IFAD'S INTERNAL GUIDELINES

Economic and Financial Analysis of rural investment projects

Case studies

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Investing in rural people

Acknowledgements

These guidelines have been jointly developed by the Policy and Technical Advisory Division (PTA) of IFAD, and the FAO Investment Centre (TCI). Designed as a ‘sourcebook’, they address recurrent problems faced by practitioners in the preparation of EFA during design, supervision and ex post evaluation of projects.

Volume 3 of the guidelines is the result of a team effort. The overall work was coordinated by Eloisa de Villalobos (economic technical adviser, IFAD) and Julien Vallet (Economist, TCI), with substantial contributions from Enrico Mazzoli (Economist, IFAD), Dino Francescutti (Senior Economist, TCI) and TCI Economists Blanca Amado, Lisa Hubert, Luís Dias Pereira and Jennifer Braun.

In FAO, the team would like particularly to thank Rimma Dankova (Senior Adviser, TCI) and Thomas Muenzel (Senior Economist, TCI) for overall review of the guidelines. It is also grateful to Lisa Paglietti (Economist, TCI), Brent Simpson (Senior Agriculture Economist, TCI), Uwe Grewer (Economist, Agricultural Development Economics Division (ESA)), Charlotte Dufour (Nutrition Policy and Programme Officer, Nutrition and Food Systems Division (ESN)), Johanna Jelensperger (Programme Officer, ESA), Marc Moens (Senior Livestock Investment Officer, TCI), Mario Castejon (Investment Officer, Subregional Office for Mesoamerica (SLM)), Anna Lisa Noack (Consultant, TCI) and Sophia Lyamouri (Intern Economist, FAO) for their inputs into and review of individual EFA guidance notes.

In IFAD, the team would sincerely like to thank PTA Lead Technical Advisers Michael Hamp, Mawira Chitima, Harold Liversage and Antonio Rota; PTA Senior Technical Advisers Jonathan Agwe, Olivera Rikke Grand, James Garrett, Robert Delve, Marco Camagni and Norman Messer; PTA Technical Advisers Audrey Nepveu de Villemarceau and Guido Rotten; Marie-Lara Hubert Chartier (legal adviser) and Elisabeth Steinmayr (land expert).

Lastly, the team is grateful to Alberta Mascaretti (Chief, Africa Service, TCI), Guy Evers (Deputy Director, TCI), Takayuki Hagiwara (Chief, East Asia, TCI) and Mohamed Manssouri (Chief, Europe, Central Asia, Near East, North Africa, Latin America and the Caribbean Service, TCI) for their support and strategic guidance during the development of these guidelines.

This publication has received funding from the European Union through the “Improved Global Governance for Hunger Reduction Programme”.*

* Global Governance Program website: http://www.fao.org/europeanunion/eu-projects/global-governance/en/
EU website http://europa.eu/

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Policy and Technical Advisory Division, IFAD

Printed November 2016

FOREWORD

This document is the third volume of IFAD's Internal Guidelines: Economic and Financial Analysis (EFA) of Rural Investment Projects. Volumes 1 and 2 provide the basic theoretical background and technical concepts of EFA, together with a definition of the minimum requirements for elaboration of comprehensive EFAs for IFAD-funded rural investment projects. Volume 3 offers a 'sourcebook' of practical, short and well-referenced EFA guidance notes built on actual cases from EFA of various development projects. The target audience comprises consultants working for governments, IFAD and other international financial institutions (IFIs), FAO Investment Centre economists in charge of preparing EFAs, and project design team members and mission leaders, particularly country programme managers.

Volume 3 aims to offer methodological 'hints', guidance and inspiration for EFAs of a wide array of development interventions, including: nutrition, climate-smart agriculture, natural resource management, livestock production, land tenure security, water and sanitation, rural finance, irrigation, rural roads, value chains and demand-driven investments. Methodologies complementary to cost-benefit analysis, such as probabilistic risk analysis, are also illustrated in some examples. These topics are closely related to the current development agenda of governments, IFIs and the wider development community.

These case studies aim to demonstrate that IFAD's requirements can be met in contexts where assessing returns on interventions in monetary terms is challenging and where benefits are not only related to production or productivity objectives. Although the cases provide some guidance to EFA practitioners in quantifying certain benefits and calculating their returns, they do not pretend to illustrate what a complete, quality EFA project should be about, as this aspect is covered in volume 2 [in press].

The authors have selected examples based on positive feedback received by IFIs (more particularly IFAD and the World Bank) on the quality of EFAs. Cases were also chosen based on the subjective appreciation of the authors of the quality, relevance and usefulness of EFAs found in various project appraisal documents and completion reports.

All thematic guidance notes contain a 'conceptual section', describing the main interventions and some methodologies and tools for assessing benefits, and a 'practical section', with from one to four examples. Each case study describes: (i) the project chosen; (ii) the project costs and benefits; (iii) the methodology for calculating the main financial and economic parameters; (iv) the results of the analysis; together with (v) some annexes of tables and figures; and (vi) a bibliography.

CONTENTS

ABBREVIATIONS AND ACRONYMS

AFOLU	Agriculture, Forestry and Other Land Use
ALive	ALive Partnership for Livestock Development, Poverty Alleviation and Sustainable Growth in Africa
ASAP	Adaptation for Smallholder Agriculture Programme
ANR	assisted natural regeneration
AsDB	Asian Development Bank
B/C	benefit/cost (ratio)
BCC	Behavior Change Communication
C	carbon
CBA	cost-benefit analysis
CDD	community-driven development
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CIRAD	International Cooperation Centre on Agrarian Research for Development
CO_2e	carbon dioxide equivalent
CPMP	community pasture management plans
CSA	climate-smart agriculture
CSCG	community-based savings and credit group
DALY	disability-adjusted life year
DDI	demand-driven investment
DIIS	Danish Institute for International Studies
EFA	economic and financial analysis
EIRR	economic internal rate of return
ERR	economic rate of return
EX-ACT	Ex ante Carbon-balance Tool
FAO	Food and Agriculture Organization of the United Nations
GEF	Global Environment Fund
GHG	greenhouse gas
GIE	*groupes d'intérêt economique*
HH	Households
HPVAHIB	high-provitamin A and high-iron banana

IFI	international financial institution
IFPRI	International Food Policy Research Institute
ILRI	International Livestock Research Institute
IPCC	Intergovernmental Panel on Climate Change
IRD	Institut de Recherche pour le Développement
IRR	internal rate of return
KfW	Kreditanstalt für Wiederaufbau
LSIPT	Livestock Sector Investment Policy Toolkit
M&E	monitoring and evaluation
MSME	micro, small and medium enterprises
NPV	net present value
O&M	operation and maintenance
OFID	OPEC Fund for International Development
PC	pasture committee
PDE	*pôles de développement economique*
PRA	participatory rural assessment
ProDAF	Family Farming Development Programme
PRODEP	Land Administration Project (World Bank)
R&D	research and development
RSPSP	Regional Sahel Pastoralism Support Project
SACCO	savings and credit cooperative
SME	small and medium enterprises
TA	technical assistance
TCI	FAO Investment Centre
TTC	travel time costs
UNECA	United Nations Economic Commission for Africa
UNIDO	United Nations Industrial Development Organization
VA	value added
VC	value chain
VCA	value chain analysis
VOC	vehicle operating costs
WHO	World Health Organization
WOP	'without project'
WP	'with project'
WRM	water resources management

CASE STUDY 1

Demand-driven investments

Conceptual section

Scope of the note

Since the 1990s, rural development approaches have been increasingly driven by beneficiary communities, groups and producers' organizations, and have adopted participatory methodologies during design and implementation. The main force behind this change is the recognition that narrowly defined top-down development strategies offer limited and sometimes inappropriate support interventions for small- and medium-scale producers and their households – considering their broad range of interests, priorities and abilities to adopt new practices and technologies (FAO 2011, p. 25). Demand-driven investment (DDI) projects (more generally known as community-driven development [CDD][1] projects) have increased within the portfolios of international development institutions and government agencies in developing nations. Often, they aim to reduce poverty and/or promote economic and social development. Given that such projects support locally identified opportunities, mostly in the form of subprojects identified during the course of implementation, they do not lend themselves to detailed, ex ante cost-benefit analysis. In a typical productive project, the uncertainty related to successful implementation of investment activities or change in current practices is dealt with by assuming conservative adoption rates. In a DDI project, on the other hand, answers to this question can be found through consultative and participatory processes. This note will present some examples of how cost-benefit analyses can be conducted based on these consultative processes.

Interventions

DDI projects finance goods and services, mainly in the form of matching grants to communities and producers' organizations and, sometimes, to other stakeholders involved in locally identified investment subprojects. They generally support income- and non-income-generating initiatives: production support, community infrastructure and sociocultural inclusion. DDI can involve rural business development projects that basically aim to facilitate access to productive goods and services for production, post-harvest processing, transportation, distribution and marketing. In order to identify the goods and services to be funded, many DDI projects also finance bottom-up planning mechanisms, including community development plans to be consolidated into higher-level (e.g. district) plans.

Benefits

With production support and community infrastructure investments, expected benefits include: (i) increased productivity and/or production; (ii) reduction of production losses; and (iii) reduction of input and labour costs. With business development investments, expected benefits include: (i) improvement of production and product/service quality (often conducive to better prices); and (ii) expansion of market opportunities and thus increased sales. CDD seeks to empower rural target groups in decentralized decision-making processes. It is often the approach of choice in post-conflict situations and fragile states, as it involves investing in community-level 'social capital', thus contributing to reknitting the social fabric and building trust among local residents. This has indirect economic benefits, as it decreases transaction costs in general

1 DDI and CDD are used interchangeably in this note.

BOX 1

RuralInvest Toolkit

RuralInvest is a toolkit developed by FAO based on accumulated experience from numerous investment projects funded by IFAD, the World Bank and other funding agencies (national and international). It includes practitioner guides for participatory planning and participatory analysis of investment subprojects. Its software, conceived and developed as a subproject database, allows preparation and feasibility assessment of subprojects based on standard routines, but also serves as a results-monitoring tool through the subproject life cycle.

For further information, see: www.fao.org/investment/ruralinvest/software/en/.

and the cost of doing business in particular. Social subprojects, for example those dealing with potable water, also bring about indirect economic benefits (time saved by not walking long distances to collect potable water, which can then be invested in income-generating activities).

Methodologies and tools

Major types of community-based investments are broadly identified in local development plans (if any). However, in any CDD project, communities or producers' organizations determine the scope and mix of investments through a local participatory planning process.

Primary information can be obtained in participatory diagnostic workshops with those producer groups and communities participating in the selected subprojects. Well-documented methodologies and toolkits are available for this purpose, and are thus not described in the present note.[2] These methodologies assess: (i) the population and its characteristics; (ii) the territory, natural resources and the environment; (iii) the main economic activities; (iv) local institutions and organizations; and (v) social and productive infrastructures. Such information allows the identification of solutions to communities' main challenges and problems and of priority actions and subprojects (FAO 2006).

To complement participatory analysis, there are tools – such as the FAO RuralInvest methodology – to prepare and analyse small-to-medium-scale investment subprojects in greater detail and precision, and from a financial and economic perspective (box 1). In this participatory process of EFA performed in the field, a facilitator (for example, the economist carrying out the EFA) supports a group of applicants (a business, producers' organization, cooperative, etc.) in identifying: (i) investments; (ii) operating and fixed costs, together with incomes per activity; (iii) total income and costs; and (iv) preliminary estimates of economic and financial viability. Key steps in the participatory EFA process are presented in box 2.

Accurate, representative economic and financial estimates must be generated during project start-up activities, with primary information from a representative sample of investment subprojects. For demand-driven projects, EFA is not only relevant during project preparation. Cost-benefit analyses (CBAs) of local investment subprojects are also useful during implementation – as they should determine which subprojects are eligible for funding – and clearly during final evaluation. Example 1 from the Bolivarian Republic of Venezuela illustrates common challenges in undertaking CBAs throughout the project cycle. Example 2 illustrates the selection of a representative sample of subprojects from which to generate an EFA. These two examples demonstrate applications of participatory analysis, coupled with inclusive financial analysis, on various development subprojects.

Sometimes the assessment of benefits and costs is set up as part of the monitoring and evaluation (M&E) process of every subproject. In such cases – with an M&E system that integrates EFA-related indicators – information is available for analysing all subprojects and not just representative samples.

2 Methodologies such as participatory rural assessment (PRA) are well developed in the literature of the Food and Agriculture Organization of the United Nations (FAO) (see FAO 2003). In addition, the reader is advised to consult module 1 (FAO 2006) of the RuralInvest methodology (FAO 2015) on participatory identification of local investment priorities. See also FAO 2011.

BOX 2

Participatory approach for financial analysis

The facilitator/economist will lead a group of applicants through the following analytical steps:

Step 1. Investment analysis. The group prepares a list of investment ideas and identifies the elements needed (purchased or supplied by the group) for implementation. For each item, the average working life is estimated and the provider defined (loan, donation, contribution by the community). The average annual financial cost of each item is calculated.

Step 2. Operating costs and income per activity analysis. At this stage, all incomes and costs (inputs, labour) resulting from carrying out activities made possible by the project are calculated, as well as assessing which changes will occur according to the scale of the activity. The key concepts to be understood at this step of the analysis are: production units, unit sales and production cycles.

Step 3. Total income and cost analysis. After estimating income and operating costs for each activity, results are aggregated to obtain total figures.

Step 4. General and maintenance cost analysis. Applicants identify costs that do not change with variations in the scale of production, but arise from the project in general (fixed or recurrent costs).

Step 5. Preliminary estimate of financial viability. The facilitator helps communities perform key calculations such as: (i) annual net income (to determine if projected income is higher than direct and general costs); and (ii) number of years of net income needed to cover the investment (to determine if the annual net income is high enough to pay back the investment cost within a reasonable period of time).

If the information is available, these five steps can be performed for the 'with project' (WP) and 'without project' (WOP) ('business as usual' or baseline) scenarios to calculate incremental net incomes.

Source: FAO 2006.

Sensitivity analysis has been the traditional method for exploring uncertain situations, including in DDI projects. For such analyses, it is advised that scenario-setting be based on: (i) minimum acceptable returns; (ii) observed technical and socio-economic parameters; and (iii) desired targets within feasible technical parameters (box 3).

Accounting for risks and uncertainty in EFAs of DDI projects can also be addressed through the use of probability-based software tools (see the note on 'Probabilistic risk analysis').

BOX 3

Accounting for risks and uncertainties in DDI projects

To account for the risks and uncertainties of illustrative or real subprojects – not yet implemented or recently implemented, but far from maturity – three scenarios can be assessed in the Brazilian State of Pará (World Bank 2015b): (i) projections based on the current operational and organizational level; (ii) a minimum scenario, with the minimum sales levels that must be attained to achieve a positive net present value (NPV) for a 12 per cent discount rate; and (iii) a desired scenario according to the sales targets set by the associations (within a framework of realistic assumptions, given local knowledge, experience, markets and production potential). This three-step scenario-setting was preferred by all parties involved over the scenario-setting traditionally adopted for sensitivity analysis (expected results, 10-20-30 per cent reduction in revenues and 10-20-30 per cent increase in costs).

Demand-driven investments

EXAMPLE 1

Second Sustainable Rural Development Project for Semi-Arid Zones of Falcon and Lara States

(Bolivarian Republic of Venezuela, IFAD, 2010)

Project description

The project aimed to improve the livelihoods of poor rural communities in semi-arid zones of the States of Falcon and Lara (Bolivarian Republic of Venezuela) through comprehensive territorial interventions in 14 microwatersheds. Based on IFAD's interventions in the first phase of the project, the components comprised: (i) human and social capital development; (ii) natural resource rehabilitation; (iii) management and conservation; (iv) production development; and (v) rural financial services. Production development interventions were identified through participatory planning processes at community and microwatershed levels. During implementation, project supervision missions identified the economic and financial justifications of productive activities as a major weakness. Producer groups and local extension staff lacked both experience and interest in assessing the economic/financial results of their activities. Baseline information on economic/financial performance was scarce and fragmented. IFAD and FAO introduced a financial assessment methodology to assist project teams and producer groups in overcoming this situation.

Costs and benefits

Based on the major production activities supported, the expected benefits from productive development interventions are shown in table 1. In general terms, project interventions increased incomes of the households involved, essentially through productivity improvements and an enhanced productive base and capacity.

Methodology

Analysis was performed at the ex post stage. The methodology, based on the RuralInvest tool, essentially involved workshops with producers to assess production parameters (productive base, crop intensity and yields), revenues (sales and self-consumption) and costs (investment, operational and fixed costs) in situations with and without project

TABLE 1

Perceived benefits of productive development interventions

Tangible benefits from	Key benefits
Goat production	▶ Increased productivity (milk per goat/year) and production resulting from improved production technology (improved feed and increased inputs) and value added production (cheeses and milk caramels)
Poultry production	▶ Increased productivity (increased meat/feed ratio and reduced mortality) and production resulting from improved production technology and equipment
Swine production	▶ Increased productivity (increased living weight) and production resulting from improved production technology (improved facilities, feed quality and sanitary practices) and improved reproduction
Fish farming	▶ Increased production of *cachama* (*Piaractus brachypomus*) resulting from improved fish-farming technology
Vegetable production	▶ Increased productivity, production and value added of pepper, tomato, onion and coriander resulting from improved production technology (irrigation) and increased crop area
Fruit production	▶ Increased productivity and production of melon and watermelon resulting from improved production technology (irrigation) and increased crop area
Native plant processing	▶ Improved processing of sisal (*Agave sisalana*) and *cocuy* (*Agave cocui*)
Crafts production	▶ Improved crafts production (mainly hammocks), product quality and labour savings from improved manufacturing technology and design

support. Field project staff (responsible for the productive development component) and producer groups were trained in participatory feasibility analysis, thus improving their capacities to identify sustainable investment proposals. Initial assessment reports completed by project staff were reviewed by IFAD and FAO, and adjustments were incorporated for the remaining assessments. The project provided funds and/or technical assistance to 644 production units[3] (PUs), including 1,650 producers and their families. The staff workload allowed for field workshops with 57 PUs. Review and adjustment of assessment reports were completed in 33 PUs (5 per cent of the project universe), involving 271 producer families (16 per cent of the project universe).

