park. Located entirely at high altitude, and in human environment, this road is put in the highest maintenance cost category due to landslide risk (cf. Nyungwe forest road experience). It is the final, currently impassable stretch of a road crossing the border into Rwanda. By proximity of the Imbo plain, there is supposedly potential for cross-border trade. It also enhances access to an agricultural area of 4500 ha, inhabited by 25,000 people. Financial profitability is very high when combined with agricultural intensification.

**Table 4: Summary of the financial profitability of different options on the HIMO menu, for various agro-ecological zones.**

| HIMO type | Zone* | Crop rotation** | Investment | Production situation | | | |
|---|---|---|---|---|---|---|---|
| | | | | B. Without intensification | | C. With intensification | |
| | | | | NPV | IRR | NPV | IRR |
| Radical terrace | AEZ 5B | POT-MAI-BEA-MAI | 1,358,834 FRW | -883,843 FRW | 1% | -139,365 FRW | 9% |
| | AEZ 5C | POT-WHE-BEA-WHE | 1,358,834 FRW | -1,464,463 FRW | n/a | -642,260 FRW | 3% |
| Progressive terrace | AEZ 5B | POT-MAI-BEA-MAI | 595,834 FRW | 53,762 FRW | 11% | 827,814 FRW | 24% |
| | AEZ 2A | MAI-BEA-SWP-CAS | 595,834 FRW | -139,972 FRW | 7% | -170,564 FRW | 7% |
| Hillside ditch | AEZ 2A | MAI-BEA-SWP-CAS | 197,167 FRW | 170,339 FRW | 17% | 142,286 FRW | 16% |
| Agro-forestry | AEZ 2A | MAI-BEA-SWP-CAS | 123,300 FRW | -57,979 FRW | 6% | -82,621 FRW | 4% |
| | AEZ 4E | SWP-WHE-SOY | 123,300 FRW | -395,162 FRW | n/a | 804,779 FRW | 82% |
| Agro-forestry + | AEZ 2A | MAI-BEA-SWP-CAS | 197,300 FRW | -97,923 FRW | 5% | -124,807 FRW | 4% |
| Hillside ditch | AEZ 4E | SWP-WHE-SOY | 197,300 FRW | -391,229 FRW | n/a | 665,696 FRW | 46% |
| Rotational woodlot | AEZ 5A | POT-WHE-BEA-WHE | 520,000 FRW | 2,995,029 FRW | 91% | 2,839,993 FRW | 81% |
| | AEZ 5C | POT-WHE-BEA-WHE | 520,000 FRW | 5,376,911 FRW | 110% | 5,637,460 FRW | 128% |
| Road rehabilitation: | | | | | | | |
| Kinigi – Gahuna2 | AEZ 5C | POT-WHE-BEA-WHE | 189,934,500 FRW | -28,399,601 FRW | 7% | 5,190,279,911 FRW | 479% |
| Nyabitsinde – Mutovu2 | AEZ 5C | POT-WHE-BEA-WHE | 531,696,200 FRW | 345,775,737 FRW | 22% | 27,412,069,742 FRW | 915% |
| Kibumba - Mudende | C3 | MAI-WHE-BEA | 412,082 US$ | -8,217,033 US$ | n/a | 29,475,224 US$ | 1078% |
| Mparamirundi - Muvumo | B4 | MAI-WHE-BEA | 1,404,313,400 FBU | -2,209,326,789 FBU | n/a | 85,123,785,379 FBU | 929% |
| Mabayi – Ruhororo | B3 | POT-MAI-SWP-BEA | 502,761,000 FBU | -1,576,866,448 FBU | n/a | 28,819,619,631 FBU | 1156% |

Notes: *Codes for AEZ are explained in the Annex Report; **Abbreviations for crops used: BEA = Beans; CAS = Cassava; MAI = Maize; POT = Potato; SOY = Soybean; SWP = Sweet potato; WHE = Wheat.

### *6.3. Robustness of financial profitability of HIMO activities*

Section 6.2 presented various assessments of the financial profitability of HIMO activities. Many assumptions were made to arrive at the stated levels of profitability. This section has a threefold objective: i) to identify the factors with major influence on financial profitability; ii) to document some selected sensitivity analyses; and iii) to make suggestions for improved robustness of estimates. The following factors have a major influence on financial profitability while themselves uncertain:

- **Agricultural productivity (current and potential).** It is not hard to see that under- or overestimation of either current (without case) or future (with-case) agricultural production will have a significant effect on the profitability of HIMO investment.
- **Trends of agricultural productivity.** The assessment tool includes modules for erosion, soil water availability, soil nutrient availability, soil acidity and competition between agro-forestry and crops. Effects are accumulated over the total simulation period, and under- or overestimations can therefore have a large influence. An important issue is for example that in the without case, farmers already undertake management practices that affect these factors.

- **Input and output prices.** Price information was mainly available from markets. Farm gate prices were estimated from these available data. The most difficult to price is labor. If labor opportunity costs are lower than assumed, than profitability of agriculture raises substantially – even in the case without HIMO investment. Moreover, the influence of HIMO activities (most notably road rehabilitation) on price levels is largely unknown and includes effects of increased accessibility, comparative advantages between regions, and shifts in supply and demand.

From extensive sensitivity analyses, agricultural productivity and output price levels appear to have the largest influence on the financial profitability of HIMO investments[56].

Three special cases were considered for a further sensitivity analysis: a) the combination of agroforestry and terraces, and b) the costs of agricultural inputs (lime); and c) the scale effect of road rehabilitation. These case studies will be based on a single example, as it may be assumed that results will be more or less similar under other agro-ecological conditions[57].

**Agroforestry and (radical) terraces**; agro-forestry (AF) interferes with crop production. Nutrient competition reduced yields to 55-80% of the level without AF (differences per crop, beans in this case being more heavily affected than maize), when the amount of nutrients taken up by AF is a fraction of the standard nutrient requirement at AF productivity of 5 ton fodder $ha^{-1}$ and 8 ton fuel wood $ha^{-1}$. Spatial competition until 50% overlap between AF and cropped area (AF being in addition also capable of exploiting the risers of terraces) did not result in yield reduction. However, thereafter maize is rapidly affected by water shortage. Potatoes and beans seem to profit somewhat from this reduction: the nutrients not taken up by maize can now be consumed by these crops. At still higher spatial competition, potato yields also start to get affected.

**Costs of agricultural inputs (lime);** lime price affects the profitability of a combination of agro-forestry and hillside ditches in AEZ 4E. Increasing lime prices lead to the optimum lime application being a bit reduced.

**Scale effect of road rehabilitation;** In the analyses of Section 6.2, it is assumed that the entire agricultural zone which experiences improved access participates in the agricultural intensification process and takes benefit from increased marketing opportunities. Although there is a direct linear relation between the size of the area benefiting and the financial profitability, even a reduction by e.g. 50% leads to unparalleled results. Only when the participating area would be below 10%, would the IRR perhaps enter in the danger zone. Road rehabilitation will usually lead to alterations in the price levels of agricultural inputs and outputs – that is in any case the primary reason to embark upon such projects. Expectations are that prices of outputs increase and those of agricultural inputs decrease. The magnitude of these changes is uncertain, and in some cases adverse price trends may manifest themselves. However, price levels of agricultural outputs would need to fall by more than 30% to do harm to profitability. Price level changes of agricultural inputs (e.g. fertilizers) have a lower impact on profitability.

### *6.4. Economic evaluation of HIMO interventions*

The previous section dealt with the financial profitability of HIMO interventions. An economic evaluation takes into account all costs and benefits from a societal perspective. At the level of investment, maintenance and production costs, this means that some prices of inputs need to be adjusted to account for shadow prices, opportunity costs and fiscal

[56] Detailed analyses are presented in Section 6.3 in the Annex Report.
[57] The results from these analyses can be better understood by referring to Figures 24-26 in the Annex Report.

measures. More important, and also more difficult to quantify, are the negative and positive effects of the investment to the society. These include employment creation, environmental effects, and socio-economic effects each of which will be touched upon below. This section is mainly qualitative in nature, as it is impossible to quantify all effects.

**Economic costs of inputs;** considering that the two major cost types that need to be adjusted, labor and imported goods, work in opposite direction and the net economic cost of HIMO activities is generally not very different from the financial cost.

**Employment creation;** The combination of war-related destruction of previous productive infrastructure, large-scale displacement, and ongoing population growth has contributed to the current situation in which the rural workforce is only partially deployed. An important precondition for stabilization and poverty reduction is the creation of employment. Mellor (2002) stresses the important role smallholder agriculture has to play in this respect, not only because in Rwanda (like in Burundi and Kivu Provinces of Congo DRC) 90% of the population lives from agriculture, but also because agricultural growth leads to multipliers in the rural non-farm sector.

Table 5 shows the cumulative effect of direct employment in investment in HIMO interventions, the multiplier effect it generates through increased expenditure of laborers, and the net effect of employment creation by the investment[58]. The multiplier was thereby set conservatively at 1.5, the lower end of Keddeman (1998). The table shows notably an effect of 'density': bench terraces create a lot of employment but also require high investment. It is therefore useful to analyze how much employment is generated per dollar invested. The results of this analysis are remarkable in that they clearly normalize the previously skewed distribution. While agroforestry interventions are good 'employment for money', roads in combination with agricultural intensification (and only then) may be very efficient.

**Table 5: Total employment creation through HIMO: direct employment, multiplier effect and agricultural intensification**

| HIMO Activity | Employment creation (PD ha$^{-1}$ equivalent) | | Id. (PD ha$^{-1}$ eq. \$$^{-1}$) | |
|---|---|---|---|---|
| | Situation B | Situation C | Situation B | Situation C |
| Bench terraces | | | | |
| AEZ 5B | 2289 | 2413 | 0.93 | 0.98 |
| AEZ 5C | 2289 | 2471 | 0.93 | 1.00 |
| Progressive terraces | | | | |
| AEZ 5B | 745 | 867 | 0.69 | 0.80 |
| AEZ 2A | 757 | 846 | 0.70 | 0.78 |
| Hillside ditch | | | | |
| AEZ 2A | 366 | 465 | 1.02 | 1.30 |
| Agroforestry | | | | |
| AEZ 2A | 465 | 575 | 2.07 | 2.56 |
| AEZ 4E | 454 | 591 | 2.02 | 2.63 |
| Agroforestry+Hillside ditch | | | | |
| AEZ 2A | 443 | 546 | 1.23 | 1.52 |
| AEZ 4E | 426 | 550 | 1.19 | 1.53 |
| Woodlot | | | | |
| AEZ 5A | 957 | 1055 | 1.01 | 1.12 |
| AEZ 5C | 996 | 1099 | 1.05 | 1.16 |
| Roads | | | | |
| Kinigi-Gahuna2 | 34 | 229 | 0.33 | 2.19 |
| Nyabitsindi-Mutovu2 | 26 | 221 | 0.36 | 3.06 |
| Kibumba-Mudende | 13 | 186 | 0.33 | 4.86 |
| Mparamirundi-Muvumo | 18 | 134 | 0.26 | 1.95 |
| Mabayi-Ruhororo | 19 | 135 | 0.19 | 1.31 |

[58] The latter factor is also presented separately in Section 6.4 in the Annex Report.

Apart from generating employment, HIMO activities with or without agricultural intensification also (generally) increase the return to labor. This is particularly welcome, as many of the analyses in Section 6.2 demonstrated current returns to labor (much) below the wage rate of $1 per day considered as the poverty line[59].

**Environmental externalities; Soil erosion** has frequently been mentioned as one of the major agricultural problems of the African Great Lakes region. From a societal perspective, it is a question how serious this is a problem. In the financial analysis, the reduced on-farm yields were accounted for (through nutrient losses[60]). Off-site effects are external to the farmer and do not end up in the financial analysis. Such off-site effects could include destruction of infrastructure, sedimentation on valley fields or in reservoirs (reducing hydro-electric capacity) and in lakes (threatening lacustrine biodiversity), and flashfloods and mud streams (endangering human lives). **Deforestation** is also of alarming concern. Rwanda lost 57% of its natural forests between 1980 and 1999 (from 513,600 ha to 212,000 ha). Presently 18% of the country is covered by forest, 47% of which is natural. The country can only sustain about 70% of its forest products needs (Mihigo 2001). Burundi similarly lost more than half of its natural forest in the same period, from 104,000 ha in 1980 to less than 50,000 ha in 1997. The total forested area in 1997 was 113,000 ha (Mihigo 1999). Major deforestation is also taking place in the Virungas National Park (North Kivu, Congo DRC). Any HIMO activity geared towards reforestation or introducing alternative sources for wood may help reduce the destruction of natural forests. Besides, improved control and better livelihoods for communities living close to the remaining forests should help protect these resources. On the other hand, increasing access to forested areas without proper control mechanisms in place may lead to further pressure. Intrinsically linked to the problem of deforestation is the threat to biodiversity.