Results

Investment costs, incremental net income per annum and incremental income, including annual labour and years to recover investment, were calculated. Results are presented in table 2. Steps to calculate these simple outputs are explained in EFS volumes 1 and 2, but also in the RuralInvest guidelines. Incremental annual net income per family is about 2,619 Venezuelan bolívares fuertes (BsF) or US$610. Incremental annual labour amounts to some 130 person-days per family. Incremental net income from vegetable production is 67 per cent higher than from production/processing of goat milk. Average per-family investment costs born directly by producers are higher in goat production and milk processing than in other activities (even considering per-family average investment in the water reservoirs generally associated with vegetable production). The relatively high investment contribution of goat producers is essentially due to the value of their goat herds. On average, estimated incremental annual net income (considering labour costs and annual reserve for replacing investments) would roughly recover initial investment[4] after 11 years (i.e. after 9 years of vegetable production and 13 years of production/processing of goat milk).

TABLE 2

Bolivarian Republic of Venezuela – PROSALAFA II – assessment of financial results – average per participating family

(Venezuelan bolívares fuertes*)

Groupings	Investment			Incremental annual NI			Inc. AL (p-days)	Years to rec. inv.
	Project	PF	Total	With/t LC	With LC	With LC+R		
Overall aggregate								
On-farm investments only	6,116	14,627	20,743	9,072	4,542	2,857	143	7
On-farm investments + water reservoir	16,543	14,627	31,171	9,072	4,542	2,857	143	11
Vegetables and fruits production								
On-farm investments only	6,582	9,855	16,438	9,785	5,016	3,456	150	5
On-farm investments + water reservoir	20,374	9,855	30,229	9,785	5,016	3,456	150	9
Production and processing of goat milk	4,578	36,566	41,144	9,096	4,628	2,604	141	16
Other production activities	4,896	11,349	16,245	1,206	-857	-3,055	65	n/a

Note: PF = producer families. NI = net income. LC = labour costs. R = annual reserve to replace investment. AL = annual labour. p-days = person-days. Years to rec. inv. = years to recover initial investment (simple feasibility indicator) = total investment/inc. annual NI with LC+R.

Other production activities include: sisal production, manufacturing hamacas, agave licor, *cachama* fish, pork and eggs production.

* Venezuelan bolívares fuertes (BsF) 2010 nominal values.

3 In this case, a production unit can be defined as a family farm, a small processing plant, a business, etc.

4 If the opportunity cost of time were accounted for, the period would be longer.

EXAMPLE 2

Rural Productivity Project

(Panama, World Bank, 2015)

Project description

This World Bank-funded project aimed to increase the productivity of small-scale producers' organizations by supporting market-driven business ventures. It did this through matching grants for capital goods, working capital, technical assistance and training – within the framework of a business plan and a productive alliance with stable market partners. The project reached nearly 4,600 producers through 130 subprojects. Total investments reached some US$20.9 million, involving several value chains: (i) dairy cattle, meat cattle, poultry, small livestock, apiculture and artisanal fishing; (ii) maize, roots and tubers, and pulses; and (iii) sugar cane, fruit, etc.

Costs and benefits

In the light of the production activities involved in the sample subprojects, the expected benefits from the financial resources channelled by the project are shown in table 3. In general terms, productive subprojects increased household incomes through productivity improvements and enhanced productive capacity/base (productive investments and increased working capital).

Methodology

A cost-benefit analysis of productive subprojects was performed at the ex post stage and entailed three distinct phases: (i) *sample selection and systematization* of secondary information to identify information gaps; (ii) *gathering and validation of data* in the field through a participatory process; and (iii) *data analysis*. These three steps are essential when dealing with ex post EFA of a CDD project. The sampling universe of subprojects was established at 111 of the 130 subprojects, as 19 subprojects were not mature enough to show results. From this sampling universe of 111 subprojects, a random sample of 12 subprojects (11 per cent) was selected. The sample was stratified with respect to the

TABLE 3

Perceived benefits of supported productive subprojects

Tangible benefits from	Key benefits
Artisanal fishing	▶ Increased artisanal fishing resulting from improved asset base (fishing boats) and equipment
Poultry production	▶ Increased productivity (increased meat/feed ratio and reduced mortality) and production resulting from improved production technology and equipment
Cattle finishing	▶ Increased productivity (increased living weight) and production resulting from improved production technology (improved pastures and increased inputs per animal) and increased intensity (increased number of cattle finished)
Dairy cattle production	▶ Increased productivity (milk per cow/year) and production resulting from improved production technology (improved pastures and increased inputs) and increased asset base (increased number of dairy cows)
Honey production	▶ Increased production and value added resulting from increased asset base (increased number of beehives) and post-harvest equipment
Sugar cane production	▶ Increased productivity and production resulting from improved production technology and increased crop area
Pulse production	▶ Increased productivity and production resulting from improved production technology and increased crop area
Maize production	▶ Increased productivity and production resulting from improved production technology (mechanization) and increased crop area
Tuber production	▶ Increased productivity, production and value added resulting from improved production technology (irrigation), increased crop area and post-harvest facilities
Watermelon production	▶ Increased productivity and production resulting from improved production technology (irrigation) and increased crop area

six productive value chain categories. Time and resource limitations, coupled with labour-intensive data reconstruction efforts, did not allow for a larger sample.[1] As the productive subprojects were the result of a demand-driven process during project implementation, ex ante and ex post cost-benefit analyses are comparable at the aggregate level, but not at the subproject level. All information available for sample subprojects was gathered and systematized. Field visits and participatory analysis workshops were conducted with sample subproject producer groups.

Subprojects for dairy production, cow/calf operation, artisanal fishing and sugar cane production had been operating from three to four years at the time of analysis. However, the other subprojects had only two years of implementation, and the poultry subproject only one. Thus actual data on costs and revenues were not sufficient to undertake the cost-benefit analysis. As a result, a set of assumptions was made about the likely development of the business ventures (productivity, added value, marketing prospects, etc.), according to the situation found during workshops and field visits and taking into account local technical advice. Output prices and input unit costs, observed during field visits and participatory assessment workshops, were applied to both WP and WOP situations. For all sample subprojects, costs and revenues were projected for future years based on the assumptions made. The projections assumed regular weather conditions and factors of production, leaving aside overly optimistic or pessimistic forecasts.

Using flows of incremental net revenues, the NPV, internal rate of return (IRR) and benefit/cost (B/C) ratio were calculated and are presented in table 4. Financial analysis used a 10 per cent discount rate and covered a period of 10 years.

Results

When including all subprojects in the sample, average NPV per family was estimated at nearly US$190. This value represents the average net revenue generated per family, with family labour devoted to subproject implementation compensated at the local daily rate for unskilled labour. Of the eight subprojects with positive financial feasibility indicators, three had NPVs per family above US$1,000. The other five ranged from US$150 to US$400 per family, which is a modest return when taking into account the risks associated with agriculture-based enterprises.

A sensitivity analysis was conducted on the basis of the financial models constructed for the sample subprojects. It considers switching values for costs and revenues where NPV equals zero. As shown in table 4, only two of eight subprojects with positive financial feasibility indicators could withstand an increase in costs, or a decrease in revenue, of over 5 per cent and still remain profitable, and only one if the relative change is above 10 per cent.

TABLE 4

Panama – Rural Productivity Project – assessment of financial results at the subproject level

(United States dollars)

Subproject description			Subproject funds (investment + operation)							Financial feasibility indicators					Switching values	
Product – service	Producer group – territory	Number of families	Total funding	Project funds	%	Group funds	%	Total funds per family	Capital investment (US$)	IRR	NPV (US$)	NPV per family (US$)	B/C	Investment repayment period	Increasing cost where NPV=0	Reducing revenue where NPV=0
Milk	Producer association – Las Guabas	45	303,667	224,858	74%	78,809	26%	6,748	192,435	5%	-54,980	-1,222	0.9	Negative cash-flow	-13.0%	15.0%
Cow-calf operation	Producer association – South Soná	23	168,917	109,516	65%	59,401	35%	7,344	34,145	14%	6,312	274	1.0	8.7	0.4%	-0.4%
Corn	Producer association – San José	36	247,294	180,000	73%	67,294	27%	6,869	3,360	<12%	-57,799	-1,606	0.8	Negative cash-flow	-19.6%	24.4%
Corn	Producer association – San Joaquín	16	124,012	90,590	73%	33,422	27%	7,751	5,176	12%	2,881	180	1.0	9.9	0.2%	-0.2%
Tubers – ñame	Cooperative – Unión de Campesinos Mésanos	47	307,237	234,281	76%	72,956	24%	6,537	91,028	<12%	-152,165	-3,238	0.7	Negative cash-flow	-32.5%	48.3%
Tuber – otoe	Producer/conservation association – ASCODE	29	181,002	140,985	78%	40,017	22%	6,241	34,932	14%	8,776	303	1.0	9.4	0.8%	-0.8%
Artisanal fishing	Fishing and ecotourism association – Palo Seco	30	236,275	145,890	62%	90,385	38%	7,876	156,954	34%	315,464	10,515	1.9	4.2	89.0%	-47.1%
Pigeon peas – guandú	Producer/conservation association – La Montañuelita	16	121,919	73,679	60%	48,240	40%	7,620	63,476	19%	32,981	2,061	1.0	6.9	3.8%	-3.7%
Others – sugarcane	Producer association – Veraguas	52	404,167	321,964	80%	82,203	20%	7,772	2,037	14%	8,000	154	1.0	9.3	0.7%	-0.7%
Others – honey	Producer association – La Mesa	54	338,987	270,000	80%	68,987	20%	6,278	177,844	12%	21,456	397	1.0	10.0	0.0%	-0.0%
Others – watermelon	Women producer association – Emmanuel	17	127,386	79,781	63%	47,605	37%	7,493	39,183	<12%	-116,788	-6,870	0.4	Negative cash-flow	-49.2%	97.0%
Others – poultry	Land reform settlement – Santa Rosa de París de Parita	20	126,000	100,000	79%	26,000	21%	6,300	100,788	21%	58,333	2,917	1.1	5.8	8.5%	-7.8%
Total		**385**	**2,686,863**	**1,971,544**		**715,319**			**901,357**		**72,471**					
Average		32	223,905	164,295	73%	59,610	27%	6,979	75,113	11%	6,039	189	1.0			

1 With a larger sample size (necessitating more resources), results of the analysis would have been representative of the sampling universe with a higher degree of statistical confidence.

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CASE STUDY 2

Climate-smart agriculture

Conceptual section

Scope of the note

Climate-smart agriculture (CSA) projects aim to contribute to the achievement of national food security and development goals through: (i) sustainable increase in productivity; (ii) improved resilience (through climate change adaptation); and (iii) reduction and/or removal of greenhouse gases (GHGs[1]) (mitigation). The conceptual section of this note is structured around these three CSA pillars, offering methodological guidance to economists, agronomists and project design team members on EFA of sustainable intensification, adaptation and mitigation activities. Due to the historical indifference to achieving mitigation benefits through agricultural investments, and the lack of operational tools and associated modelling complexity, most EFAs of donor-funded projects did not integrate mitigation benefits in NPV and IRR calculations (Belli and Anderson 2013). To address this gap, this note illustrates an approach to quantifying the social benefits from reducing GHG emissions. The methodology of the approach is closely linked to the increasing interest of international financial institutions (IFIs) in systematically accounting for project GHG impacts in their investment decisions (World Bank 2012).

Interventions

CSA projects include a range of potential interventions, including: (i) prevention of land degradation (desertification and deforestation) and promotion of land rehabilitation (reforestation and rehabilitation of riparian zones); (ii) sustainable intensification of crop production and management (i.e. integrated pest management, plant and soil nutrient management, promotion of technologies that reduce the vulnerability of rural livelihoods, etc.); (iii) rangeland management; (iv) agroforestry and sustainable forest management; (v) preservation of water, land and soils (water availability, use

BOX 1

Agriculture is a major source of GHG emissions[2]

According to FAOSTAT (FAO 2015a), emissions from crop and livestock production grew from 4.7 billion tons of carbon dioxide equivalent (CO_2e) in 2001, to over 5.3 billion tons in 2011, a 14 per cent increase, coming mainly from developing countries. At the same time, net GHG emissions due to deforestation and land-use changes declined by nearly 10 per cent over the 2001-2010 period, reducing on average 3 billion tons of CO_2e per year over the decade. The breakdown in net AFOLU emissions, averaged over the same period, is as follows: (i) 5 billion tons CO_2e per year from crop and livestock production; (ii) 4 billion tons from net forest conversion to other land uses; (iii) 1 billion tons from degraded peatland; and (iv) 0.2 billion tons from biomass fires.

1 The main GHGs considered in the Agriculture, Forestry and Other Land Use (AFOLU) sector are carbon dioxide, methane and nitrous oxide.

2 More details on GHG emissions from AFOLU are available at www.fao.org/assets/infographics/FAO-Infographic-GHG-en.pdf.

and efficiency, minimum tillage); (vii) biodiversity protection and conservation; and (viii) improved livestock management, among others (table 1).

Benefits

From a private viewpoint, climate-smart practices such as reduced tillage, crop rotations and associations, manure application and nutrient management can yield tangible (financial) benefits at the farm level by increasing productivity and profitability (examples 1 and 2; box 2), with some potential for reducing input costs, especially labour, as in the case of conservation agriculture.[3] Conversely, the intangible benefits from GHG mitigation can generate significant economic (social) benefits for the society as a whole (positive externalities) by reducing GHG emissions from agriculture (box 1) and sequestering carbon in biomass and soils. These social benefits can be valued in monetary terms using a *social price of carbon* (box 3) and their benefits incorporated in the economic analysis for IRR/NPV calculation (example 1).

Methodologies and tools

Various approaches to assessing the benefits of CSA projects can be followed:

(i) *Sustainable intensification*. Crop models and whole/partial farm budgets built around scenarios are the most appropriate tools to simulate changes in farming practices and input use, productivity improvements (yields) and revenue increases (gross and net margins). Only a few programmes (such as FARMOD[4] and RuralInvest[5]) offer the possibility of designing standardized farm models, but Excel-based modelling is by far the most popular technique. The methodology

TABLE 1
Example of tangible and intangible benefits from climate-smart activities

Tangible benefits	Due to …
Increased yields	▶ sustainable cropping systems (intercropping, crop rotation, etc.), conservation agriculture, drought management, erosion and nutrient depletion control
Increased livestock production: lower mortality rates and higher parturition rates	▶ improved access to high-value pasture lands, improved feed digestibility
Increased resilience to weather variability and shocks	▶ increased soil water retention, permanent soil cover, trees used for wind breaks and temperature shading, adoption of water-harvesting structures
Reduced land degradation and soil rehabilitation	▶ watershed management, flood risk management, sustainable cropping systems, conservation agriculture, erosion and nutrient depletion control
Food security and rural poverty reduction	▶ increased self-consumption of crops, increased incomes from sustainable agriculture production

Intangible benefits	Due to …
Carbon sequestration, reduced emissions at local and global levels	▶ increased carbon in biomass and soils due to improved watershed management, drought management, sustainable cropping systems, conservation agriculture, erosion and nutrient depletion control, reduced rate of deforestation, reduction in forest degradation, restoration of degraded land
Biodiversity conservation	▶ reduced negative externalities from the use of synthetic pesticides, increased areas with natural vegetation (e.g. buffer strips), higher diversity of agricultural production systems (integration of agroforestry species and intercropping)
Healthier farm families: losses due to illness or death avoided, including losses avoided in the public health and education systems and for private income	▶ reduced exposure to synthetic pesticides and the likelihood of pesticide poisoning

3 A recent article from the International Maize and Wheat Improvement Center (CIMMYT) (Thierfelder, Trent Bunderson and Mupangwa 2015), based on experience in Malawi and Zimbabwe, showed that conservation agriculture could reduce labour costs by 52-65 per cent (i.e. 34-42 labour days/ha). Herbicides were used for weed control.

4 Software developed by the Asian Development Bank. It is now outdated (working only on Microsoft XP) and needs to be revised.

5 See example 1 in the case study 'Demand-driven investments', which describes and uses the RuralInvest methodology developed by the FAO Investment Centre (TCI).

for building such models and budgets in Excel is well documented in the literature (Gittinger 1982; Belli et al. 2001; FAO 2007) and detailed in volumes 1 and 2 of these guidelines (IFAD 2015a; IFAD n.d.). In the light of this abundant literature, a specific example on use of these tools is not warranted here. Rather, and more importantly, it is advised that analysts assessing benefits from CSA investments perform a thorough literature review and consult appropriate experts in designing WP and WOP scenarios, making realistic and credible assumptions about the expected impact (e.g. on yields) of sustainable intensification measures and what would happen in the absence of any intervention (best done in consultation with the design mission agronomist). A report by IFAD (2011)[6] showed that, of 198 sampled yield comparisons, the mean yield increase over four years was 79 per cent, and most of those projects with available data substantially reduced pesticide use while increasing yields. Other examples are offered that provide insights into the expected yield increases and financial returns arising from improved nutrient management practices (box 2).

(ii) *Adaptation and resilience*. Adaptation to climate change involves strengthening local capacity to anticipate, avoid, absorb, accommodate or recover from the effects of such hazards, for example droughts and floods (resilience). Climate change adaptation and enhanced resiliency are dynamic concepts; thus EFAs of adaptation activities should be modelled dynamically. 'Dynamically' means that effects of adaptive interventions in the WP situation and impacts on non-adaptation in the WOP scenario need to be modelled *before*, *during* and *after* a shock. Depending on the anticipated climate scenario and length of time included in the analysis, modelled WP and WOP simulations may need to be subjected to multiple shocks, and possibly shocks of different types. Ideally, each subsequent shock should reflect the changing status of household assets and productivity based on the effect(s) of the shock that came before. One approach, as described in example 2, is to model the impact of climate shocks at appropriate intervals (for example assuming a drought every five years) in the financial cash flow of WP and WOP scenarios. Such shocks would impact yields, incomes and assets. Depending on the nature of the WP adaptation measures and weather shocks, the result of improved resiliency should reflect less dramatic drops in yield and income, but also possibly a quicker recovery time after a shock (i.e. the time taken for production to reach potential levels). The @RISK tool (described in the note on 'Probabilistic risk analysis') can be used in more complex assessments. The tool employs a stochastic model and can involve probability distributions on yields/prices, as well as timing and severity in climate change stressors.

(iii) *Mitigation*. Academia and the development community have developed models that estimate the mitigation potential from changes in agricultural

BOX 2

Financial benefits from improved nutrient management practices (World Bank 2016)

Several studies (World Bank 2011; Vanlauwe and Giller 2006; Tittonell et al. 2008; Musahara, Musabe and Kabenga 2007; Doraiswamy et al. 2007) show that integrated soil fertility management (ISFM) approaches are more profitable (in terms of B/C ratio and NPV) than techniques using either mineral fertilizer or organic soil fertility management practices alone. In Kenya, Tittonell et al. (2008) showed that maize yields were substantially larger when manure was combined with synthetic fertilizer, with increases 100 per cent above control groups using chemical fertilizer alone. Studies from Musahara, Musabe and Kabenga (2007) in Rwanda indicate that on-farm soil conservation investments alone can increase the marginal productivity of land by over 30 per cent. In Nigeria, tests combining different farming options showed that ISFM practices produced the greatest maize and rice yields, B/C ratios (on the order of 5-6.6 for maize) and NPV (World Bank 2011).

6 The IFAD paper quotes the broadest available assessment of sustainable agricultural approaches in developing countries (based on a study of 286 initiatives in 57 countries, involving 12.6 million farms on 37 million ha).

BOX 3

Social price of carbon

In conducting economic appraisals, the value of carbon can be derived from three different measures: (i) the social cost of carbon; (ii) marginal abatement costs; and (iii) carbon market prices.

The **'social cost of carbon'** attempts to capture the marginal global damage (cost) of an additional unit of CO_2e emitted. This approach derives a social value of carbon emissions expressed as the present value of expected future damages caused by an additional ton of CO_2e emitted into the atmosphere in diverse years. Integrated assessment models, which simulate relationships between global climate and the economy, provide a range of estimates depending on assumptions such as the discount rate. These estimates are reviewed in the last report (IPCC 2014) of the Intergovernmental Panel on Climate Change (IPCC). With a 5 per cent discount rate, the 5-95 per cent range in value is from US$0 to US$60, with no consensus on lower and upper bounds. These estimates are partial and still disputed in the literature, owing to the underrepresentation of uncertainty in the models. Some aspects of uncertainty include future adaptive capacity, difficulty in appraising non-market impacts and the risk of catastrophic outcomes, as well as scarce agreement regarding the appropriate framework for aggregating impacts over time and across regions globally.

'Marginal abatement costs' aims to measure the carbon price necessary to achieve a particular climate change target. This approach derives a shadow price of carbon from large energy/environment/economy models. The shadow price of carbon is conceived as the uniform global carbon price or tax that would cover the marginal cost of achieving a particular climate policy target – such as the internationally accepted goal of limiting mean global warming to 2°C above pre-industrial temperatures. IPCC Working Group estimates suggest that atmospheric concentrations of about 450 parts per million (ppm) of CO_2e are consistent with the 2°C target.[7] Different models provide different estimates on the price of abatement; these are reviewed in the latest IPCC report. They range from US$15 to US$200 per ton of CO_2e in 2020. There are large uncertainties, notably those linked to the availability, acceptability and cost of various mitigation technologies (carbon capture and sequestration, nuclear energy, etc.) and the response of economic actors to price signals. Most analyses place the price within the range of US$30-70 per ton of CO_2e in 2020.

'Carbon market prices' is the market value of CO_2e emission reductions or sequestration (offsets) that are registered and sold through various market structures. Future market values are derived from forecasting models using prices in existing and emerging carbon markets. Outside of wholly voluntary markets, carbon offset values depend largely on policy triggers, including decisions on the stringency of emissions caps that determine demand for emission allowances and offsets, as well as the availability and costs of abatement measures. Market prices of carbon have exhibited great volatility in recent years, based on (policy) uncertainty and diversity among different jurisdictions and instruments.

'Carbon market prices' appears to bear little relation to the value of climate damages or the carbon price needed to achieve a 2°C target. For this reason, the World Bank (2014) note – for the time being – recommends against the use of carbon market prices for project evaluation. It is thus recommended that analysts/projects use a social value of carbon (in real terms) starting at US$30 per ton in 2015 and increasing to US$80 per ton by 2050.

Source: World Bank 2014, p.3.

production systems. These tools are intended to support project analysts in incorporating mitigation benefits into project design and selection.[8]
The Ex ante Carbon-balance Tool (EX-ACT), developed by FAO and IRD,[9] is an Excel-based model providing an ex ante evaluation of the impact of AFOLU projects on GHG emissions and carbon sequestration. The tool can also be

7 Author's note: Anand and Hanson (1997) and others estimate that atmospheric concentrations of CO_2e must be kept below 350 ppm, based on a present CO_2 atmospheric concentration of 400 ppm.

8 Belli and Anderson (2014) include several techniques for valuing environmental externalities, as well as references to additional sources: Hufschmidt et al. (1983), Dixon and Hufschmidt (1986), Dixon et al. (1994), Belli et al. (2001) and Hanemann (1994). Other sources include: the United States Environmental Protection Agency (2010); Dixon (2012); and the Treasury Board of Canada Secretariat (2007).

9 EX-ACT user guidelines (quick guidance and detailed user manual), case studies and software are available free of charge on the EX-ACT home page at www.fao.org/tc/exact/ex-act-home/en/.

used to account for the negative effects of many common interventions for increasing productivity on natural resources (these aspects are generally omitted from classic EFA). The main output of the tool consists of the carbon balance (expressed in metric tons of CO_2 equivalent [CO_2e] per hectare per year) resulting from the difference between WP and WOP scenarios. EX-ACT can be used to include carbon financing benefits in project appraisal (box 4) and also in economic analysis of projects (example 1) by valuing the mitigation potential, using a social price for carbon (box 3).

BOX 4

Typology of GHG mitigation benefits from investment projects

Within the private carbon finance context, one can differentiate among three types of projects (figure 1).

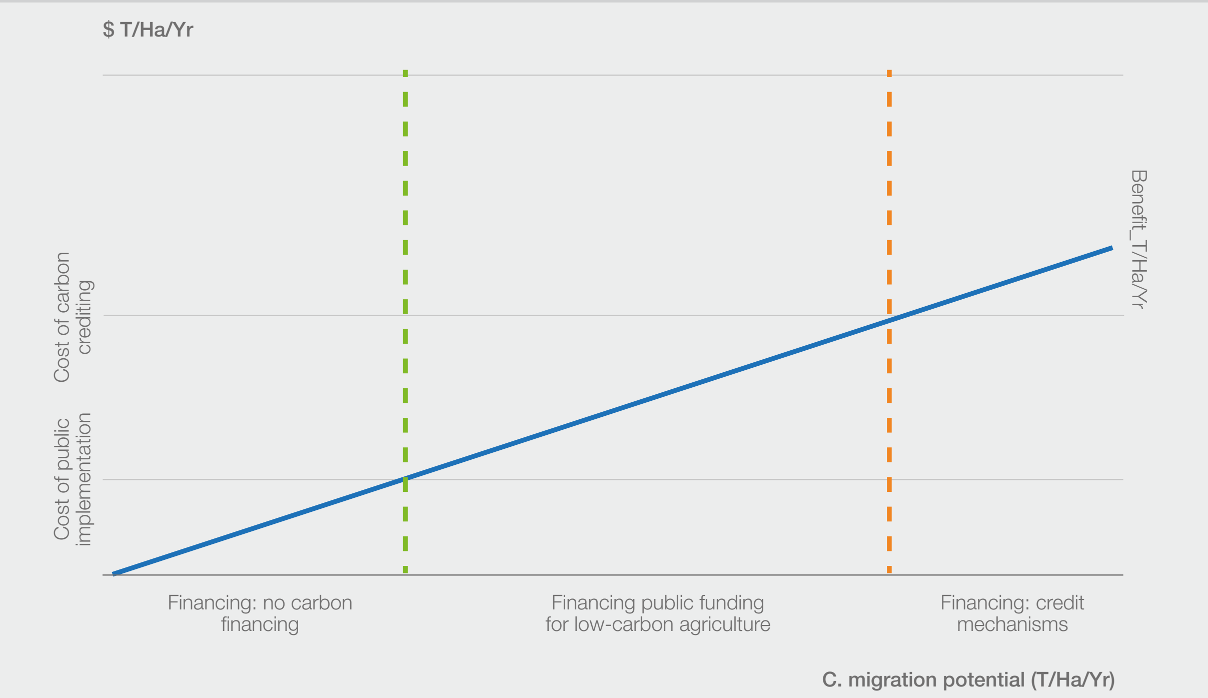
The **first project type** provides only a low level of global (public) benefits from GHG mitigation – benefits that are lower than project implementation costs. Such interventions thus have no potential for carbon financing, neither by public climate funds nor through the voluntary carbon market.

The **second project type** provides relevant mitigation benefits that clearly exceed the costs of project implementation. Such project types can be supported through public and international finance, as they cost-effectively prevent future damaging climate change impacts.

The **third project type** also fulfils this requirement, but provides mitigation benefits even more cost-effectively, so that project implementation costs are lower than the financial benefits that can be received from the voluntary carbon market. Past experience with carbon finance thus underlines that, in any case, carbon payments should only be an additional incentive for project implementation and should complement other long-term beneficial outcomes.

FIGURE 1

Financing options for agricultural development and mitigation projects



Source: Adapted from FAO 2009.

Climate-smart agriculture

EXAMPLE 1

Family Farming Development Programme (ProDAF) – EX-ACT-based programme economic analysis

(Niger, IFAD, 2015)

Programme description

The ProDAF, a US$207 million programme to be implemented over eight years in the Niger, targets the Maradi, Tahoua and Zinder regions. It is financed through several sources (IFAD, the OPEC Fund for International Development (OFID), the Italian Cooperation, beneficiaries and the Government of the Niger) and includes grants from IFAD's Adaptation for Smallholder Agriculture Programme (ASAP) (US$13 million) and the Global Environment Fund (GEF) (US$8 million). Programme objectives are to support the emergence of resilient family agriculture enterprises and promote the economic development of agro-sylvo-pastoral production. The programme is structured into two technical components: (i) strengthening sustainable family farming systems; and (ii) facilitating market access and trade.

The ASAP and GEF will finance a number of sustainable land management activities: (i) implementation of assisted natural regeneration (ANR) on 190,000 hectares (ha) of agricultural land planted with *Faidherbia albida* ('Gao' trees); (ii) development of 10,130 ha of watersheds that will allow the conversion of degraded land into agricultural land (for water recession agriculture and market gardening); (iii) stabilization of 4,000 ha of dunes with plantations of *Acacia senegal*; (iv) restoration of 2,500 ha of pastoral land (combatting *cordifolia* and reseeding pasture); and (v) establishment of 400 ha of hedgerows/windbreaks (reforestation) around the newly developed gardens. The programme will also rehabilitate 19,000 ha of farmland through introduction of ANR, coupled with integrated soil fertility and water management measures (e.g. the introduction of 'zai' holes through farmer field schools).

Costs and benefits

Total programme costs are provided by the Costab database.[10] The costs of components 1 and 2 are US$103.5 million and US$78.3 million respectively.[11] Total GEF costs are US$8 million, while ASAP financing amounts to US$13 million.

TABLE 2

Tangible and intangible benefits of the ProDAF

Tangible benefits	Due to …
Increased yields	▶ watershed and drought management, sustainable cropping systems, conservation agriculture, erosion and nutrient depletion control, flood risk management
Increased incomes	▶ increased yields and production arising from more sustainable cropping systems, increased marketing in the *marches de collecte*, *comptoirs maraichers* and *marchés de demi-gros*
Soil rehabilitation	▶ watershed and drought management, conservation agriculture, erosion and nutrient depletion control, flood risk management
Food security	▶ increased self-consumption of crops

Intangible benefits	Due to …
Carbon sequestration/ reduced GHG emissions	▶ increased carbon in biomass and soils resulting from improved watershed and drought management, sustainability of cropping systems, conservation agriculture, erosion and nutrient depletion control, flood risk management

10 Costab is software for preparing, organizing and analysing project/programme costs. It was originally designed by the World Bank and is available for free download. Costab tracks changes in project costs due to monetary fluctuations, changes in taxes and other contingencies.

11 Total costs of programme coordination are US$25.5 million.

The programme will generate *financial benefits* for farmers through increased yields, volumes of products marketed and resilience of agricultural systems to drought, and improved adaptation to climate change. GEF and ASAP investments will also generate positive environmental externalities *(economic co-benefits)* at local and global levels (carbon sequestration and reduced carbon emissions) that are more difficult to assess in monetary terms. Using the FAO EX-ACT tool described above, the carbon footprint of the ProDAF shows a mitigation potential of (-) 28.9 t CO_2e/ha at the end of 20 years, or an annual balance sheet (i.e. carbon balance) of (-) 1.4 t CO_2e/ha/year. EX-ACT results are presented in table 3.

Methodology

A social value of carbon was used to translate the mitigation potential of the ProDAF into economic terms. Based on 2013 estimates of the United States Interagency Working Group on Social Cost of Carbon (IWGSCC), the estimated social price for carbon averaged US$25 per ton of CO_2e. The guidance note on social prices prepared by the World Bank (2014) recommends that analysts/projects use a social value of carbon (in real terms) starting at US$30 per ton in 2015 and increasing to US$80 per ton CO_2e by 2050.

Results (box 5 and tables 3-5)

The economic benefits of GHG mitigation were factored into the annual economic cash flows to complement the productive and regenerating activity cash flows listed above. The annual economic cash flows are the basis for calculating the programme's IRR and NPV. Results indicate that the programme is economically justified. Over the 20-year period, and under the assumptions used in the analysis, the economic IRR (EIRR) is 15.7 per cent and the NPV (at 10 per cent discount rate) averages

BOX 5

Additional analysis of the ProDAF using EX-ACT

Price incentives from carbon markets. AFOLU projects currently have only limited possibilities to access existing forms of the voluntary carbon market and face low carbon prices. However, early initiatives that propose to increase the inclusion for the AFOLU sector to carbon markets can already be perceived. It is relevant to evaluate whether AFOLU projects such as the ProDAF would provide sufficient cost-effective mitigation benefits to be profitable under such mechanisms. In the context of carbon markets, the above social costs of carbon are unlikely to be realized, while CO_2e prices of US$2-10/ton might be more realistic under a scenario of positive price development on carbon markets (Hamilton et al. 2009). When assuming these carbon prices in financial analysis, the ProDAF would be able to generate US$2.89-US$14.45/ha annually. Thus this value would not occur as a net benefit; instead, costs of monitoring, reporting and verification (MRV) would still need to be subtracted.

Scenario-building of environmental outcomes. An important aspect of the environmental and economic appraisal process of investment projects is the ex ante evaluation of diverse project scenarios. Two key scenarios in the appraisal process of the ProDAF were: (i) consideration of achieving higher tree densities on naturally generated cropland (optimistic scenario: 100 instead of 60 trees/ha); and (ii) assuming a lower increase in soil carbon stocks (pessimistic scenario: increase by 3 t C/ha instead of 5 t C/ha on land targeted by ANR) (IFAD 2015b). The EX-ACT analysis demonstrates that higher tree densities on cropland would lead to a strong increase in the mitigation benefits achieved by the programme. The new benefits would account for 2.03 t CO_2e/ha, which is equivalent to increasing mitigation benefits by 40 per cent. This would lead to strong financial advantages in the case of programme participation in the carbon market or payment systems for environmental services. The pessimistic scenario – reduced impact of soil carbon improvements – would instead reduce mitigation benefits per hectare to 1.2 t CO_2e/ha – equivalent to a reduction of 16 per cent. Thus it is advisable to monitor soil carbon impacts throughout implementation, as this also identifies a related variation in potential programme benefits. In comparison, practice-related variations with regard to actual achieved total number of hectares of ANR, as well as actual achieved tree and vegetation densities, will be the more important impacts at which priority monitoring measures should be targeted.

US$43.8 million. A sensitivity analysis was performed assuming: (i) alternative social prices for carbon (from US$30 to US$80); (ii) more conservative carbon sequestration estimates; and (iii) various adoption rates for sustainable land management practices.