**Socio-economic effects;** as was referred in Section 5.3, accessibility plays a crucial role in rural development. Apart from its contribution to agricultural intensification through better linkages to input and output markets, accessibility has worldwide been found to lead to better access to education, healthcare and other services. Some alternatives on the HIMO menu of options have effects surpassing the local level. For instance, the plan to link Kisoro and Goma by rehabilitating the road connecting them may have far-reaching consequences beyond the area of intervention: i) the road is the main artery of trade between Congo DRC and Uganda, and – more importantly – eventually the ports of Mombassa and Dar es Salaam. The completion of this stretch will have national importance to Congo; ii) price levels – generally above the regional average for many products in Kivu may drop. The exact effects of a road with such importance beyond the function of a local level feeder road require closer study; iii) time savings in transport along the road and reduction of vehicle maintenance costs may become substantial by the amount of (increased) traffic.

## *6.5. Considerations for selecting the most promising HIMO activities and specific zones of interest*

Based on the financial evaluation of HIMO activities (Section 6.2), and with additional information from the sensitivity analyses and economic effects (Sections 6.3 and 6.4), it is possible to define the most promising HIMO activities for agricultural intensification. Although the data presented in this report are biased towards Rwanda, the conclusions are

[59] Results on return to labor (and land) are included in Section 6.2 in the Annex Report.
[60] In addition, direct damage to seeds being washed down the slope or damage to plants being uprooted could occur; these on-site effects were not accounted for.

also valid for Congo DRC and Burundi. The roads included in these countries have similar or higher levels of profitability than the ones in Rwanda. With similar levels of labor costs and higher levels of prices of agricultural inputs and outputs, farming under similar agro-ecological conditions should be at least as profitable. The situation of access to markets may be more constrained, with HIMO options for road construction thus having higher priority. Differences between financial profitability of similar types of investments in different areas may be small enough to base decisions on other criteria, as currently being elaborated by the CATALIST project for Congo DRC. With the possible exception of woodlots, all HIMO interventions should be promoted simultaneously with agricultural intensification. Where market access problems and environmental concerns are low, intensification without HIMO activities is sufficient. Otherwise, to create momentum it is better to start combined HIMO interventions / agricultural intensification in zones that can serve as model areas, that is zones of guaranteed success. In the next Chapter, we return to the originally proposed HIMO activities to verify whether they meet the criteria.

# 7. The HELPAGE proposal in its new context of the CATALIST project

## *7.1. The original HELPAGE proposal*[61]

The original HELPAGE proposal focuses on environmental conservation of the following transboundary ecosystems located within the Albertine Rift Valley (HELPAGE 2006): i) Virunga National Park (Congo DRC), connected with Vulcan's National Park (Rwanda); ii) Lake Kivu, shared between Rwanda and Congo DRC; iii) Nyungwe National Park (Rwanda), and its continuation as Kibira National Park (Burundi); iv) the flood plain of the Rusizi River, shared between Rwanda, Burundi and Congo DRC; and Lake Tanganyika, shared between Burundi and Congo DRC.

This region is subject to different forms of environmental degradation and pressures on its natural resources: i) soil erosion; ii) landslides; iii) sedimentation of lakes; iv) accelerated deforestation to meet household demands; v) high dependence of livelihoods on inappropriate agricultural production methods, without replenishing soil nutrients. Moreover, the region – poor and dependent on subsistence agriculture and livestock breeding – has recently gone through turbulent decades of extreme violence and severe socio-economic changes, to the detriment of its ecological and economic assets.

Justification is given that abovementioned protected areas have suffered surface area losses ranging from 10% (Kibira NP) to 65% (Vulcan's NP), and should be saved from following the fate of smaller protected areas such as Mukura Forest and Gishwati Natural Reserve, which have lost 73% and 98% of their original area (1960) respectively. Besides their important biodiversity, the Afro-mountain forest areas regulate the hydrological cycle of the lakes and the river basins they belong to, and the lowering of the water table of some of the lakes can be attributed to the loss of these natural forests.

The general objective of the original HELPAGE proposal was to "contribute to the sustainable management of natural resources for the socio-economic development of the transboundary population in Burundi, Rwanda and Congo DRC to promote stability, peace and poverty reduction". This was to be achieved through promotion of alternative energy sources to substitute scarce firewood resources, capacity building of profitable economic

[61] A more detailed account of this section is included in the Annex Report (Section 7.1), which is in turn based on the original HELPAGE proposal.

marketing chains to assure food security, promotion of HIMO activities for employment creation and increased income-generating opportunities in rural environments, and supporting environmental governance.

The project proposal had adopted a transboundary approach because: i) the African Great lakes region presents high ecological and socio-economic potential which merit a global, integrated conservation and development approach; ii) up to date, natural resources management capacity at the regional level is non-existent, with the exception of collaboration between Virunga, Vulcan's and Mgahinga (Uganda) National Parks; iii) as a consequence, actions are currently undertaken in isolation in each country and experiences are not exchanged, albeit ecosystems and communities are similar.

Further details of the HELPAGE proposal will be limited to the HIMO works envisaged under Specific Objective Number 3[62]. Targeted beneficiaries of HIMO employment include the most vulnerable and disfavored groups: women, demobilized militia, youngsters, unemployed, and aged persons. HIMO activities such as reforestation, agro-forestry and erosion control (including agricultural terraces where possible and necessary) will be undertaken in watersheds together with manure and mineral fertilizers to conserve soils and soil fertility, to diminish the impacts of water erosion and to augment infiltration of rainfall while at the same time controlling sediment losses to water courses.

These activities will generate important revenues and enable the development of income diversification activities and creation of off-farm employment which can diminish the pressure on natural resources. The program will, through rehabilitation of road infrastructure, also breach the isolation barriers of the transboundary populations in the three countries in terms of facilitating growth of socio-economic exchanges and enhanced availability of agricultural products.

Table 6 presents a list of proposed HIMO activities, for which, however the requested funding would not suffice. For those activities for which funding was included in the original proposal, costs are presented.

### *7.2. Assessment of the HELPAGE proposal within the CATALIST project framework*

The original HELPAGE proposal was clearly focused on improved environmental management to contribute to nature conservation. Within the CATALIST project, the objective of HIMO activities is creating synergy for agricultural development. This change of objective creates an entirely different perspective.

There are a number of criticisms on the HIMO activities presented in the original proposal, which should be addressed while planning HIMO activities in the CATALIST project:

- The choice of areas for intervention is not sufficiently substantiated. The original proposal mentions a multitude of physical and socio-economic factors threatening the protected areas and livelihoods of populations surrounding them, but fails to prioritize what problems exercise the biggest threat.
- The areas identified for intervention are sometimes large. So large, that it is impossible to treat them entirely with funds requested. The solution chosen to solve this problem is simple: a reduction of the area initially identified (see Table 6).