TABLE 3

Detailed EX-ACT results (ProDAF/Niger)

Name of project: ProDAF	**Climate: tropical (dry)**	**Duration (yrs): 20**
Continent: Africa	**Soil: sandy**	**Total area (ha): 239,616**

Project component	Gross fluxes		Balance	Share per GHG of the balance					Results per year		
	WOP	WP		Result per GHG					WOP	WP	Balance
	All GHG in t CO_2e			CO_2			N_2O	CH_4			
	+ source/- sink			Biomass	Soil	Other					
Land use											
Deforestation	0	0	0	0	0		0	0	0	0	0
Afforestation	0	0	0	0	0		0	0	0	0	0
Other	0	-1,357,575	-1,357,575	-2,017,165	-3,374,740		0	0	0	-67,879	-67,879
Agriculture											
Annual	0	-557,304	-557,304	0	-557,304		0	0	0	-27,865	-27,865
Perennial	0	-4,965,703	-4,965,703	-3,939,271	-1,026,432		0	0	0	-248,285	-248,285
Rice	0	0	0	0	0		0	0	0	0	0
Grassland & livestock											
Grassland	0	-45,467	-45,467	0	-45,467		0	0	0	-2,273	-2,273
Livestock	0	0					0	0	0	0	0
Degradation	0	0	0	0	0	0	0	0	0	0	0
Inputs & investments	0	0	0			0		0	0	0	0
Total	**0**	**-6,926,048**	**-6,926,048**	**-1,922,106**	**-5,003,943**	**0**	**0**	**0**	**0**	**-346,302**	**-346,302**
Per hectare	0	-29.0	-29.0	-8.0	-20.9	0.0	0.0	0.0			
Per hectare per year	0	-1.4	-1.4	-0.4	-1.0	0.0	0.0	0.0	0.0	-1.4	-1.4

The results presented in the Detailed EX-ACT results tables and graphs can be interpreted as follow:
(i) The 'detailed results' module of EX-ACT summarizes results.
(ii) Results show that the ProDAF has a mitigation potential of -1.4 t CO_2e/ha per year.
(iii) The most important carbon sinks are perennial crops, which sequester -4.9 million t CO_2e.

TABLE 3A

Detailed EX-ACT results (ProDAF/Niger)

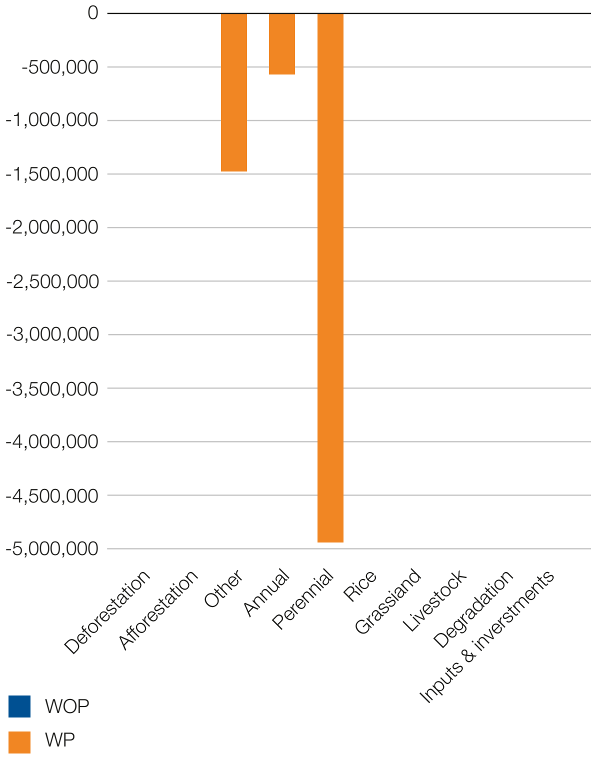


TABLE 3B

Detailed EX-ACT results (ProDAF/Niger)

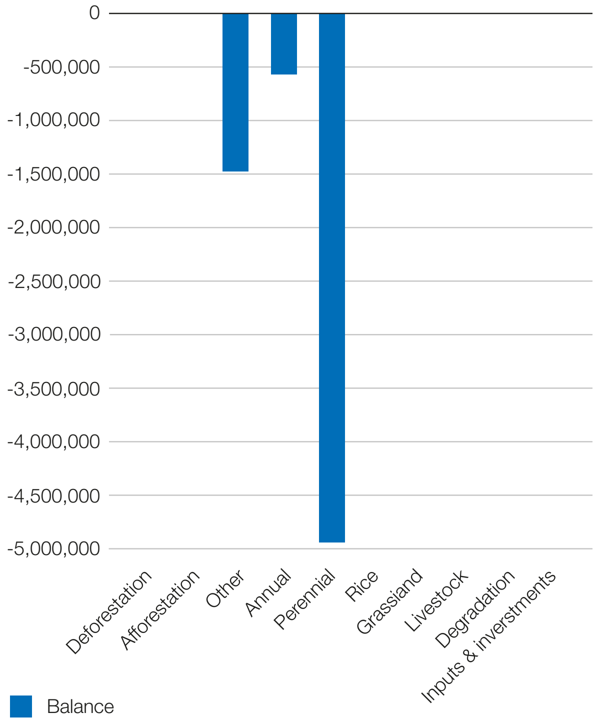


TABLE 3C

Detailed EX-ACT results (ProDAF/Niger)

Total WOP and WP and balance

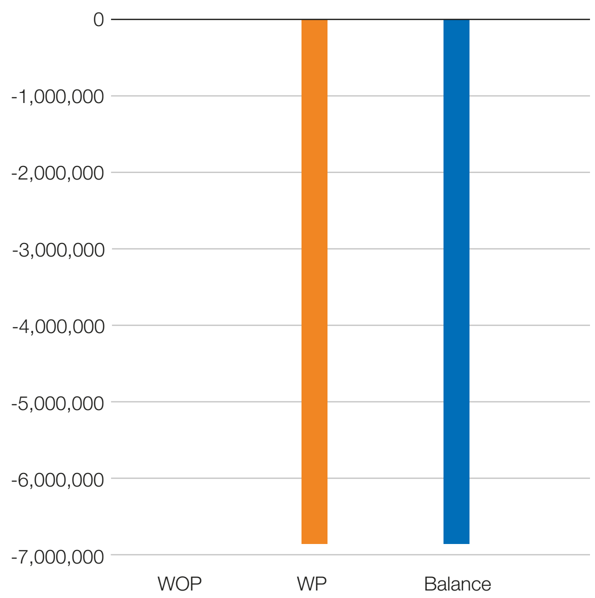


TABLE 3D

Detailed EX-ACT results (ProDAF/Niger)

Share of the balance per GHG (plus origin for CO_2)

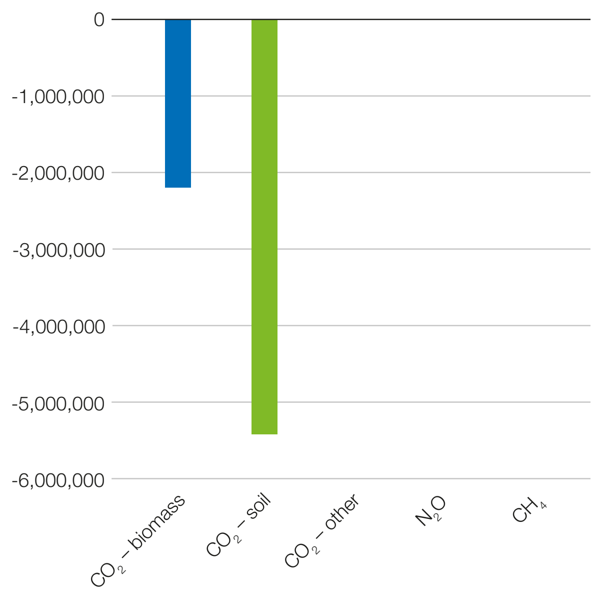


TABLE 4

Niger – ProDAF – integration of environmental benefits in economic analysis

	Tableau de calcul du TRIE et de la VAN	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10-20
	Bénéfices FCFA										
A	Bénéfices issus de l'agriculture pluviale	9,000,340	27,001,020	72,846,502	146,536,787	253,415,825	377,733,022	473,221,005	622,992,289	710,323,714	761,091,257
B	Bénéfices issus de l'agriculture irriguée	0	1,101,154,984	3,184,257,494	4,014,047,304	4,802,869,874	5,142,461,003	5,529,024,439	5,937,022,346	6,283,548,017	6,460,796,890
C	Bénéfices issus des marchés (PDE et CC)	0	0	299,367,965	869,376,230	1,439,384,495	2,009,392,760	2,280,033,060	2,280,033,060	2,280,033,060	2,280,033,060
D	Bénéfices issus des pistes	0	0	608,563,300	2,359,121,928	3,628,840,418	5,169,031,486	6,138,224,890	6,386,158,086	6,386,158,086	6,386,158,086
E	Externalités environnementales	22,898,400	68,695,200	185,333,925	372,814,575	644,733,075	961,017,225	1,266,925,538	1,519,165,725	1,675,518,863	1,738,847,250
F	**Bénéfices totaux**	**31,898,740**	**1,196,851,204**	**4,350,369,187**	**7,761,896,824**	**10,769,243,688**	**13,659,635,497**	**15,687,428,931**	**16,745,371,506**	**17,335,581,740**	**17,626,926,544**
	Coûts										
G	Coûts économiques du programme	11,394,354,934	15,367,625,902	17,033,500,496	15,858,903,804	11,628,871,286	6,763,565,071	3,322,327,092	2,013,537,111	0	2,412,079,059
H	**Coûts totaux**	**11,394,354,934**	**15,367,625,902**	**17,033,500,496**	**15,858,903,804**	**11,628,871,286**	**6,763,565,071**	**3,322,327,092**	**2,013,537,111**	**0**	**2,412,079,059**
I	Bénéfice additionnel du PRODAF	-11,362,456,194	-14,170,774,698	-12,683,131,309	-8,097,006,980	-859,627,598	6,896,070,426	12,365,101,839	14,731,834,395	17,335,581,740	15,214,847,485

TRIE	15.7%
VAN (@ 10%, 20 ans, FCFA)	21,904,358,522.8
VAN (@ 10%, 20 ans, US$)	43,808,717.0

Guide to table 4:
(i) This table highlights the economic benefits of the ProDAF (lines A-E), together with its economic costs (line G).
(ii) Environmental benefits are factored into the calculation of economic benefits (line E).
(iii) IRR and NPV were calculated from the stream of incremental benefits (line I = F-H). A 10 per cent opportunity cost of capital was assumed in calculating NPV.

TABLE 5

Niger – ProDAF – methodology for calculating the economic cash flow from environmental externalities

Tableau: évaluation des co-bénéfices environnementaux	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10-20
Surfaces	16,356.0	16,356.0	34,245.4	34,245.4	34,245.4	30,156.4				
Adoption	0.1	0.2	0.4	0.6	0.8					
Bénéfices	1,635.6	3,271.2	6,542.4	9,813.6	12,267.0	12,267.0	12,267.0	12,267.0	12,267.0	12,267.0
	0.0	1,635.6	3,271.2	6,542.4	9,813.6	12,267.0	12,267.0	12,267.0	12,267.0	12,267.0
	0.0	0.0	3,424.5	6,849.1	13,698.2	20,547.2	25,684.0	25,684.0	25,684.0	25,684.0
	0.0	0.0	0.0	3,424.5	6,849.1	13,698.2	20,547.2	25,684.0	25,684.0	25,684.0
	0.0	0.0	0.0	0.0	3,424.5	6,849.1	13,698.2	20,547.2	25,684.0	25,684.0
	0.0	0.0	0.0	0.0	0.0	3,015.6	6,031.3	12,062.6	18,093.8	22,617.3
Surface sous GDT	**1,635.6**	**4,906.8**	**13,238.1**	**26,629.6**	**46,052.4**	**68,644.1**	**90,494.7**	**108,511.8**	**119,679.9**	**124,203.4**
Coût social carbone (US$.tonne CO_2)*	20.0									
Carbone séquestré par hectare et par an	1.4									
Cash flow	**22,898,400.0**	**68,695,200.0**	**185,333,925.0**	**372,814,575.0**	**644,733,075.0**	**961,017,225.0**	**1,266,925,537.5**	**1,519,165,725.0**	**1,675,518,862.5**	**1,738,847,250.0**

Guide to table 5:
(i) According to carbon balance modelling (table 3), the quantity of carbon sequestered per hectare per year is 1.4 t CO_2e.
(ii) The ProDAF targets a total of 16,356 ha in year 1 (line 1), and EFA assumed that 10 per cent of that target would be achieved (line 2).
(iii) A social price of US$20 per ton of CO_2 was assumed.
(iv) An exchange rate of US$1 = 500 West African CFA* francs (CFAF) was chosen.
(v) Total benefits in year 1 reach CFAF 22,898,400.
(vi) The same rationale can be applied to the other years.
* CFA = Communauté financière d'Afrique (Financial Community of Africa) or Communauté financière Africaine (African Financial Community).

EXAMPLE 2

South Sudan Agricultural Development and Food Security Project

(South Sudan, World Bank, 2015)

Project description

This World Bank-funded project (US$50 million), implemented over six years, is targeting the Greater Equatorial and Greater Upper Nile regions. Project objectives are to lay the foundations for recovery of the agriculture sector by building its capacity, and to contribute to increased crop production and productivity of farmers in the selected project areas. The project comprises three technical components: (i) extension and capacity-building; (ii) seed industry development; and (iii) modernization initiatives. Production and marketing of common crops will be the main focus of project interventions.

In South Sudan,[1] climate greatly influences crop yields and can display changes of from +7.5 to -7.6 per cent. The observed warming trends are more likely to continue than are the moderate rainfall trends, which markedly increases the number of expected poor harvests. Thus adaptation to climate change is a crucial element of project implementation. According to the World Bank's Climate Change Knowledge Portal, adaptation options for the agriculture sector in South Sudan are, for example: (i) mixing and replanting crops and alternating planting dates; (ii) planting drought-resistant crops; (iii) improving road links to regions with crop surpluses, such as the Greenbelt Zone; and (iv) improving agricultural practices through inputs and equipment to increase crop performance and productivity.[2]

Costs and benefits

Project costs, detailed in Costab, include implementation of the farmer field school (FFS) approach, which aims to build vulnerable communities' resilience through learning on climate change adaptation.[3] Project implementation foresees combining this with support for a sustainable seed production and marketing system, investments in on-farm modernization equipment and community infrastructure improvements (e.g. storage, processing equipment, roads). For this project, in addition to extension support, it is assumed that all 33,000 participating farm households would receive a grant from the project of US$4,000 per group (approximately 30 farmers each).

Benefits captured by this analysis will mainly be generated by implementation of extension support, including FFS, combined with agricultural input services (seeds) and demand-driven productive infrastructure investments. More specifically, financial benefits accrue to farmers from increased yields, crop production, sales, and the resilience of agricultural systems to drought and flooding, as well as reduced post-harvest losses. In the light of climate change challenges in South Sudan, the impact of recurrent shocks and disasters can be mitigated – and recovery greatly facilitated – if appropriate agricultural practices are put in place.[4] Strengthening the capacities and resilience of households and communities will enable them to protect their lives and livelihoods through measures to avoid (prevention) or limit (mitigation) adverse effects of hazards, and to provide timely and reliable hazard forecasts.[5] Given the current high level of cereal imports, it is expected that farmers will have a market for the surplus they produce.

Methodology

Climate change adaptation and resilience through improved farming practices (including diversification and higher-yield/drought-resistant varieties) is expected to help farmers anticipate, avoid, accommodate and recover from yield reductions caused by drought and flooding. With almost all agricultural production being rainfed, rainfall variability in terms of quantity, frequency and distribution is the major factor in determining crop performance (FAO 2015b). Considering the unavailability of fertilizers and

1 World Bank (2010). Within the referenced study, yield assumptions are related to Sudan in a broader sense, without making the distinction between South Sudan and Sudan.

2 Information based on the World Bank's Climate Change Knowledge Portal. http://sdwebx.worldbank.org/climateportal/

3 www.fao.org/3/a-i3766e.pdf, p. 25.

4 www.fao.org/3/a-i3766e.pdf, pp. 3, 7.

5 www.fao.org/3/a-i3766e.pdf, pp. 19, 23.

TABLE 6

Tangible and intangible benefits of the project

Tangible benefits	Due to …
Increased yields	▶ improved farm management (due to extension advice), soil management, planting material/varieties, and increased resilience of agricultural systems to drought
Increased income	▶ increased yields and production arising from more sustainable and efficient cropping systems/patterns, increased marketing due to improved means of transportation and storage, increased on- and off-farm employment, increased resilience of agricultural systems to drought
Soil rehabilitation	▶ soil fertility management
Food security	▶ increased self-consumption of crops, including diversification, increased resilience of agricultural systems to drought

Intangible benefits	Due to …
Improved support to farmers	▶ strengthened management capacities of the national extension system, improved seed testing and certification procedures, improved data availability for informed policy action and better risk management
Healthier population	▶ improved nutrition at the household level due to the promotion of agricultural food and production diversification
Improved business/market climate	▶ enhanced market/business opportunities and economies of scale, enhanced bargaining power, understanding of markets and management capacity among smallholders and small-scale business people/artisans

pesticides, it is expected that adoption of improved seed material and farm management techniques, including mulching and weeding, will have a strong impact on yields.