[62] Only these HIMO activities have been incorporated in the CATALIST project, and the other project components fall outside the scope of this study.

However, will it be possible to solve the immense problems when only a fraction of the area is treated?

**Table 6: HIMO activities foreseen in the original HELPAGE proposal**

| HIMO Option and Localization | Problem | Size | Activities foreseen and budget ($) | Motivation | Scope in new context* |
|---|---|---|---|---|---|
| *Road construction* | | | | | |
| [DRC] Kingarame – Ruhunde | Impassable road | 11.7 km (3 bridges) 18 km | Widening, Clean weeding, Drainage channels ($412,082) | 2 markets in DRC Exchange of agricultural and livestock products | ++ |
| [RWA] Nyabitsindi – Muhingo – Mutovu | Road in bad condition | 46.8 km | Widening, Clean weeding, Quarrying, Stone crushing ($1,002,627) | Promote tourism Surveillance Virunga NP Exchange of agricultural products | + |
| [RWA] Kinigi – Gahunga 2 | Impassable road | 15 km | Widening, Clean weeding, Quarrying, Stone crushing, Compaction ($358,149) | Promote tourism Surveillance Virunga NP Exchange of agricultural products | ++ |
| [BUR] Mparamirundi – Butegana – Kabarore – Muvumo (Rugazi) | Impassable road | 46.8 km | Repaving, Drainage channels, Clean weeding, Widening, Bridges, Culverts ($1,324,067) | Surveillance Kibira NP Exchange with Rwanda Exchange of agricultural products | ++ |
| [BUR] Mabayi – Bweyeye | Impassable road | 12.9 km | Repaving, Drainage channels, Clean weeding, Widening, Bridges, Culverts ($474,032) | Surveillance Kibira NP Exchange with Rwanda Exchange of agricultural products | ++ |
| *Reforestation* | | | | | |
| [DRC] Sake – Kingi – Kilolirwe – Ngandjo – Burungu – Kitchanga | Severe poaching | 55,609 ha 4000 ha | Tree nurseries and reforestation ($850,040) | Diminution of human pressure on charcoal production and agricultural encroachment | +++ |
| [DRC] Katale – Kabaya – Bweza - Kamira | Deforestation | 3072 ha 400 ha | Reforestation ($85,004) | Diminution of access to Virunga NP | – |
| [DRC] Rugari | Pressure on Virunga NP resources | 8921 ha 200 ha | Reforestation ($42,504) | Community forest resources | +++ |
| [BUR] Ruhororo – Mabaye | Deforestation, pressure on Kibira NP | 2000 ha 3000 ha | Reforestation, Tree nursery 2 million plants ($637,560) | Diminution of pressure Kibira NP Regeneration of vegetation | +++ |
| [BUR] Rusizi | Pressure on NR Rusizi | 1000 ha | Reforestation of delta (RAMSAR zone) | Aquatic and vegetal ecosystem conservation | – |
| *Agro-forestry and Erosion control* | | | | | |
| [DRC] Kingi – Kilolirwe | | 3620 ha | | | ? |
| [DRC] Jomba – Gasura | Soil degradation | 4391 ha 490 ha | Watershed management ($104,135) | | – |
| [DRC] Gahuna | Soil degradation | 10,040 ha 300 ha | Watershed management ($63,756) | Soil fertility improvement | + |
| [DRC] Kabuye | Soil degradation | 1925 ha 200 ha | Watershed management ($42,504) | Soil fertility improvement | + |
| [DRC] Bukuvu – Mudaka – Kavumu | Deforestation and Water erosion | 7000 ha | Reforestation and watershed management ($1,487,640) | Diminution of soil erosion Environmental restoration | – |
| [BUR] Mparamirundi – Buvumo | Soil degradation | 2000 ha 3000 ha | Agro-forestry hedge rows ($637,560) | Soil fertility restoration | + |
| [BUR] Bujumbura – Rumonge | Soil degradation in watersheds of Lake Tanganyika | 7000 ha | Watershed management ($1,487,640) | Diminution of soil degradation Environmental restoration | – |
| *Waterfront protection* | | | | | |
| [DRC] Sake – Bukavu | Degradation of waterfront Lake Kivu | 34 km/ 340 ha | Waterfront protection by 50 m wide agro-forestry band ($132,396) | Diminution of lake degradation Restoration of fish breeding places | – |
| [BUR] Rusizi | Degradation of riverbanks | 1000 ha | Protection of riverbanks with 50 m wide agro-forestry band | Ecosystem conservation | – |
| [BUR] Bujumbura – Rumonge | Degradation of waterfront Lake Tanganyika | 8750 ha | Waterfront protection by 50 m wide agro-forestry band ($1,859,550) | Diminution of lake degradation Erosion and sedimentation control Restoration of fish breeding places | – |

*Note: +++ heavily recommended activity; ++ strongly recommended activity; + recommended activity; ? unknown; – rejected activity.

- The areas identified for intervention are sometimes large. So large, that it is impossible to treat them entirely with funds requested. The solution chosen to solve this problem is simple: a reduction of the area initially identified (see Table 6). However, will it be possible to solve the immense problems when only a fraction of the area is treated?
- While the transboundary dimension of the problem is well-defined, and the propositions made in the proposal reflect this, the potential for transboundary regional development and conservation is not fully exploited.

The above points remain relevant when using HIMO investments for agricultural intensification. Some additional considerations can however also be made:

- Transboundary trade development may help each region to take advantage of its comparative advantages. The highest potential for increased trade exists: i) where borders divide different agro-ecological zones with mutual demand for each others products; ii) where important centers of supply and demand are separated by these borders; and iii) where current accessibility is severely limited. With the current dynamic prices of agricultural inputs and outputs, road rehabilitation in boundary areas offers an opportunity to create more stability and exchange between countries. These HIMO activities should receive the highest priority.
- Zones with high potential for agricultural intensification *without* HIMO, i.e. areas with good accessibility, high soil fertility and limited problems of environmental degradation are not priority zones for HIMO projects. Here, alternative sources of funding the investments for intensification should be developed if necessary (such as credit services).
- Similarly, highly degraded areas offer very limited potential for agricultural intensification – at least in the short run. HIMO interventions in these areas are not likely to lead to synergy for agricultural intensification. It is important not to see HIMO projects as a goal in itself, but as a means to agricultural development. The prioritization approach followed in the present study offers a decision-making tool of where to allocate funds available for HIMO activities.
- HIMO options recommended to farmers should be able to recoup investment costs at an acceptable rate of return. In this way, chances are highest that a process of adoption and adaptation is triggered, which will ensure continuity of agricultural intensification and environmental conservation beyond the end of the project.