Climate change adaptation and enhanced resilience are dynamic concepts. Thus adaptation activities are modelled dynamically in EFA, notably by including a drought/climate hazard every five years (tables 7 and 8).[6] In accordance with good practice, economic analysis compared WP and WOP situations, while the technical soundness of modelling parameters was systematically ensured by the design mission agronomist and backed by other relevant literature.[7] Depending on the nature of WP adaptations and weather shocks, the results of improved resilience reflect less dramatic drops in yields and a quicker recovery time (i.e. time taken for production to reach potential levels). In this case, the assumption is that, in the WP situation, yields will decline to 50 per cent, and in the WOP situation, to 30 per cent. Recovery in the WP situation is 80 per cent in the following year and 100 per cent in year 3. In comparison, the WOP situation increases to 50 per cent in year 2, then to 80 per cent, and reaches 100 per cent only in year 4. In the WOP situation, it is assumed that yields will increase on an annual basis by about 15 per cent, whereas in the WP situation they increase by 20 per cent in year 1, 50 per cent in year 2, and reach 100 per cent in years 3-20. Based on regional experience, farmers are likely to adopt new technologies and seed material on 25 per cent of their land in year 1 of the intervention, on 75 per cent in year 2 and on 100 per cent in year 3.

6 Assumptions on drought/shock frequency were estimated jointly with the project agronomist. Other countries' programming papers in the Horn of Africa assumed equivalent drought frequencies.

7 See the World Bank's Climate Change Knowledge Portal, 2015. http://sdwebx.worldbank.org/climateportalb/home.cfm?page=country_profile&CCode=SSD&ThisTab=ClimateFuture

TABLE 7

South Sudan Agricultural Development and Food Security Project – overview of economic analysis results

				Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
A	Costs ('000)			12,786	10,232	11,672	11,108	9,809	9,203	3,844	3,844
B	Subtract farm investment ('000)				798	420	1,482	780	1,482		
C	**Costs total ('000)**			**12,786**	**9,434**	**11,252**	**9,626**	**9,029**	**7,721**	**3,844**	**3,844**
		Phase 1	*65%*								
D		Y2			-1,292	2,065	3,026	3,520	3,964	1,818	3,485
E		Y3				-680	1,087	1,593	1,852	2,086	957
G		Y4					-1,292	2,065	3,026	3,520	3,964
G		Y5						-680	1,087	1,593	1,852
I		Y6	*adoption rate*						-1,292	2,065	3,026
	Benefits	Phase 2	*65%*								
		Y2									
		Y3									
J		Y4					-1,108	1,770	2,594	3,017	3,398
K		Y5						-583	931	1,365	1,588
L		Y6							-1,108	1,770	2,594
M	**Benefits total ('000)**			**0**	**-1,292**	**1,384**	**1,713**	**7,683**	**11,055**	**17,233**	**20,864**
N	**Incremental benefits ('000)**			-12,786	-10,726	-9,868	-7,914	-1,346	3,334	13,389	17,021

				Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
A	Costs ('000)			3,844	3,844	3,844	3,844	3,844	3,844	3,844	3,844	3,844	3,844	3,844	3,844
B	Subtract farm investment ('000)														
C	**Costs total ('000)**			**3,844**	**3,844**	**3,844**	**3,844**	**3,844**	**3,844**	**3,844**	**3,844**	**3,844**	**3,844**	**3,844**	**3,844**
		Phase 1	*65%*												
D		Y2		3,520	3,520	3,964	1,818	3,485	3,520	3,520	3,964	1,818	3,485	3,520	3,520
E		Y3		1,834	1,852	1,852	2,086	957	1,834	1,852	1,852	2,086	957	1,834	1,852
G		Y4		1,818	3,485	3,520	3,520	3,964	1,818	3,485	3,520	3,520	3,964	1,818	3,485
G		Y5		2,086	957	1,834	1,852	1,852	2,086	957	1,834	1,852	1,852	2,086	957
I		Y6	*adoption rate*	3,520	3,964	1,818	3,485	3,520	3,520	3,964	1,818	3,485	3,520	3,520	3,964
	Benefits	Phase 2	*65%*												
		Y2													
		Y3													
J		Y4		1,558	2,987	3,017	3,017	3,398	1,558	2,987	3,017	3,017	3,398	1,558	2,987
K		Y5		1,788	820	1,572	1,588	1,588	1,788	820	1,572	1,588	1,588	1,788	820
L		Y6		3,017	3,398	1,558	2,987	3,017	3,017	3,398	1,558	2,987	3,017	3,017	3,398
M	**Benefits total ('000)**			**19,141**	**20,983**	**19,136**	**20,354**	**21,780**	**19,141**	**20,983**	**19,136**	**20,354**	**21,780**	**19,141**	**20,983**
N	**Incremental benefits ('000)**			15,298	17,140	15,292	16,510	17,937	15,298	17,140	15,292	16,510	17,937	15,298	17,140

EIRR	**19%**
NPV (US$ '000) @ 10%	34,463
NPV/HH (US$ '000)	1

Guide to table 7:

(i) This table highlights economic benefits of the South Sudan Agricultural Development and Food Security Project (lines D-M), together with its economic costs (line C).

(ii) EIRR and NPV were calculated from the stream of incremental benefits (line N = M-C). A 10 per cent opportunity cost of capital was assumed in calculating NPV.

TABLE 8

South Sudan Agricultural Development and Food Security Project – methodology for calculating incremental benefits, including climate change adaptation/farmer resilience

(per feddan)

Maize crop model, yields and inputs				Existing technology			New technology		
	Unit	Quantity	Price				25%	75%	100% land use
				1	2	3 to 20	1	2	3 to 20
Yields	kg			283	328	381	312	408	491
Home consumption	kg			116	135	156	107	99	98
Post harvest loss	kg			48	56	65	46	47	49
Total quantity sold	kg			110	128	149	153	260	344
Sales value (includes seeds)	SSP		3	**362**	**420**	**487**	**501**	**853**	**1128**
Total (incremental) benefits	**SSP**			771	894	1037	874	1185	1450
Operating costs									
Input									
Seeds	kg	10	6				3	8	10
Used for seeds/ own seeds	kg		3	8	10	11	6	2	0
Total	**kg**			**8**	**10**	**11**	**9**	**10**	**10**

Incremental costs and benefits	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20
Total (incremental) benefits	103	291	413	413	414	642	621	413	413	414	642	621	413	413	414	642	621	413	413	414

Guide to table 8:

(i) Model assumes yield increases in the WP situation (improved yield in year 1, 20 per cent of fully improved yield on 25 per cent of the land; in year 2, 50 per cent of fully improved yield on 75 per cent of the land; in year 3, 100 per cent of fully improved yield on 100 per cent of the land) and the WOP situation (16 per cent per year).

(ii) 'Home consumption' is a percentage of yields: 41 per cent in WOP vs. 20 per cent in WP situation.

(iii) 'Post-harvest loss' is a percentage of yields: 17 per cent in WOP vs. 10 per cent in WP situation.

(iv) 'Total quantity sold' also considers own production, foregone sales used as seed. Share decreases under new farm management system and reaches 0 in year 3.

(v) Model assumes a drought/climate hazard every five years, which would reduce harvest in the WP situation by 30 per cent and in the WOP situation by 50 per cent. Recovery in the WP situation is 80 per cent in the following year and 100 per cent in year 3. In comparison, yields in the WOP situation increase to 50 per cent and 80 per cent, reaching 100 per cent only in year 4.

Results

Economic analysis is carried out over a 20-year period. The economic IRR is 19 per cent, which is above the assumed opportunity costs of capital (10 per cent). The NPV generated by the project is US$35 million total or US$1,000 per beneficiary. Comparing overall discounted benefits with respective costs produces a benefit/cost ratio of 1.6. The project can thus be regarded as economically viable. The sensitivity analysis scenarios most relevant to climate change adaptation in this example look at longer recovery times after a shock and more frequent droughts/ climate hazards. A four-year recovery period for the WP situation also (50 per cent, 65 per cent, 85 per cent, 100 per cent), compared with the previous WOP situation (30 per cent, 50 per cent, 80 per cent, 100 per cent), reduces EIRR to 15 per cent and NPV to US$15 million or US$500 per beneficiary. A shock every three years, with a reduction to 50 per cent in the WP situation and to 40 per cent and 80 per cent in the WOP situation, reduces EIRR to 16 per cent and NPV to US$22 million or US$700 per beneficiary.

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CASE STUDY 3

Land tenure security

Conceptual section

Scope of the note

Built on four examples, the note aims to support economists, land tenure specialists and project design teams in analysing return on investments in improved land tenure security. The note offers some methodological guidance on quantifying and including tangible and intangible benefits through general methodological advice and examples from Kyrgyzstan, Nicaragua and Rwanda.

Interventions and rationale

In rural societies, the poorest people often have weak or unprotected tenure rights. Women and indigenous communities are particularly vulnerable. A failure to properly address land access and tenure issues in development projects can directly impact their livelihoods. Doing so, on the other hand, allows for a strengthening of poor rural peoples' rights and means of production. It also generates positive impacts on the local economy. Equitable access to land and tenure security are essential to rural development and poverty eradication.

Land tenure security interventions can cover a range of activities, either in stand-alone projects – aimed at supporting land policy implementation – or integrated into broader agricultural or rural development projects. Typically, activities supported in large-scale stand-alone projects may include: (i) rehabilitation or development of national and decentralized land information management systems and land-use planning frameworks; (ii) strengthening of national decentralized land administration institutions; and (iii) systematic land regularization and large-scale land redistribution programmes. Interventions integrated into broader programmes might focus more on developing new and innovative approaches to land reform and to strengthening the impacts of tenure security and good land governance on poverty eradication and social stability. This may include, for example: (i) strengthening the integration of community-based institutions into land and natural resource governance; (ii) recognizing and recording multiple and sometimes overlapping rights in: community-level land-use; watershed management; and territorial, rangeland and forest management planning processes; (iii) improving equitable access by marginalized and vulnerable groups to land in irrigation schemes or to communal forests and grazing lands; (iv) facilitating community-based conflict resolution and access to judiciary and legal aid; (v) developing enforcement mechanisms for provincial and national legislation; (vi) recognizing customary, women's and youth rights; (vii) achieving shared use of rangelands and demarcation of stock routes; and (vii) developing participatory land-use planning, community-based management, etc. Civic education and public awareness-raising activities can also be supported by governments and NGOs as part of large-scale land reform programmes, piloting activities or broader programmes. IFAD does not finance stand-alone land administration projects, but supports tenure security, equitable access and good governance of land and natural resources – generally integrated into broader programmes.

Benefits

According to the existing literature,[1] strengthening poor rural peoples' access and tenure, improving their ability to better manage land and natural resources, individually and collectively, and promoting sustainable, shared use of public land leads to tangible and intangible benefits. Sustainable land management generates economic benefits

1 Pagiola 1999; Goldstein and Udry 2008; FAO 2016.

greater than its associated costs.[2] As presented in table 1, the main tangible benefits are as follows:

(i) *Greater motivation to invest*. Land registration, and the associated land tenure security, can remove uncertainty regarding whether or not landowners can reap the benefits of any long-term investments they make, i.e. on-farm tertiary irrigation systems, drainage, soil and water conservation, and construction of rental houses. Positive expectations of exclusive enjoyment of any returns earned from investment mean that landowners develop an interest in investing in land improvements, as well as in making land-based investments in agriculture and non-agricultural activities.

(ii) *Improved access to credit*. Where people have a proper title to their land, they can use the property as collateral for a loan, or transfer land parcels in which they have invested. Moreover, titles can serve as a valuable insurance and savings tool for families, providing security during difficult times and in retirement.

(iii) *Greater dynamism in land markets*. The result of greater efficiency and agility in the purchase, sale, division, merging and transfer of land.

(iv) *Higher government revenues*. Clear land tenure systems would allow the government to levy user fees and taxes on communal and private land.

Intangible benefits are essentially social and environmental benefits.[3] Customary practices and inheritance laws often prohibit women's ownership of land. Promoting changes in this respect will not only empower women, but will also increase household incomes, as women would start investing time and resources in sustainable practices for the land they do have rights to. Due to the lack of appropriate information and methodology, these benefits are generally not included in quantitative ex ante evaluation. In qualitative terms, benefits include:

(i) Better conservation of protected areas: biodiversity and sustainable management of natural resources;

(ii) Reduction of boundary conflicts in protected areas and indigenous territories;

(iii) Improved overall governance;

(iv) Improved empowerment of women.

Efforts to register land or keep registries up to date will be socially desirable only if the benefits (from investment, efficiency-enhancing transfers and conflict avoidance) exceed the costs. There is recognition of potential adverse impacts or social costs if project actions eventually lead to changes in land use that have negative environmental impacts or lead to more intense conflicts between landowners and land occupants. Beyond routine registry operation, a critical component of the cost of recording land rights relates to boundary demarcation. As many observers mistakenly equate high-precision boundary surveys with greater security of rights, interventions often spend large sums in this area,[4] making land registration uneconomical (Ali, Deininger and Goldstein 2014).

Methodology and tools

Consistent with economic theory, the value of rural land represents the NPV of optimal use over the medium to long term. In other terms, the economic value of land is the NPV of services and/or net annual income flows from land production. Using that theory, case studies 1 and 2 illustrate EFAs of IFAD-supported land tenure investments in Kyrgyzstan and Rwanda.

Some other, more comprehensive, analytical methodologies have been developed for EFA of investments in land tenure regularization and administration. Example 3 uses the 'perceived land value' approach for land tenure investments, while example 4 uses the 'reduction of transaction costs' approach for land regularization and administrative services (improved land cadastre/registry) for a project in Nicaragua. In a relatively competitive land rental market, rent can also serve as a good proxy for the opportunity cost used to estimate the value of rural land (AsDB 1997).

2 The ELD 6+1 steps approach, designed by the Economics of Land Degradation (ELD) Initiative, aims to provide information relevant to policy and decision makers. This tool permits assessment of costs related to sustainable land management, as well as its benefits, with a view to materializing the net benefits of improved land management practices through increased productivity and production, or through establishment of alternative livelihoods (ELD Initiative 2015).

3 See the case studies in the notes on 'Natural resource management' and 'Climate-smart agriculture'.

4 Burns 2007.

This note on land tenure security complements materials found in the Guidelines on Land Administration Projects (LAP) that TCI is preparing for the Latin America region, and for which a specific module on EFA has been developed (module 5).[5] These draft guidelines and tools on LAP contain some theory, methodological hints and case studies for the evaluation of land tenure interventions. Readers of the present note are advised to refer to these guidelines for more details on measuring economic and financial returns from land administration investments.

TABLE 1

Tangible and intangible benefits from interventions in land tenure regularization and administration

Tangible benefits	Due to …
Greater security of land tenancy	▶ avoided land expropriations or invasions ▶ avoided land-ownership conflicts and administrative entanglements on property issues
Motivation to invest	▶ land tenancy security. Owners are often motivated to undertake investments that they would not otherwise undertake, such as housing improvements, additional buildings, irrigation systems, permanent crops, pastures, forestry, etc.
Access to credit	▶ titled land, which can be used as collateral guarantee for credit
Dynamism of land markets	▶ improved land registry and cadastre services, greater efficiency and agility in the purchase, sale, division, merger and transfer of land*
Fiscal revenues for local governments	▶ costs savings due to net reductions of transaction costs for land regularization and administration (improved efficiency) ▶ enhanced user fees and tax collection on private and communal land

Intangible benefits	Due to …
Environmental	▶ security of tenure, as people improve or maintain forest and/or tree cover and undertake water conservation investments. First, owners can expect to reap the benefits of long-term investments such as reforestation. Second, landholders no longer need to clear forests to prove land tenure through 'use of land'
Long-term local development	▶ enhanced attractiveness of the project target areas for public and private investments (linked to the motivation to invest benefit) ▶ improved overall governance ▶ improved empowerment of women and vulnerable groups

* Belli and Anderson (2013) did an external review of FAO-TCI's EFA. These last two cases were flagged as good examples of EFA of land titling projects carried out according to the findings of that review.

5 www.fao.org/in-action/herramienta-administracion-tierras/modulos/en/.

Land tenure security

EXAMPLE 1

Livestock and Market Development Project II

(Kyrgyzstan, IFAD, 2014)

Project description[6]

Although livestock plays a critical role in Kyrgyzstan, both economically and culturally, the subsector's productivity is far below its potential. The close link between livestock productivity and the rational and efficient use of pastures requires a concurrent focus on the pasture/natural resource management aspects of livestock production. One effort IFAD made to address these challenges was to support development of the new Pasture Law in Kyrgyzstan, adopted in 2009, which provides the legal basis for community-based pasture management. Prior pasture management practices resulted in pasture degradation, and fragmented management by government was unfair and disrupted seasonal grazing. A critical element of the new arrangements for pasture management is the compulsory preparation of community pasture management plans (CPMPs) by pasture committees (PCs), which set out a five-year plan of pasture management, improvement and investment. The CPMP constitutes the first component of the Livestock and Market Development Project II. The project includes three other components: (i) value chain and income diversification; (ii) an early warning system; and (iii) climate change mitigation. Based on these CPMPs and an annual use plan, pasture use rights are allocated. These are reflected in pasture 'tickets', which state the number of animal grazing days and grazing routes to be used, and the volume and location of collection and harvesting of other pasture resources by each pasture ticket holder. The aim is to help achieve maximum pasture use rates based on improved methods of assessment and monitoring of pasture health.

Costs and benefits

Total project costs are US$23.5 million, of which US$3.3 million is a domestic contribution from the Government. In the economic analysis, all investment and recurrent financial costs were converted into economic values by Costab. The benefits deriving from enforcement of the CPMPs are mainly related to decreased degradation of pastures. This leads to an increase in yields and income, better animal health and a decrease in farmer vulnerability. Moreover, it contributes to greater environmental sustainability and a greater ability to cope with climate change.

Methodology

A comprehensive set of financial analyses of the project's different investments has been undertaken. This includes preparation of five production models: (i) superficial pasture improvement; (ii) radical pasture improvement; (iii) controlled grazing; (iv) alfalfa production (fodder crops); and (v) production of annual grasses. A financial model has also been prepared for project investments in the PCs, as captured in the CPMP. In addition, financial models have been prepared for the two milk value chain interventions (milk collection and cooling centres and women's milk processing groups), as well as for a solar greenhouse that represents an opportunity for income diversification. The five production models, assessing income in WOP and WP scenarios, show incremental net profits ranging from US$10/ha for the controlled grazing model to US$306/ha for the radical improvement model, with an average incremental net profit of US$114/ha over the five models. Benefit/cost (B/C) ratios were also calculated for each model that demonstrate the attractiveness of the technologies.

The model for a typical CPMP assumes: 19,061 ha of pasture, including 2,136 ha of winter pasture, 5,233 ha of spring and autumn pasture and 11,691 ha of summer pasture; about 4,000 ha of summer pasture are not used due to limited access; PC also cultivates about 200 ha of forage crops, and it harvests hay and straw from about 150 ha of hay fields and about 1,200 ha of grain fields on average; about 3,725 head of cattle, 13,889 head of sheep and goats and 644 head of horses belonging to about 1,985 households on average.

6 IFAD internal document: https://xdesk.ifad.org/sites/pn/kgz/Operations/2%20-%20LMDP%202/DESIGN%20REPORT_AIDE%20MEMOIRE/LMDPII%20-%20PDR%20%20.pdf.

TABLE 2

Physical budget

Items	Unit	Price (US$)	Without project	With project			With project						
				1	2	3	4	5	6	7	8	9	10-20
Land structure and livestock number													
Pastures													
Summer pasture, total	ha		7,691	9,691	9,691	9,691	9,691	9,691	9,691	9,691	9,691	9,691	9,691
Existing	ha		7,691	7,691	7,691	7,691	7,691	7,691	7,691	7,691	7,691	7,691	7,691
Improved access	ha		0	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Winter pasture	ha		2,136	2,036	2,036	2,,036	2,036	2,036	2,036	2,036	2,036	2,036	2,036
Spring/autumn pasture	ha		5,233	5,233	5,233	5,233	5,233	5,233	5,233	5,233	5,233	5,233	5,233
Subtotal pasture			***15,061***	***16,961***	***16,961***	***16,961***	***16,961***	***16,961***	***16,961***	***16,961***	***16,961***	***16,961***	***16,961***
Fodder crops													
Alfalfa	ha		100	150	150	150	150	150	150	150	150	150	150
Annual grass	ha		150	200	200	200	200	200	200	200	200	200	200
Subtotal fodder crops			250	350	350	350	350	350	350	350	350	350	350
Haymaking fields	ha		200	200	200	200	200	200	200	200	200	200	200
Livestock number (in LUs)	LU		***4,240***	***4,377***	***4,620***	***4,742***	***4,815***	***4,864***	***4,864***	***4,864***	***4,864***	***4,864***	***4,864***
Production													
Meat	kg	4.5	245,579	245,579	254,890	264,202	273,513	282,824	282,824	282,824	282,824	282,824	282,824
Milk	kg	0.4	1,709,316	1,709,316	1,816,148	1,922,981	2,029,813	2,136,645	2,136,645	2,136,645	2,136,645	2,136,645	2,136,645
Incremental production													
Meat	kg			0	9,311	18,622	27,933	37,244	37,244	37,244	37,244	37,244	37,244
Milk	kg			0	106,832	213,665	320,497	427,329	427,329	427,329	427,329	427,329	427,329
Inputs – *investment*													
Pasture Improvement													
Superficial improvement (SI)	per year			1,786	2,977	1,191	0	711	1,184	474	0	0	0
Radical improvement (RI)	per year			0	4,806	267	267	267	2,550	267	267	267	267
Fodder crops													
Alfalfa production	ha	132.0		150	0	0	0	150	0	0	0	0	150
Other operations													
Improved access to pasture	lump sum	10,000.0		1									
Machinery package[a]	set	60,000.0		1	0	0	0	0	0	0	1	0	0
Inputs – *recurrent*													
Pasture improvement													
Controlled grazing (CG)	per year			0	3,323	6,647	6,647	6,647	6,647	6,647	6,647	6,647	6,647
Payment to shepherd[b]	LU	12.2	1,060	2,189	2,310	2,371	2,407	2,432	2,432	2,432	2,432	2,432	2,432
Vet services, vaccination[c]	LU	10.2	2,120	4,377	4,620	4,742	4,815	4,864	4,864	4,864	4,864	4,864	4,864
Improved access pasture O&M	ha	0.5	0	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Fodder crops													
Alfalfa production (WOP)	ha	56.1	100										
Alfalfa production (WP)	ha	41.8		150	150	150	150	150	150	150	150	150	150
Annual grass production (WOP)	ha	42.6	150										
Annual grass production (WP)	ha	62.2		200	200	200	200	200	200	200	200	200	200
Other operations													
Haymaking	ha	40.8	200	200	200	200	200	200	200	200	200	200	200
Oilcake	ton	204.0	130	117	104	100	100	100	100	100	100	100	100
Land tax	ha	0.1	15,511	15,511	15,511	15,511	15,511	15,511	15,511	15,511	15,511	15,511	15,511
Pasture Users Union (PUU) fee	LU	1.2	4,240	4,377	4,620	4,742	4,815	4,864	4,864	4,864	4,864	4,864	4,864
Machinery O&M	per year	6,000.0		1	1	1	1	1	1	1	1	1	1

[a] A machinery package per one villages (indicative investment, other investments may include construction of watering points, shelters, spot road improvement, etc. as demanded by communities).

[b] Coverage: WOP – for only 25% of livestock; WP – for 50% of grazing livestock (mostly for sheep and goats).

[c] Approximately 500 Kgs per one CU. Coverage: WOP – 50% and WP – 100% of livestock.

TABLE 3

Financial budget

(United States dollars)

Items	Without project	With project			With project						
		1	2	3	4	5	6	7	8	9	10-20
Revenues											
Meat	1,102,602	1,102,602	1,144,406	1,186,211	1,228,016	1,269,820	1,269,820	1,269,820	1,269,820	1,269,820	1,269,820
Milk	697,680	697,680	741,285	784,890	828,495	872,100	872,100	872,100	872,100	872,100	872,100
Total revenues	1,800,282	1,800,282	1,885,691	1,971,101	2,056,511	2,141,920	2,141,920	2,141,920	2,141,920	2,141,920	2,141,920
Incremental revenues											
Meat	0	0	41,805	83,609	125,414	167,219	167,219	167,219	167,219	167,219	167,219
Milk	0	0	43,605	87,210	130,815	174,420	174,420	174,420	174,420	174,420	174,420
Total incremental revenues	0	0	85,410	170,819	256,229	341,639	341,639	341,639	341,639	341,639	341,639
NPV @ 12% (US$)	1,866,688										
Production cost – *investment cost*											
Pasture improvement											
Superficial improvement (si)	0	1,786	2,977	1,191	0	711	1,184	474	0	0	0
Radical improvement (ri)	0	0	4,806	267	267	267	2,550	267	267	267	267
Fodder crops											
Alfalfa production	0	19,837	0	0	0	19,837	0	0	0	0	19,837
Other operations											
Improved access to pasture	0	10,000									
Machinery package [a]	0	60,000	0	0	0	0	0	0	60,000	0	0
Subtotal investment cost	0	91,623	7,782	1,458	267	20,814	3,734	741	60,267	267	20,104
NPV @ 12% (US$)	171,833										
Production cost – *recurrent cost*											
Pasture improvement											
Controlled grazing (CG)		0	3,323	6,647	6,647	6,647	6,647	6,647	6,647	6,647	6,647
Payment to shepherd [b]	12,981	26,799	28,288	29,033	29,479	29,777	29,777	29,777	29,777	29,777	29,777
Vet services, vaccination [c]	21,634	44,666	47,147	48,388	49,132	49,628	49,628	49,628	49,628	49,628	49,628
Improved access pasture O&M	0	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Fodder crops											
Alfalfa production	5,608	6,268	6,268	6,268	6,268	6,268	6,268	6,268	6,268	6,268	6,268
Annual grass production	6,392	12,441	12,441	12,441	12,441	12,441	12,441	12,441	12,441	12,441	12,441
Other operations											
Haymaking	8,163	8,163	8,163	8,163	8,163	8,163	8,163	8,163	8,163	8,163	8,163
Oilcake	26,531	23,878	21,224	20,408	20,408	20,408	20,408	20,408	20,408	20,408	20,408
Land tax	839	839	839	839	839	839	839	839	839	839	839
Puu fee	5,192	5,360	5,658	5,807	5,896	5,955	5,955	5,955	5,955	5,955	5,955
Machinery o&m	0	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Subtotal recurrent cost	87,340	135,413	140,352	144,993	146,273	147,127	147,127	147,127	147,127	147,127	147,127
Total production cost	**87,340**	**227,036**	**148,134**	**146,450**	**146,540**	**167,941**	**150,861**	**147,868**	**207,394**	**147,394**	**167,230**
Total net income	**1,712,942**	**1,573,246**	**1,737,557**	**1,824,651**	**1,909,971**	**1,973,979**	**1,991,060**	**1,994,053**	**1,934,527**	**1,994,527**	**1,974,690**
Benefit/cost ratio	20.6	13.3	13.4	13.6	14.1	14.6	14.6	14.6	14.6	14.6	14.6
Total incremental cost	0	139,696	60,794	59,111	59,200	80,601	63,521	60,528	120,054	60,054	79,891
NPV @ 12% (US$)	600,487										
Incremental net income		-139,696	24,616	111,709	197,029	261,038	278,118	281,111	221,585	281,585	261,748
NPV @ 12% (US$)	1,266,201										
IRR	79.7%										

[c] A machinery package per one villages (indicative investment, other investments may include construction of watering points, shelters, spot road improvement, etc. as demanded by communities).

[b] Coverage: WOP – for only 25% of livestock; WP – for 50% of grazing livestock (mostly for sheep and goats).

[c] Approximately 500 Kgs per one CU. Coverage: WOP – 50% and WP – 100% of livestock.

Results (tables 2 and 3)

Financial analysis of the CPMP shows: (i) an increase in livestock herders' net profits by 15 per cent; and (ii) a high B/C ratio (14.6) and IRR (80 per cent), demonstrating the attractiveness of the investments. Sensitivity analysis shows that the model is more sensitive to changes in price and productivity assumptions than to variations in production and investment costs. The analysis also shows that the PC would be able to finance its CPMP beyond the project, supported by fee collection, which would increase from the present US$5,000 to US$20,000 annually (or about 230 Kyrgyz soms per head, versus the 60 soms/head/year currently applied on average). The two milk value chains and income diversification models also produce attractive results, with IRRs being in the range of 55-63 per cent.

The economic IRR of the overall project averages 26 per cent, with an NPV of US$47 million over 20 years. The switching values and sensitivity analysis show that the project would be economically viable even if benefits decrease by 62 per cent and investment costs increase by 163 per cent. A one-year delay in project benefits reduces EIRR to 23 per cent. With a two-year delay in project benefits, EIRR falls to approximately 20 per cent.

EXAMPLE 2

Kirehe Community-based Watershed Management Project (KWAMP)

(Rwanda, IFAD, 2009-2016)

Project description

The project aims to increase producers' incomes and food security by increasing the production of crops and livestock in the district of Kirehe. Key interventions include the establishment of affordable irrigation facilities, allowing farmers to shift to crops of higher value, and the preservation of natural resources through the establishment of water and land-use planning and management practices. However, in a context where some 13 per cent of households are landless and up to 31 per cent rent land because they own too little to feed themselves, land disputes are widespread. The outcome is also largely dependent on farmers adopting improved agronomic and water management practices. The project is promoting these practices *directly* through water and soil conservation-focused interventions, as well as *indirectly* by improving poor farmers' access to land and their capacity to invest. Land reform is key to boosting rural incomes and to stimulating investments that conserve the natural resource base. Thus the project also promotes the institutional and legal framework needed to achieve effective water and land use in the district. It endorses the existing regularization process for land tenure to enable access by all farmers to land with registered rights; and the introduction of water-use management on newly irrigated farmland through the creation of a water users' association for each new scheme.

Costs and benefits

Total project costs are US$33.5 million, of which US$33.0 million represent investment costs and US$500,000 support operation and maintenance (O&M). In the economic analysis, all investment and recurrent costs were converted into economic values by Costab. In addition, provision was made for: (i) replacement of irrigation and water infrastructure; and (ii) annual recurrent costs, after the project implementation period, equal to the recurrent costs incurred in the last year. Investments in agricultural intensification, irrigation and land management are expected to increase production and farmers' and rural entrepreneurs' incomes (expected outcomes). The project logic is that access to land and land regularization are the triggers for many of these

TABLE 4

Land ownership in Kirehe District

Sector	Landless	Less than 0.5 ha	0.5 to 1.0 ha	Total households with less than 1.0 ha		Total households with 1.0 ha or more		Total households
				Number	%	Number	%	
Gahara	12%	45%	32%	4,976	89%	608	10.8%	5,584
Gatore	10%	48%	32%	4,617	90%	515	10.0%	5,132
Kigarama	15%	25%	52%	4,632	92%	396	7.8%	5,028
Kigina	13%	32%	40%	3,402	85%	594	14.8%	3,996
Kirehe	10%	38%	34%	3,317	82%	732	18.1%	4,049
Mahama	16%	20%	55%	3,391	91%	346	9.2%	3,737
Mpanga	15%	22%	56%	4,901	93%	374	7.1%	5,275
Musaza	10%	36%	40%	3,732	85%	662	15.0%	4,394
Mushikiri	8%	48%	33%	4,108	88%	563	12.0%	4,671
Nasho	12%	32%	29%	3,328	73%	1,243	27.2%	4,571
Nyamugari	19%	15%	47%	4,206	82%	942	18.3%	5,148
Nyarubuye	11%	42%	34%	3,311	87%	509	13.3%	3,820
Total	**13%**	**34%**	**40%**	**47,921**	**86%**	**7,484**	**13.5%**	**55,405**

Source: Project design report.

outcomes. The basic assumption in this respect is that strengthening land tenure security will facilitate statutory land registration for project beneficiaries, mainly the landless and women, encouraging and motivating the population to invest in agricultural intensification and natural resource conservation. Additional benefits that were not included are those relating to: (i) acquisition of land documents, which

TABLE 5

Farm models – financial results, ratios and switching values

Model	NPV – after financing (RFW)	NPV – after financing (US$)	IRR – before financing (%)	Switching values %*				
				Incremental revenues	Incremental inflows	Incremental production costs	Incremental Investment costs	Incremental outflows
Model 1: dryland with paddy rice and livestock	421,186	766	58%	-29%	-25%	-42%	-184%	-34%
Model 2: dryland with treadle pump kitchen garden	302,901	551	62%	-31%	-30%	-43%	>100%	-43%
Model 3: high value crops with treadle pump irrigation	2,103,327	3,824	185%	-76%	-75%	-388%	>100%	-362%
Model 4: in-field water management	637,415	1,159	89%	-111%	-100%	-136%	>100%	-120%
Model 5: milk production	12,755	23	n/a	n/a	n/a	n/a	n/a	n/a
Model 6: soil and water conservation	259,176	471	29%	n/a	n/a	n/a	n/a	n/a

* The switching values show the percentage by which the costs would need to rise or benefits decrease before the NPV reached zero, associated with each of the values (at 8% financial opportunity costs as a prevailing deposit in Rwandian franc).

TABLE 6

Economic analysis of the overall project

	PY1	PY2	PY3	PY4	PY5	PY6	PY7	PY8
Project benefits (US$ '000)								
Incremental returns to soil and water conservation	0.0	23.3	66.7	210.0	943.4	1,110.1	1,172.2	1,207.0
Incremental returns to agricultural production	37.7	94.3	188.6	377.2	754.4	1,131.6	1,508.8	1,886.0
Incremental returns to in-field water management	-70.7	-14.5	88.5	237.0	340.0	443.1	515.1	515.1
Incremental returns to pumped, hillside and marshland irrigation	-158.7	-580.2	-927.1	-941.8	-1,553.2	176.1	414.2	414.2
Incremental returns to livestock	68.6	-434.2	-262.7	115.7	801.7	2,057.9	2,743.9	3,429.9
Total incremental benefits of financed activities	-123.1	-911.2	-846.1	-1.7	1,286.4	4,918.8	6,354.1	7,452.1
Incremental production costs*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Production net benefits	-123.1	-911.2	-846.1	-1.7	1,286.4	4,918.8	6,354.1	7,452.1
Total project benefits	-123.1	-911.2	-846.1	-1.7	1,286.4	4,918.8	6,354.1	7,452.1
Project costs (US$ '000)								
Investment costs	3,338.1	3,767.8	4,117.5	3,825.4	3,948.8	927.9	0.0	0.0
Replacement of vehicle and equipment					501.4			
Recurrent costs	280.0	281.2	283.0	170.2	269.5	275.5	200.0	200.0
Total project costs	3,618.2	4,049.1	4,400.5	3,995.6	4,719.7	1,203.3	200.0	200.0
Total project incremental net benefits	**-3,741.3**	**-4,960.3**	**-5,246.6**	**-3,997.4**	**-3,433.3**	**3,715.5**	**6,154.1**	**7,252.1**

IRR	16.8%
NPV @ 8% (US$ '000)	12,960.1

* Incremental benefits already include production cost changes.

can also be used as collateral in applying for loans or credit; and (ii) strengthening of women's status in rural areas through increased participation in managing local affairs and better access to productive factors such as land, inputs, markets and knowledge.