# 8. Recommendations

## *8.1. Creating synergy*

1. HIMO activities are fully subsidized by the project; farmers do not make investments themselves. While this is a good approach for public infrastructures, it might be counterproductive in private fields. The human capital remains a decisive factor in catalyzing agricultural development. **Motivated beneficiaries should attract HIMO investment, HIMO infrastructure lying idle will not motivate people.**
2. Agricultural intensification is a prerequisite for the profitability of HIMO activities. The potential for synergy creation is large. The art is to choose those combinations and locations that catalyze the development process. HIMO projects can be a powerful tool to **simultaneously develop infrastructure that conditions**

**intensification processes and provides (part of) the financial injection to start exploiting that potential.**

3. **Synergy could be enhanced by changing focus of direct poverty alleviation to stimulating investment in agriculture.** Targeting HIMO employment to organized farmers with potential to invest wages rather than consume, and longer participation in HIMO employment are two means to do this. Another option is the promotion of input vouchers instead of cash payment. Increased access to financial services (credit) should be developed to assure continuity.

4. The full potential for synergy creation is vested in adopting a participatory approach. Farmers with a keen interest in increasing productivity should be guided and involved in HIMO technology development. If the analyses and assumptions made in the present study are correct, **recommended HIMO investments should be profitable even if beneficiaries had to pay for all costs themselves**. Building the capacity to replicate successful experiences will be the key for successful development.

### *8.2. Maintaining momentum*

5. Clear maintenance plans should be made prior to implementation of HIMO activities. Investments may rapidly degrade again when not receiving due maintenance. **All analyses were executed assuming good maintenance, and profitability of investments is sure to decrease (strongly) when not carried out.**

6. **Private and public sector agents** should be pinpointed to the opportunities created by the investment. They **should be aided in developing the services needed to assure continued benefits in the future**.

7. Provided that investments on private land are recognized as beneficial and farmers are motivated to maintain them, maintenance of public infrastructure should especially receive attention. Taking roads as an example, **maintenance requirements are often grossly underestimated – both in terms of cost and institutional capacity**, and as a consequence may not be kept up to standard. A **successful maintenance strategy addresses these issues**.

### *8.3. Prioritizing specific HIMO activities and locations*

8. As a general rule, **creating synergy between HIMO investments is most successful in zones with fertile soils and marketing potential**. Their implementation on degraded soils and isolated areas (if not opened up) increase costs and reduce benefits and is less likely to catalyze agricultural intensification and rural development. Despite this general rule, HIMO can play a role in reviving areas with specific handicaps such as acid soils. The most profitable combinations probably require much less project support in order to realize potential (project support could suffice with organizing demonstration fields and private sector development).

9. There are several reasons to belief that prices of agricultural inputs and outputs are strongly dynamic at present. **Road rehabilitation decreases susceptibility to price fluctuations by lowering transaction costs and offering new market opportunities. They have the highest priority**. Moreover, road rehabilitation

offers economies of scale in creating long-term employment – in agriculture, and through multiplier effects, in rural non-farm activities.

10. The staggering increases in (fuel) wood and charcoal in some regions indicate a severe shortage of these products. **Rotational woodlots and agro-forestry interventions give a high rate of return in deficit areas**. **They have second priority.** For poor small-scale farmers, the woodlot technology might not be accessible in view of the size of their properties and the lack of capital for investments that only after several years start producing revenues. However, as woodlots require less labor (with high returns) than alternative land use, they may free up labor for other agricultural enterprises or off-farm work.
11. Volcanic soils respond best to fertilization. Although generally less susceptible to erosion, **an important synergy creation is possible between agricultural intensification practices requiring the removal of stones from fields on andosols, and the use of these stones to construct stone wall terraces. This has third priority**.
12. Erosion control should not be the final objective, but a means to achieve agricultural intensification. **The standard priority order should not be radical terraces > progressive terraces > agro-forestry activities because of erosion control, but agro-forestry activities > progressive terraces > radical terraces unless cost-benefit analysis proves otherwise.**
13. **Reforestation and lake border protection** may have important social benefits but **are not able to create synergy for agricultural intensification**. Financial profitability is weak and may be negative. These activities, while important from an environmental perspective, **should not remain on the project's menu of HIMO options**. An exception maybe granted to particular projects where downstream benefits to agricultural intensification are substantial, but such cases were not encountered by the consultant.
14. A strategy for **prioritization of specific projects and locations** should start with those activities with rapid, tangible returns and follow a **logical sequence**. The **availability of fertilizers** is crucial for agricultural intensification (in turn indispensable for profitable HIMO investments). Those roads that will allow inputs to arrive in zones with intensification potential presently not well served, and if possible with a further hinterland, are the first step. A typical example is the connection Kisoro – Goma[63]. Furthermore, the access road to the Graben (near Butembo) is highly interesting because of motivation on behalf of the local communities (see recommendation 1, and the fact that a road has been constructed by the community itself already)[64]. The Mabayi – Muhororo road in Burundi also potentially qualifies. Concerning woodlots and agro-forestry interventions, considerations for project locations are: i) (fire) wood scarcity; ii) possibility and profitability of agricultural intensification; iii) contribution to environmental conservation; and iv) for woodlots: is synergy creation possible for labor freed up? Northern Rwanda and southern North Kivu qualify on criteria i) and ii). The Virunga's and Kibira NP are vulnerable areas, respectively for the massive scale of destruction and the elongated area.

[63] The consultant took notice of other considerations of the CATALIST project, i.e. the security situation, that may require a different sequence of action.
[64] The profitability of both roads mentioned was not assessed in this study because of a lack of (financial) data.

### *8.4. The role as CATALIST*

15. **The project should work at all levels to promote and divulgate successful synergies**. This includes everything from local level demonstration fields to national level liaising with government and NGO staff and private sector agents involved in agricultural development and HIMO activities in particular.

16. In this respect, there is an **urgent need for the development of a decision-making tool for prioritization of HIMO interventions and training of government and NGO staff in its use**. The basis for such a tool could be the spreadsheet model developed and utilized in the present study.

17. The CATALIST project being a regional project, and Rwanda being both a country with extensive experience in HIMO approaches and bilingual (French/English), the idea to establish a regional HIMO Training Center (van Imschoot and Wandera 2005) is warmly recommended. **CATALIST could, as initiator as well as client, actively support the creation of such a training center, which allows sharing experiences regionally**.

18. **For assessing impact of HIMO interventions, it is crucial to establish a good monitoring and evaluation system.** A better documentation of HIMO investment costs under different circumstances is needed. Coordination between HIMO development agencies is desirable, and such initiative (Gaude 2005) is to be supported. However, a wider context for data collection is needed to obtain such crucial information as labor input in crop production with and without HIMO interventions and intensification, and their effect on net revenue of different crops.