Methodology and assumptions

EFA is built on models representing tangible benefits from five direct interventions: (i) soil and water conservation; (ii) agricultural production; (iii) in-field water management; (iv) irrigation infrastructure and equipment; and (v) livestock. Other key assumptions on land ownership are presented in table 4.

Results (tables 5 and 6)

Each individual intervention is proven financially viable with IRRs from 29 per cent to 89 per cent.

The economic analysis expresses all financial models in economic values and aggregates them according to the number of households benefiting from each intervention. Although the current analysis does not specifically attribute any revenues to land regularization activities, it could be assumed that at least 30 per cent of revenues targeting landless households or small landholders will depend on the success of these interventions.[1]

1 For more information on the project, see IFAD internal documents: project design report and working papers, including a working paper on land tenure security interventions: https://xdesk.ifad.org/sites/pf/rwa/Operations/1431%20-%20KWAMP%20-%208020-RW/02.%20Project%20Design/04.%20Project%20Final%20Design%20Stage%20-%20Appraisal/FINAL%20AFTER%20NEGOTIATIONS.zip; and the formulation report and working paper, including EFA: https://xdesk.ifad.org/sites/pf/rwa/Operations/1431%20-%20KWAMP%20-%208020-RW/02.%20Project%20Design/03.%20Project%20Design%20Stage%20-%20Formulation/Formulation%20report%20draft.zip.

EXAMPLE 3

Land tenure regularization (under the PRODEP)

(Nicaragua, World Bank, 2002)

Project description

In Nicaragua, securing property rights and modernizing land administration were central to the country's social and economic development. In 2002, poverty was overwhelmingly concentrated in rural areas, and it was estimated that over one third of rural land was held without a clear title. The share of land with no or improper ownership documents was high among poor, small-scale producers and indigenous peoples. To address these challenges, the World Bank supported the Government of Nicaragua through the Land Administration Project (PRODEP). It implemented an approach focused on legal and policy changes, institutional consolidation, organizational capacity-building, modernization of land records and information systems, and land tenancy regularization and demarcation initiatives. A pivotal process of the project has been the Cadastral Sweep, which essentially consists of systemic geographical positioning, measurement and land tenure revision of all parcels in a given target area.

Benefits

Project benefits are mainly those described in the conceptual section and table 1 of this note. In principle, the actions foreseen in the project would generate benefits among institutions and land owners beyond the process of land tenancy regularization. Nevertheless, as explained below, the information available only allows analysis of the benefits derived from land regularization, which ends with an adequate inscription in the Public Property Registry.

Project costs

Economic analysis includes costs related to: (i) project coordination and administration; (ii) land tenancy regularization; and (iii) information systems for land administration. Certain preparatory activities, such as the design and implementation of integrated cadastre/registry information systems, would generate benefits beyond the Cadastral Sweep target area foreseen in the project. Land tenancy regularization would also involve demand-driven titling activities in areas other than the Cadastral Sweep target area. Finally, incremental/decremental transaction costs during and after project implementation were included, as they reflect savings from an improved land administration system, and potential increases in annual transactions due to greater land market activity. Based on available quantitative information in the country regarding land tenancy and use, the analysis included potential tenancy regularization transactions ending with secure registration in the Property Registry. Based on rough estimates, some 20 to 60 per cent of the land is likely to be involved. Project-related unitary costs were estimated based on pilot experiences in Nicaragua and experiences in other countries.

Methodology and assumptions

Economic analysis is based on estimating the expected impact on land values of securing tenancy through land title registration. EFA benefited from data series from a major survey (Carter and Chamorro 2001). These data series showed expected, statistically significant value differentials in favour of registered rural land, with respect to non-registered rural land. A t-student test of estimated parameters was used, significant at 90 per cent of reliance level. However, data on land values represent *perceptions of landowners or occupants* interviewed; hence they do not represent values of direct market transactions. The regression model used for the econometric analysis was:

$$Y = \sum_{i=1}^{9} m_i * X_i + b$$

Where: Y = expected value per *manzana* (*mz*) of rural land;[2] m_i = difference on mean land values per *manzana* to be attributed to variable X_i; and the variables $X_{i=1...9}$ would be:

X_1 = 1 for agrarian title or public title deed, 0 for no title and other documents

X_2 = 1 for registered document or in process of registration,[3] 0 for no registration

X_3 = 1 flat or moderately irregular topography, 0 for highly irregular or abrupt topography

X_4 = 1 for annual crops, 0 for other uses

X_5 = 1 for perennial crops, 0 for other uses

X_6 = 1 for pastures, 0 for other uses

X_7 = 1 for forests, 0 for other uses

X_8 = 1 for idle land, 0 for other uses

X_9 = 1 for housing and related use, 0 for other uses

2 A *manzana* is a unit of area in Latin American countries; one *manzana* is equivalent to almost 0.7 ha.

3 In the Property Registry.

From the econometric analysis, the parameters m_i were statistically significant for variables X_2, X_3, X_5, X_6 and X_9. According to these parameters, the value of rural land per *manzana* is positively correlated with: (i) title registration; (ii) flat or moderately irregular topography; (iii) presence of perennial crops; and (iv) use as housing and related activities. With these precedents, the parameter m_2, which represents the difference in mean land values per *manzana* between registered and unregistered rural land, was used as a proxy for economic benefits to be generated by land ownership regularization (through title registration). This parameter was US$45/*mz*.[4]

Three-to-five-year lags were assumed for increased economic values (as a result of land tenancy regularization) to materialize. As shown below, the economic benefit would be US$36/*mz* for a three-year lag and US$26/*mz* for a five-year lag (discounted at a 12 per cent annual rate, reflecting the opportunity cost of capital at the international level at the time of the analysis).

Results

Table 7 shows summary results on value differentials between registered and non-registered land, for different land qualities and land-use categories. Table 8 presents overall averages of the analysed information on rural farm size and land value per *manzana* as perceived by landowners and occupants surveyed. The values in tables 7 and 8 are average figures and distribution ranges. Thus value differences may not apply to location-specific comparisons. According to table 1 (in the conceptual section), in flat or moderately irregular lands, tenancy regularization could bring about value increases of: 25 per cent for land with annual crops; 14 per cent for land with perennial crops; 45 per cent for grasslands; 23 per cent for forest lands; 26 per cent for idle lands; and 2 per cent for land used for housing and related activities. According to table 7, average land value increases of 22 per cent would be expected.

According to the project proposal, the Cadastral Sweep would include all properties in the project area, comprising a total of 28 municipalities.

TABLE 7

Apparent values of rural land

(US$/*mz*)

Topography	Use	Situation without registry				Situation with registry			
		m	Range (-s+m; m+s)			m	Range (-s+m; m+s)		
Flat-irregular	Annual crops	184	136	-	232	229	181	-	277
Flat-irregular	*Perennial crops*	325	260	-	390	370	305	-	435
Flat-irregular	Pastures	99	49	-	149	144	94	-	194
Flat-irregular	Forest	193	99	-	287	129	35	-	223
Flat-irregular	Idle	174	84	-	264	219	129	-	309
Flat-irregular	Housing-*solar*	2,160	2,086	-	2,234	2,205	2,131	-	2,279
Abrupt	Annual crops	88	40	-	136	133	85	-	181
Abrupt	*Perennial crops*	216	151	-	281	261	196	-	326
Abrupt	Pastures	-		-	50	35		-	85
Abrupt	Forest	84		-	178	129	35	-	223
Abrupt	Idle	65		-	155	110	20	-	200
Abrupt	Housing-*solar*	1,976	1,902	-	2,050	2,021	1,947	-	2,095

Note: m represents the mean or average value and s represents the standard deviation. The range (-s+m; m+s) in a normal distribution includes 68% of the observed values.

4 Parameter m_1, which represents the difference on mean land values per *manzana* between titled/registered and untitled/unregistered rural land, could have been used as an incremental estimate of economic benefits. However, it was not found to be statistically significant.

TABLE 8

Project cost estimates

(Thousand units)

Concept	Unit	Implementation/operation period					
		1	2	3	4	5-20	Total
Regularization							
Sweep coverage	parcel	-	18.4	18.4	9.2	-	46.0
Sweep regularization	parcel	-	7.3	7.3	3.8	-	18.4
Titling outside sweep	parcel	-	3.9	3.9	2.0	-	9.8
Sweep coverage	*mz*	-	500.5	500.5	250.2	-	1,251.2
Sweep regularization	*mz*	-	200.1	200.1	100.2	-	500.4
Titling outside sweep	*mz*	-	90.2	90.2	45.0	-	225.4
Recurrent transactions							
Buy/sale transactions	parcel	2.7	2.7	2.7	2.7	2.7	53.7
Other transactions	parcel	18.8	18.8	18.8	18.8	18.8	376.3

TABLE 9

Summary of economic feasibility base indicators

Assumption	NPV (US$ '000)	IRR (%)
Benefits with a lapse of three years after regularization	7,414	39%
Benefits deferred 20 years after the third year of regularization	7,414	19%

Note: Annual discount rate for NPV was 12%.

According to project estimates reflected in table 8, there would be some 46,000 properties to cover – about 1,640 properties per municipality on average. According to descriptive statistics of the analysed data, about 20-40 per cent of all properties have regularization problems that have prevented them from being registered. A parallel study estimated that 66 per cent of all non-registered properties had resource limitations to register. This would lead to the conclusion that, from a 40 per cent regularization universe, the real demand for regularization services would be 26 per cent – whereas from a 20 per cent universe, the real demand is 13 per cent.

Taking the 40 per cent regularization universe as a base-case scenario, some 46,000 properties would be covered by the Cadastral Sweep and 18,400 would benefit from greater tenancy security. According to estimated average farm sizes in Cadastral Sweep target areas, about 500,400 *mz* would likely generate incremental economic benefits. In addition, the project is expected to benefit some 9,800 properties or lots outside the Cadastral Sweep target area through demand-driven tilting activities. Based on average farm size for non-registered lands, about 225,400 *mz* benefit from these rural titling/registration activities.

The NPV and IRR of expected incremental economic benefits, derived from tenancy regularization, were estimated under two schemes: (i) a three-year lag between regularization and accrued incremental benefits; and (ii) deferred benefits for 20 years after the three-year lag. The first scheme represents a capitalization due to land investments. The second simulates an annual flow of net economic benefits as a result of land investments. As shown in table 9, NPV is the same for both schemes[5] – about US$7.4 million – but IRR is lower under the second scheme.

5 In both schemes, the present value of expected benefits is US$36/*mz*.

Sensitivity analysis

Considering the limited experience in conducting large-scale land management/administration projects in the country, and recognizing that the data series analysed reflect only apparent (though consistent) values provided by people surveyed, a sensitivity analysis was conducted varying the parameters listed in table 10.

In view of this sensitivity analysis, project benefits are likely to exceed associated costs and the opportunity cost of capital, unless: the Cadastral Sweep benefits 30 per cent or less of rural properties in terms of tenancy regularization; project costs increase more than 50 per cent; or there is an increase in annual transactions (related to property transfer) significantly larger than 40 per cent.

Finally, when comparing the baseline WP scenario with the traditional WOP regularization scenario (with demand-driven techniques), it could be concluded that the project with the Cadastral Sweep would generate an NPV US$6.8 million larger than the traditional regularization process (IRR would be 6 percentage points higher).

TABLE 10

Sensitivity analysis

Scenario	Assumptions		NPV (US$)	IRR (%)
Benefits with a lapse of three years after regularization	Greater delay in the generation of benefits associated with regularization		3.6 million	15%
Lower proportion of plots benefit from the Cadastral Sweep	20% – instead of 40% – of total plots covered in the Cadastral Sweep obtain benefits from regularization, representing a total beneficiary area of 250,200 *mz*. Benefits start five years after regularization		-6.4 million	5%
Unforeseen increase of project costs	Inclusion of other essential activities	30% increase	3.1 million	14%
		50% increase	0.2 million	12%
Increase in annual activity of land transactions	Due to land tenancy regularization and improvement of the cadastre/register system, a higher activity of property transfer transactions is likely to be generated	20% increase in annual transactions *ceteris paribus*	5.4 million	17%
		40% increase in annual transactions* *ceteris paribus*	3.5 million	12%
Land tenancy regularization with current demand-driven techniques	The WOP demand-driven methodology is applied. Under this scenario, the land tenancy regularization demand in the target area is expected to be one-half what would be achieved with the Cadastral Sweep		0.6 million	13%
Earlier generation of benefits due to transaction time reductions	Considering that the project could bring time reductions of about 100 days in titling and similar regularization transactions, a scenario was defined that considered the start of annual benefit flows as two years and eight months after regularization (instead of the three years considered in the baseline scenario)		8.2 million	20%

* The detrimental effect of increased annual transactions on project feasibility would hold true if estimated average economic gains per *manzana* would be generated independently of the number of property transfers (or related transactions). This hypothesis, however, is yet to be tested. Economic theory suggests that an increased annual transaction rate would bring about decreasing marginal returns. This would result in more gradual reductions in NPV and IRR than the ones reflected above.

EXAMPLE 4

Land tenure administration strengthening (under the PRODEP)

(Nicaragua, World Bank, 2002)

Project description

The same Nicaragua PRODEP project described in example 3 was used for this example as well.

Benefits

Financial analysis is based on potential net reductions of transaction costs for land regularization and administration. Thus analysis is limited to activities in Cadastral Sweep target areas where such reductions in transaction costs were likely to take place. However, it is recognized that systematic cadastre development is mainly aimed at regularizing all land tenancy throughout the territory – rather than at reducing costs – and laying the foundations for an updated land administration system. A systematic approach would legalize a significantly larger proportion of non-regularized land than do current demand-driven regularization techniques.

Methodology and assumptions

The most common land *regularization* transactions would be titling and title rectification/legalization. The most common land *administration* transactions would be buy/sell and ownership transfer in general. Typical/average cases have been defined for the two macroregions involved, and WP and WOP transaction costs have been calculated. With the project, regularization costs per *manzana* would increase or decrease (with respect to WOP regularization costs) depending on the percentage of land covered by the Cadastral Sweep that requires regularization. On the other hand, cost reductions in recurrent property transfer transactions would take place due to modernization and integration of cadastre/registry information systems in target areas. Moreover, WP regularization time would be reduced (with respect to WOP time) due to technological and process improvements. In principle, the WOP situation reflects costs incurred by the institutions involved under their current work schemes and available technology.

Results for titling regularization

Table 11 presents estimated WP and WOP transaction costs in rural land titling. The proposed systematic regularization approach would simplify or substitute for activities currently performed, such as: (i) demand-identification and -documentation; (ii) recurrent fieldwork programming; (iii) land measurement; and (iv) beneficiary characterization. In the light of difficulties encountered in estimating

TABLE 11

Rural titling costs

(United States dollars

Scenario and transaction type	Unit	Without project	With project	Cost reduction
20% of parcels to regularize				
Pacific – 360 *mz* for 14 titles	mz	11.5	16.9	-47%
Centre – 757 *mz* for 26 titles	mz	9.8	29.6	-202%
40% of parcels to regularize				
Pacific – 360 *mz* for 14 titles	mz	11.5	9.8	15%
Centre – 757 *mz* for 26 titles	mz	9.8	15.9	-62%
60% of parcels to regularize				
Pacific – 360 *mz* for 14 titles	mz	11.5	7.5	35%
Centre – 757 *mz* for 26 titles	mz	9.8	11.3	-15%
100% of parcels to regularize				
Pacific – 360 *mz* for 14 titles	mz	11.5	5.9	49%
Centre – 757 *mz* for 26 titles	mz	9.8	7.6	22%

non-regularized areas with available information, four Cadastral Sweep scenarios have been considered for regularization coverage of rural land parcels: 20 per cent, 40 per cent, 60 per cent and 100 per cent. This implies that, for example, if 20 per cent of rural parcels need tenancy regularization, the proposed Cadastral Sweep or systematic cadastre/regularization (WP situation) should cover five properties to regularize one. Thus sweep field costs would be five times higher if 20 per cent require regularization than if 100 per cent require it – costs on activities other than cadastral sweep field activities would not be affected. Based on available evidence, a base-case situation has been constructed assuming 40 per cent of parcels to regularize, but recognizing that this proportion can be higher.

If every parcel covered by the Cadastral Sweep would generate incremental economic benefits as a result of tenancy regularization, titling/regularization costs would be reduced (compared with the WOP situation) by 49 per cent in the Pacific region and 22 per cent in the Centre region. If 60 per cent of parcels were to be regularized, titling costs would only be reduced in the Pacific region by 35 per cent. If 40 per cent of parcels were to be regularized, titling costs would be reduced in the Pacific region by 15 per cent. If only 20 per cent of parcels were to be regularized, titling costs would not be reduced in any region. If land titling/regularization was the only source of benefits from the Cadastral Sweep, increased costs or net financial transfers associated with increased titling costs per *manzana* would be generated, particularly in the Centre region. Nevertheless, systematic cadastre development and regularization are also necessary to lay the foundations for a secure, modern land administration system. Reduced costs of routine cadastre/registry transactions, associated with the establishment and operation of an integrated, modern cadastre/registry information system (WP), are analysed below.

The financial analysis showed that costs directly incurred by interested landholders or beneficiaries are (WOP) and would be (WP) marginal: US$0.5-0.7/*mz*, depending on the region. Thus titling costs in the country are (and would be with the current land regularization practices) mainly borne by the institutions involved. Finally, it should be noted that titling transaction times (WP) would be reduced from 312 to 211 days (or 32 per cent), and that the Cadastral Sweep would cover a massive number of parcels at the same time.