19. To emphasize the regional approach advocated by the project, **trans-boundary cooperation can be made concrete by implementing similar HIMO projects on both sides of regional national boundaries**. With the currently planned activities, cross-boundary synergy is limited to road construction.

### *8.5. Warnings and opportunities*

20. **Modalities for beneficiary participation in HIMO activities should be reviewed in light of the changed objective from poverty reduction to agricultural intensification**. Considerations for setting wage rates and recruitment practices are extensively dealt with in Tajgman and de Veen (1998).

21. The CATALIST project has a production system approach and will, besides priority crops receiving attention from production to consumption, pay due agronomic attention to other crops that are crucial for production systems. However, from a farmer's point of view there are undeniably crops with higher returns than others. This is for example the case in the volcanic soils region where potatoes constitute by far the most lucrative crop for farmers. **Focusing on one crop could lead to the creation of mono-cultural enterprises**. **Where such tendency is manifested, the project should inform farmers of the risk involved.**

22. Another observation with regard to crop choice can be made regarding acid soils. **Unless farmers are well-aware and capable of maintenance liming, it is more convenient and less risky to concentrate on crops that are tolerant of and/or thrive well in acid soils**. Pigeon peas and tea are examples of suitable crops, while wheat and peas are sensitive crops.

23. To **intensify rice production**, substantial improvements in water management of marshland areas are necessary. **These improvements are technically complicated, expensive and not replicable by local (farmer) organizations**. Unless CATALIST wants to involve in this for long-term support, this option on the menu of options is **not recommended**.

24. In the present study, only nitrogen was considered as nutritive element. This is justified as: i) nitrogen is generally the main limiting nutrient; ii) evidence for yield enhancement by inputs of other nutrients is scarce and more scattered. This should however by no means be taken as a license to ignore other nutrients. In fact, **the increased marketing that could result from HIMO activities in combination with agricultural intensification demands that product quality and conservation is improved, which is not possible by solely applying more nitrogen to crops**. Potassium plays a pivotal role in tuber crop conservation, phosphorus in leguminous crops and in efficient use of nitrogen by other crops.

25. **A specific opportunity in this respect is the fact that prices for agricultural products in the slack-season reportedly benefit disproportionally from increased access to production regions compared to prices at the time of ample availability**. Thus, an important incentive for improved crop storage is born.

# References

Andre C, Platteau JP (1998) Land relations under unbearable stress: Rwanda caught in the Malthusian trap. *Journal of Economic Behavior & Organization* **34**, 1-47.

Beernaert F (1999) 'Feasibility study of a production project of lime and/or ground travertine for the management of acid soils in Rwanda; agro-pedological report mission of 19/06 to 15/08/99.' (Ministry of Commerce, Industry and Tourism, Direction of Industry: Kigali).

Burningham S, Stankevich N (2005) Why road maintenance is important and how to get it done. Transport Note No. TRN-4. Worldbank, Washington D.C.

Byiringiro F, Reardon T (1996) Farm productivity in Rwanda: effects of farm size, erosion, and soil conservation investments. *Agricultural Economics* **15**, 127-136.

Clay DC (1996) Fighting an Uphill Battle: Population Pressure and Declining Land Productivity in Rwanda. MSU International Development Working Paper No. 58. Department of Agricultural Economics, Michigan State University, East Lansing, Michigan.

Clay DC, Byiringiro F, Kangasnieme J, Reardon T, Sibomana B, Uwamariya L, Tardif-Douglin D (1995) Promoting food security in Rwanda through sustainable agricultural productivity: meeting the challenges of population pressure, land degradation and poverty. MSU International Development Paper No. 17. Department of Agricultural Economics/Department of Economics, Michigan State University East Lansing, Michigan.

de Klein CAM, Monaghan RM, Sinclair AG (1997) Soil acidification: a provisional model for New zealand pastoral systems. *New Zealand Journal of Agricultural Research* **40**, 541-557.

Dingen R (2000) A Guide to Integrated Rural Accessibility Planning in Malawi. International Labour Organization/Advisory Support Information Services and Training Programme for Africa (ILO/ASIST – Africa), Harare.

Donnges C, Españo M, Palarca N (2006) Philippines Infrastructure for Rural Productivity Enhancement: Tools for Identifying Rural Infrastructure Investment Priorities. Rural Accessibility Technical Papers No. 14. International Labour Organization / Advisory Support, Information Services and Training in Asia-Pacific (ASIST-AP), Bangkok.

Doorenbos J, Kassam AH (1979) 'Yield response to water.' (FAO: Rome).

Gandonou EA (2006) 'Sustainable Land Use and Distance to the Market: Micro Evidence from Northern Benin.' (Doctoral Thesis Vrije Universiteit Amsterdam: Amsterdam).

Gaude J (2005) Design of a monitoring-evaluation information system aimed at assessing the PDL-HIMO’s cost-effectiveness Ministry of Local Government, Good Governance, Community Development and Social Affairs, Kigali.

He ZL, Alva AK, Calvert DV, Li YC, Banks DJ (1998) Effects of nitrogen fertilization of grapefruit trees on soil acidification and nutrient availability in a Riviera fine sand. *Plant and Soil* **206**, 11-19.

HELPAGE (2006) Programme de Gestion des Ressources Naturelles Transfrontalières par l'Approche HIMO pour la Paix et la Stabilité Socio-Economique des Populations dans les Pays des Grands Lacs (R. Démocratique du Congo, Rwanda, Burundi). Bailleur de fonds proposé: Coopération Néerlandaise. Document de programme. HELPAGE, Kigali.

Henao J, Baanante C (1999) Estimation rates of nutrient depletion in soils of agricultural lands of Africa. Technical Bulletin IFDC T-48. IFDC - An International Center for Soil Fertility and Agricultural Development., Muscle Shoals, Alabama.

Keddeman W (1998) Of nets and assets: Effects and impacts of employment-intensive programmes - a review of ILO experience. Socio-Economic Technical Papers 1. ILO, Geneva.

Kelly V, Mpyisi E, Shingiro E, Nyarwaya JB (2001) Agricultural Intensification in Rwanda: An Elusive Goal; Fertilizer Use and Conservation Investments. Food Security Research Project (FSRP) and Division of Agricultural Statistics (DSA), Ministry of Agriculture, Animal Resources, and Forestry, Kigali.

Kelly V, Murekezi A (2000) 'Fertilizer response and profitability in Rwanda: a synthesis of findings from MINAGRI studies conducted by the Food Security Research Project (FSRP) and the FAO Soil Initiative.' (FSRP/MINAGRI: Kigali).

Kiepe P (1995) No runoff, no soil loss: soil and water conservation in hedgerow barrier systems. Tropical Resource Management Papers 10. Wageningen Agricultural University, Wageningen.

Lewis LA, Nyamulinda V (1996) The critical role of human activities in land degradation in Rwanda. *Land Degradation & Development* **7**, 47-55.

Loveridge S (1991) Marketing in Rwanda - Imports and Infrastructure. *Food Policy* **16**, 95-104.

Mazzucato V, Niemeijer D (2000) 'Rethinking soil and water conservation in a changing society: a case study in eastern Burkina Faso. Tropical Resource Management Papers 32.' (Wageningen).

McKay A, Loveridge S (2005) Exploring the Paradox of Rwandan Agricultural Household Income and Nutritional Outcomes in 1990 and 2000. Staff Paper 2005-06. Department of Agricultural Economics, Michigan State University, East Lansing, Michigan.

Mellor JW (2002) How much employment can rapid agricultural growth generate? - Sectoral policies for maximum impact in Rwanda. Agricultural Policy Development Project Research Report No. 13. USAID, Kigali, Rwanda.

Mihigo A (1999) Collecte et analyse de données pour l'aménagement durable des forêts - joindre les efforts nationaux et internationaux. Programme de partenariat CE-FAO (1998-2001) Ligne budgétaire forêt tropicale B7-6201/97-15/VIII/FOR, PROJET GCP/INT/679/EC.

Mihigo A (2001) Etude prospective du secteur forestier en Afrique (FOSA) - Rwanda. Ministère des Eaux et Forêts Kigali, Rwanda.

Nyadzi GI, Janssen BH, Oenema O (2006) Analysis of the effects of rotational woodlots on the nutrition and yield of maize following trees in western Tanzania. *Agriculture, Ecosystems & Environment* **116**, 93-103.

Ong CK, Corlett JE, Singh RP, Black CR (1991) Above- and below-ground interactions in agroforestry systems. *Forest Ecology and Management* **45**, 45-59.

Porter G (2002) Living in a walking world: Rural mobility and social equity issues in sub-Saharan Africa. *World Development* **30**, 285-300.

Ramadhani T, Otsyina R, Franzel S (2002) Improving household incomes and reducing deforestation using rotational woodlots in Tabora district, Tanzania. *Agriculture, Ecosystems & Environment* **89**, 229-239.

Randall PJ, Abaidoo RC, Hocking PJ, Sanginga N (2006) Mineral nutrient uptake and removal by cowpea, soybean and maize cultivars in West Africa, and implications for carbon cycle effects on soil acidification. *Experimental Agriculture* **42**, 475-494.

Roose E, Ndayizigiyé F (1996) Chapter 11. Agroforestry, mineral fertilization and land husbandry in Rwanda: Attaining food self-sufficiency in a heavily populated tropical mountain region. In 'Land husbandry - components and strategy. FAO Soils Bulletin 70'. (Ed. E Roose). (FAO: Rome).

Schmidt H, Swoboda R (1979) Labour requirement/availability and economics of mechanisation. Farm Management Handbook of Kenya. Vol. 1. Farm Management Section, Ministry of Agriculture, Nairobi.

Tajgman D, de Veen J (1998) Employment -Intensive Infrastructure Programmes: Labour policies and practices (Blue Guide). International Labour Office, Geneva.

Tenge AJ (2005) Participatory appraisal for farm-level soil and water conservation planning in West Usumbara highlands, Tanzania. Tropical Resource Management Papers 63. Wageningen University and Research Centre, Wageningen.

Vaidya K, Tusanasorn P (2004) Review of Rural Road Maintenance in Lao PDR: Current Status, Issues and Options. Local Roads Department, Ministry of Communication, Transport, Post and Construction, Lao PDR & ILO-ASIST/AP, Vientiane.

van Imschoot M, Wandera M (2005) Feasibility study on the establishment of a HIMO Training Centre. Ministry of Local Government, Good Governance, Community Development and Social Affairs, Kigali.

Wenzl P, Mancilla LI, Mayer JE, Albert R, Rao IM (2003) Simulating infertile acid soils with nutrient solutions: The effects on Brachiaria species. *Soil Science Society of America Journal* **67**, 1457-1469.

Zhang H, Zhang G-L, Zhao Y-G, Zhao W-J, Qi Z-P (2007) Chemical degradation of a Ferralsol (Oxisol) under intensive rubber (Hevea brasiliensis) farming in tropical China. *Soil and Tillage Research* **93**, 109-116.

# Appendix 1. Terms of Reference

## *Scope of Work*

CATALIST PROJECT

A Regional Project to Intensify Agricultural Productivity and Improve Product Marketing

Terms of Reference:

Prioritizing Rural Public Works Interventions in Support of Agricultural Intensification

**Project Overview:**

The CATALIST Project *(Catalyze Accelerated Agricultural Intensification for Social and Environmental Stability)* is a five-year regional activity funded by the Dutch Government and implemented by IFDC, an International Center for Soil Fertility and Agricultural Development, headquartered in the United States. The project began in October 2006 and will run through September 2011. Field headquarters are located in Kigali, Rwanda. In addition to Rwanda, the project will work in Burundi, eastern Congo, southern Uganda, and western Tanzania where country offices are or will be established.

CATALIST's overarching goal is to contribute to regional peace and security through intensified, sustainable agricultural production and improved product marketing. The linkage between peace and productivity highlights a core belief that a *sine qua non* for regional stability is increased productivity to improve food security and rural incomes.

CATALIST will achieve its goals of sustainable agricultural productivity and improved product marketing by focusing resources on the following objectives:

- Supporting agricultural product chain development;
- Promoting an optimum and integrated use of external inputs, while insuring environmental and economic sustainability;
- Improving the efficiency and effectiveness of agricultural input markets; creating expanded marketing opportunities for agricultural products;
- Improving rural infrastructure that can directly contribute to increased productivity and marketing; this objective is implemented through a subcontract with HELPAGE, a regional NGO specializing in rural public works in support of responsible environmental stewardship.
- Contributing to the creation and deepening of enabling national and regional policy environments that that promote intensified agricultural production and improved marketing.

CATALIST works with a wide spectrum of partners that includes producer organizations, private sector operators involved in all stages of the farm to market continuum, industry associations, government policy makers, research and extension services and regional organizations.

CATALIST's sub-sectoral approach focuses on staple crops rather than high value commodities as intensification of staple production holds the greatest potential impact on poverty reduction, increased producer revenue and food security.

**Objective of the Consultancy:**

The CATALIST Project is in effect a hybrid activity which combines two different proposals submitted to the Dutch Government, to wit the original IFDC proposal which has essentially remained unchanged and that of HELPAGE, a regional NGO, focusing on environmental management. The objective of HELPAGE's original proposal was to reinforce trans-boundary environmental stewardship.

In order to promote synergy, avoid duplication of activities and facilitate oversight and management, the Dutch Government requested that IFDC and HELPAGE enter into a contractual relationship; HELPAGE became an IFDC sub-contractor. HELPAGE's budget was significantly reduced in scope; the original proposal serves as a menu of options for its interventions. These interventions concern rural labor intensive public works (HIMO: Haute Intensite de la Main d'Oeuvre) in Rwanda, eastern Congo and Burundi. The establishment of a subcontract with HELPAGE in effect altered the objective of the rural works program from employment creation in the context of improved trans-boundary environmental management to employment creation in the context of accelerated agricultural intensification.

Given that the core objectives of the rural public works program have changed, it is necessary to reassess the pertinence of activities and localities proposed in the subcontract:

- to verify that they are consistent with CATALIST's objective of intensified agricultural productivity, and
- to increase the chance that temporary employment creation leads in time to more permanent employment.

**Specific Tasks:**

The consultant will, in direct collaboration with HELPAGE:

Analyze the original HELPAGE proposal in its new context;
Identify and gather secondary data and available analyses in the sub-region regarding the economics of various labor-intensive rural investments such as secondary road rehabilitation, forestry, agro-forestry, steep slope erosion control and river and lakeside erosion control, both without and with external input based agricultural intensification, enabling estimates of costs and rates of return;
Based on an examination of the secondary data and analyses, prioritize the types of HIMO interventions in the border regions of Rwanda, Burundi and Congo;
If possible, indicate specific public works sub-projects which have been identified by host country governments, projects and donors that can have a tangible and significant impact on intensified agricultural productivity.

Pending confirmation of availability of relevant International Labor Organization personnel, the consultant should plan on spending two to three working days in Geneva, Switzerland to conduct secondary research and interview ILO officials involved with HIMO programs. Together with HELPAGE experts, the consultant should plan to visit examples of already realized labor-intensive public works.

**Estimated Level of Effort and Timing:**

The estimated level of effort for this assignment is 27 working days, plus three travel days. The consultant should plan to arrive in Rwanda on or about February 24th. Of the 27 workdays allocated for research and report writing, an estimated 17 work days should be spent in the field and by visiting resource institutes and persons and libraries, three days should be spent at the ILO and the remaining days shall be used to prioritize the types of HIMO interventions in the intervention regions and submit the final report. Prior to departure, the consultant will debrief the CATALIST and HELPAGE staff and leave a first draft of the report with the team. The CATALIST and HELPAGE teams will have seven working days to submit comments on the draft report. The consultant will submit the final report within 10 days of receiving comments.

**Mission Logistics:**

The consultant will be based in the CATALIST field headquarters in Kigali. S/he will visit already established labor intensive investments from HELPAGE or others in Rwanda and travel to eastern Congo and Burundi to gather secondary data and analyses. The consultant will visit the ILO at the beginning of the trip to project field headquarters.

**Reporting:**

The consultant will report to the chief of party or his designated representative.

# Appendix 2. List of people consulted

| Name | Position | E-mail |
|---|---|---|
| Bidogeza, Jean-Claude | Researcher business economics/erosion and soil and water conservation, Wageningen University (Wageningen) | Jean-claude.bidogeza@wur.nl |
| Breman, Henk | Principal Advisor Agriculture and Environment, CATALIST project (Kigali) | hbreman@ifdc.org |
| Byamana, Alexis | Regional coordinator, HELPAGE Rwanda (Kigali) | Byamana1@yahoo.com |
| d'Haese, Marijke | Assistant professor in development economics, Wageningen University (Wageningen) | Marijke.dhaese@wur.nl |
| De Graaff, Jan | Associate professor in impact assessment of erosion and soil and water conservation, Wageningen University (Wageningen) | Jan.degraaff@wur.nl |
| Goericke, Fred | Project coordinator ESIRU, German Agro Action (Kigali) | Fred_goericke@yahoo.de |
| Kambere, Eric | Civil engineer, HELPAGE Rwanda (Cyangugu) | erickambere@hotmail.com |
| Krijnen, John | Consultant, Royal Dutch Embassy (Kigali) | Krijnen.consulting@bluewin.ch |
| Le Turioner, Joel | Consultant, CATALIST project (Kigali) | aacjlt@yahoo.fr |
| Livingston, Geoffrey | Chief of Party, CATALIST project (Kigali) | glivingston@ifdc.org |
| Miller, Steve | Senior advisor, ILO/IEEP (Geneva) | miller@ilo.org |
| Mobamenya, Joseph | Coordinator, Union des Cooperatives Agricoles de Gikongoro | unicoopagi@yahoo.fr |
| Mukama, Laurence | Agronomist, CATALIST project (Kigali) | |
| Nabahungu, León | Researcher, erosion and soil and water conservation, Wageningen University & ISAR (Butare) | Leon.nabahungu@wur.nl |
| Ndayisaba, Maurice | Civil engineer, HELPAGE Rwanda (Ruhengeri) | |
| Ndayishimiye, Jean-Marie | Agri-business specialist, CAPAD (Bujumbura) | jmndayi@yahoo.fr |
| Ndikumana, Louis | Coordinator 'Fonds pour la relance, les conseils et les échanges en microfinance' (FORCE), HELPAGE Burundi (Bujumbura | ndiklou@yahoo.fr |
| Nkengoburundi, Christophe | Consultant, CATALIST project (Bujumbura) | Nkengubuchrist@yahoo.fr |
| Nsabimana, Boniface | Agricultural engineer, HELPAGE Rwanda (Cyangugu) | boninsab@yahoo.fr |
| Ntyabana, Innocent | National coordinator, CATALIST project (Kigali) | |
| Nzojibwami, Cyriaque | Coordinator, HELPAGE Burundi (Bujumbura) | cyrianzojibwami@yahoo.fr |
| Roy, Sylvain | Consultant, CATALIST project (Kigali) | Sylvainr80@hotmail.com |
| Rubayiza, Emanuel | Senior advisor, ILO/IEEP (Geneva) | rubayiza@ilo.org |
| Sindibona, Jean-Marie | Agricultural engineer, HELPAGE Rwanda (Ruhengeri) | |
| Stroosnijder, Leo | Professor in erosion and soil and water conservation, Wageningen University (Wageningen) | Leo.stroosnijder@wur.nl |