Results for non-titling regularization

Frequent regularization actions (WP) are likely to involve area revisions – as a result of area partitions associated with buy/sell and inheritance – and legal revisions/corrections. Currently (without project), such actions take place individually without much institutional support.[6] However, for a comparative analysis under similar conditions, non-titling regularization cases were simulated assuming institutional support similar to existing tilting programmes. Estimated transaction costs for non-titling regularization were found to be similar to titling regularization. Direct beneficiary costs were estimated at US$0.4-0.6/*mz* with and without project in both regions. Moreover, transaction time would be reduced from 197 to 166 days (or 16 per cent).

Results on ownership transfer

As mentioned above, indicative costs (with and without project) were estimated for recurrent ownership transfer transactions and other associated transactions. Without project, cadastre costs are about US$65 per transaction. With the establishment and operation of a modern, integrated cadastre/registry system, cadastre costs per transaction would be reduced to US$37. The Cadastral Sweep and integrated information system would enable sizable reductions in field inspections. With the new system, transaction time would be reduced from 22 to 18 days (or 18 per cent). Finally, indicative costs for recurrent registry transactions are not substantially reduced with the project (from US$7 to US$6 per transaction), whereas transaction time is substantially reduced: from 33 to 6 days (or 80 per cent). Only inscription and associated handling costs are reduced. Cost changes in storage and management of the old public registry were not considered, as the project focuses only on the Property Registry.

6 A detailed discussion and analysis of actual transaction costs and time is found in Strasma 2001.

Coverage projections

Table 12 presents project coverage projections for the base-case scenario. During project implementation, the Cadastral Sweep would systematically cover some 46,000 parcels (1.25 million *mz*). Under the 40 per cent regularization-needs scenario, about 5,100 parcels (137,600 *mz*) would be titled and 13,300 titled parcels (362,800 *mz*) with tenancy problems would be regularized. The table also presents yearly projections of property-related transactions in the project target area (considering a 20-year period for evaluation purposes). Such projections are based on annual transactions in registries of participating departments.

Financial impact

Table 13 presents base-case project costs and recurrent cost reductions associated with land

TABLE 12

Expected project coverage and recurrent transactions

(Thousand units)

Concept	Unit	Implementation/operation period					
		1	2	3	4	5-20	Total
Regularization							
Cadastral Sweep	parcel	-	18.4	18.4	9.2	-	46.0
Titling	parcel	-	2.0	2.0	1.1	-	5.1
Non-titling	parcel	-	5.3	5.3	2.7	-	13.3
Cadastral Sweep	*mz*	-	500.5	500.5	250.2	-	1,251.2
Titling	*mz*	-	55.0	55.0	27.6	-	137.6
Non-titling	*mz*	-	145.1	145.1	72.6	-	362.8
Recurrent transactions							
Buy/sell transactions	parcel	2.7	2.7	2.7	2.7	2.7	53.7
Other transactions	parcel	18.8	18.8	18.8	18.8	18.8	376.3

TABLE 13

Net project costs

(Thousands of United States dollars)

Concept	Present value of flows	Implementation/operation period				
		1	2	3	4	5-20
Land regularization						
Rural titling	1,412.8	-	690.6	690.6	345.3	-
Rural non-titling	3,735.3	-	1,825.7	1,825.7	912.9	-
Subtotal	5,148.1	-	2,516.3	2,516.3	1,258.1	-
Land administration						
Buy/sell transactions	-387.8	-	-	-	-	-78.1
Other transactions	-2,714.6	-	-	-	-	-546.9
Subtotal	-3,102.3	-	-	-	-	-625.0
Net impact	**2,045.8**	**-**	**2,516.3**	**2,516.3**	**1,258.1**	**-625.0**
IRR	5.0%					

Note: Annual discount rate for NPV was 12%.

regularization and future land administration in the target area. The NPV of net cost increases would be US$2.0 million. In other words, associated project costs would exceed financial benefits, in terms of future recurrent cost savings, by US$2.0 million in present value. The IRR of net financial impact flows would be 5 per cent. In the base-case scenario, no incremental government revenues from income transaction taxes and/or property taxes are expected. However, income transaction taxes would increase if there is greater annual activity in the rural land market. In turn, property taxes would eventually increase if a land valuation system is put in place.

Sensitivity analysis

Taking into account the fragmented, dispersed information on land tenancy problems and the areas involved, a sensitivity analysis of the baseline scenario was conducted assuming the other potential regularization proportions mentioned for table 11:

- If 20 per cent of rural parcels covered by the Cadastral Sweep require regularization, the NPV of net financial impact would be US$(1.5) million and the financial IRR would be 6 per cent.
- If 60 per cent of rural parcels require regularization, the NPV of net financial impact would be US$(2.6) million and the financial IRR would be 4 per cent.

In conclusion, project financial impact, in terms of future cost reductions, is likely to compensate substantially for total project costs incurred (some 60 per cent of total project costs). However, this impact could be reduced if the new administration system induces a significant increase in annual property-related transactions. In any case, the project is expected to be justified by its overall economic (rather than financial) impact.

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CASE STUDY 4

Livestock

Conceptual section

Interventions

Development projects in the livestock sector target various production systems: pastoral or grassland-based; semi-intensive smallholder farming; traditional mixed farming; specialized dairy; and livestock fattening. Interventions in the sector generally include improving access to animal health services, promoting activities such as improved feeding and breeding/artificial insemination, and supporting improved access to natural resources and markets. These interventions aim to improve communities' livelihoods through increased incomes and reduced vulnerability to risk. In recent years, in the aftermath of droughts in the Sahel and East Africa regions, interventions have focused on dryland areas, with a view towards building the resilience of pastoral and agropastoral communities, that is, to support these communities in anticipating, managing, adapting to, coping with and recovering from drought risks to their livelihoods.

Benefits

Interventions in the livestock sector are expected to generate a number of benefits. Depending on the investment, these may include: (i) herd-level benefits, such as increased herd growth through higher animal parturition rates and lower mortality rates;[1] (ii) household and community-level benefits such as increased incomes, improved nutrition from increased milk and meat production, increased resilience to economic shocks and climate hazards, increased production of hides, skins, fibres and manure, improved breeds, improved access to natural resources (water, pasture and forage), and enhanced access to productive infrastructure and veterinary services; and (iii) national-level benefits such as increased export volumes of live animals and animal products. Recent FAO studies (Gerber et al. 2013) also showed that the intensity of greenhouse gas (GHG) emissions from livestock could be significantly reduced through improved feed access, manure management, livestock husbandry and efficiencies in energy use (e.g. biogas) (table 1).

Methodologies and tools[2]

Assessment of livestock project benefits, more particularly those arising from projects supporting (semi-)extensive livestock systems in pastoral and agropastoral areas, should start with a herd modelling exercise[3] to reflect the dynamic supply of animal products arising from natural demographic growth (see example 1). However, in some other cases – such as sheep and pig fattening, milk production and commercial chicken production – adult population, sex-by-age structure and growth rates may remain constant over time. For such production systems, a demographic steady-state model can be assumed (see example 2).

As they are difficult to perform, demographic projections are often ignored in EFAs. This note

1 This benefit can sometimes be a source of controversy. In overgrazed pasture environments, for instance, increases in growth are not always the benefit projects seek to achieve. In other pastoral areas, where resilience to shocks is strongly correlated with the level of assets (animals in the case of pastoral livelihoods), herd growth is a desirable result expected from livestock interventions (for example, the Regional Pastoral Livelihoods Resilience Project, funded by the World Bank in Ethiopia, Kenya and Uganda).

2 This subsection was adapted from a methodological note on evaluation of the technical performance of livestock farming systems (ALive 2013).

3 When applicable: for example, projects investing in cattle/sheep fattening activities may not need such a modelling exercise.

TABLE 1

Tangible and intangible benefits of livestock activities

Tangible benefits	Due to ...
Increased incomes	▶ increased meat/milk/fibres and skins/manure production, improved access to livestock markets, access to a livestock market information system, increased prices due to better-quality meat and fibre products
Increased animal welfare and health	▶ improved animal parturition rates, reduced mortality rates, improved offtaking strategies, improved feeding, animal genetic improvement
Improved offtaking	▶ improved early-warning systems, livestock market information systems, access to livestock markets, improved animal husbandry, animal genetic improvement
Improved nutrition	▶ increased availability of animal proteins[a]
Increased trade	▶ increased volumes of marketed livestock, including meat and on-the-hoof animal trade

Intangible benefits	Due to ...
Climate change adaptation	▶ policies supporting livestock mobility ▶ introduction of breeds better adapted to climate change[b]
Reduced GHG emissions	▶ adoption of: (i) better quality feed and feed balancing to lower enteric and manure emissions; (ii) improved breeds to shrink emissions; (iii) manure management practices that ensure recycling of nutrients and energy contained in manure; and (iv) improvements in energy use efficiency along livestock supply chains (Gerber et al. 2013)
Improved social equity in pastoral areas	▶ reduced vulnerability of pastoralists with regard to their political marginalization and exclusion from decision-making processes and institutions of power (Catley and Lind 2013)
Increased security and peace	▶ reduced conflicts over resources

[a] The causal link between higher levels of production and improved nutrition is not automatic. A more comprehensive approach is needed to make agriculture nutrition-sensitive and to translate increases in production into healthier diets. Such an approach includes promoting nutrition education, awareness campaigns and training (behavioural change).

[b] Note that this will result in tangible benefits.

offers EFA practitioners some basic guidance in undertaking such herd modelling, while calculating project returns.

Technical tools, such as the user-friendly EcoRum interface of the Livestock Sector Investment and Policy Toolkit (LSIPT), can support the modelling effort.[4] EcoRum runs on Microsoft Excel and is based on the DYNMOD demographic model.[5] It uses the DYNMOD spreadsheets for demographic projection of all types of livestock and can be used to compare WP and WOP scenarios. EcoRum can be downloaded from the ALive website.[6]

EcoRum has two key spreadsheets: ‘Projection (Without)’ and ‘Projection (With)’. The first corresponds to a reference situation, which can be used to evaluate current animal performance (WOP), providing the baseline scenario. The second corresponds to a changed scenario in which the user simulates an improvement linked to project interventions (WP). Comparing the results of WP and

4 Developed under the ALive programme, it was financed by the World Bank (through the FAO and World Bank Cooperative Program [FAO/CP]), the International Cooperation Centre on Agrarian Research for Development (CIRAD) and the European Union.

5 DYNMOD is an Excel-based simulation tool for the livestock demography of tropical domestic ruminants, developed by CIRAD and the International Livestock Research Institute (ILRI) (Lesnoff 2013).

6 www.alive-lsiptoolkit.org/tools/download (login: alive, password: toolkit).

WOP scenarios yields the incremental outputs arising from project interventions (e.g. increased meat, milk, hides/skins and manure production). The financial and economic benefit streams are calculated by putting a financial or an economic value on these outputs (using the appropriate conversion factors to calculate shadow prices).

Four categories of parameters are needed to feed the 'Projection (Without)' and 'Projection (With)' spreadsheets in EcoRum: (i) general parameters (e.g. age groups, herd size); (ii) demographic parameters; (iii) production parameters; and (iv) parameters linked to feed requirements (see box 1 for details). Herd-modelling parameters can be obtained in several ways, either extracted from the scientific literature (FAO, ILRI, etc. – see 'Bibliography' for this note) or through field surveys (retrospective analysis or prospective/longitudinal analysis[7]) or estimates based on expert knowledge. The 'Results' subsection summarizes the results of the projection and comprises the following categories: (i) demographic results (herd growth rate, yearly herd size and structure); (ii) results for production (live-weight equivalents, meat equivalents, financial equivalents, milk, hides/skins, wool and manure production); and (iii) results for feed requirements. The 'Graphic' subsection provides summary graphs that display livestock dynamics for the period considered, as well as annual growth rates (example 1).

BOX 1

Parameters for the demographic projection of livestock populations

Four sets of parameters are needed to feed a herd growth model:

1. General parameters

These parameters include the duration of age groups by sex category (young, sub-adults and adults), the size of the herd and its structure (by age class and sex category), and the number of years of projection/analysis. The age group 'young' corresponds to lactating animals, the age group 'sub-adult' are animals up to sexual maturity, while 'adult' corresponds to animals that have reached the reproductive phase. Users can set the age class limits and the period of analysis (from 1 to 20 years).

2. Demographic parameters

- *Reproduction parameters:* (i) annual birth rate (average number of parturitions per female in the herd throughout the year); (ii) net prolificacy rate (average number of live offspring born per parturition); and (iii) proportion of females at birth;
- *Mortality parameters:* the probability of intrinsic natural mortality (mortality that would be observed if there were no offtake by the farmer);
- *Offtake parameters:* slaughter, sales, lending, gifts, etc.

3. Production parameters

- *Animal prices:* by sex and age category (in constant prices, in local or foreign exchange currency);
- *Animal live weight:* by sex and age category;
- *Dressing percentage:* carcass yield;
- *Milk yield:* per lactation and duration of lactation;
- *Other outputs:* hide/skin produced per animal slaughtered; average weight of wool produced per animal and per year; average weight of manure produced per animal and per day.

4. Feed requirements

Feed requirements are based on dry matter requirements per kg of live weight. Standard livestock models are available in the annex to volume 2 of these guidelines. Information on specific parameters is available at www.quae.com or http://livtools.cirad.fr.

7 A retrospective survey looks backwards and involves collecting herd information after the herd's events have occurred. The prospective (longitudinal) survey involves repeated observations of the herd's parameters (variables) over a long period of time. It offers more reliable results, but is rarely conducted due to time constraints.

It is important that the analyst responsible for EFA work closely with livestock experts to make the right modelling choices for both WOP and WP models. This would avoid unrealistic assumptions in EFA. The analyst can also use default data found in FAO literature (Otte and Chilonda 2002), available livestock studies (such as those described in example 1) or other sources (such as CIRAD, ILRI and others[8]). Samples of EcoRum tables are presented in example 1.

Project IRR and NPV are calculated deducting the financial (or economic) investment costs aggregated in Costab[9] from the financial (or economic) benefit streams generated by EcoRum. The sensitivity analysis can test the impact on IRR/NPV of changes in parameter values: general (e.g. number of animals per household), demographic (e.g. mortality rates) and production parameters (e.g. live weights, animal prices). The sensitivity analysis verifies the robustness and sensitivity of models' assumptions (example 1).

BOX 2

Animals – investment or production/operating costs?

An investment is an expenditure made in the present to generate benefits in the future. The purchase of animals can be considered such, as animals purchased today will produce outputs such as meat, milk, hides/skins, manure and eggs beyond the year of investment. Revenues will also arise from the marketing of offspring (animal offtaking). At the same time, the purchase of animals can be considered a production/operating cost if the purchase seeks to maintain the same production level, replacing dead animals, culling – leaving the total number of the herd unchanged. In both cases, the cost of animals should be part of the farm model.

8 See 'Bibliography' at the end of this note.

9 To avoid double-counting, those costs in Costab already captured in the livestock models should not be considered, hence deducted.

Livestock

EXAMPLE 1

Regional Sahel Pastoralism Support Project

(Burkina Faso, Chad, Mali, Mauritania, Niger and Senegal, World Bank, 2015)

Project description

The objective is to “improve access to essential productive assets, services and markets for pastoralists and agropastoralists in selected transborder areas and transhumance axes across six Sahel countries, and strengthen country capacity to respond promptly and effectively to pastoral crises or emergencies”. To achieve this objective, the project is investing in a number of activities, implemented across four technical components: (i) enhancing production services for animal health; (ii) enhancing production services for natural resource management; (iii) improving livestock-sector competitiveness and market access; and (iv) strengthening the security of the assets, rights and lifestyles of pastoral people, and providing access to basic social services and political inclusion.

Incremental benefits

Activities financed under the Regional Sahel Pastoralism Support Project (RSPSP) are expected to generate three main benefit streams: (i) private (pastoralist)-level benefits, ranging from increased herd growth and accrued production of livestock and livestock products to increased livestock productivity, due to increased parturition rates, increased animal live weights and decreased livestock mortality and morbidity. The ultimate private benefits are improved household incomes and assets, which in turn generate additional social benefits in the form of increased food security and nutrition; (ii) public benefits at national and regional levels, such as reduced transboundary animal diseases and strengthened capacity of public services and institutions, including participating ministries and the regional economic community (e.g. the Interstates Committee for Drought Control in the Sahel); and (iii) global benefits, such as natural resource protection, enhanced biodiversity and resilience to the effects of climate change.

Project costs

Total project costs were provided by the Costab tool on the basis of detailed cost tables prepared in the six countries of the project. Economic prices were generated by the Costab algorithm, which removed all taxes, duties and inflation effects (the economic analysis being carried out in constant prices).

Methodology and key assumptions

Using the EcoRum interface of the LSIPT, herd-growth projection models for cattle, sheep and goats have been designed to estimate WP and WOP situations for a typical pastoral household over a 20-year period for the selected countries. In both situations, it was assumed a drought would occur every five years. The required parameters (general, demographic, production and those linked to feed requirements) were retrieved from the livestock-sector study in Burkina Faso and Mauritania financed by the World Bank and prepared by TCI (FAO 2005) (tables 2-10). Assumptions were also triangulated with datasets found in publications from the Consultative Group on International Agricultural Research (CGIAR)/ILRI (Ejlertsen, Poole and Marshall 2012) and FAO (Otte and Chilonda 2002). Animal price data were compiled from livestock marketing information systems and from the FAOSTAT portal· assuming that market prices would reflect the economic prices of animals. Incremental benefits at the household level were extrapolated to the total number of beneficiaries (as indicated in the results framework). In line with EFAs for World Bank-funded projects in the Sahel region, a social discount rate of 12 per cent was used to calculate NPV.

Results (tables 2-10): baseline and sensitivity analysis

Results indicate that the project is economically justified. Under the modelling assumptions, IRRs in the six countries range from 18.3 to 23.5 per cent, and NPVs from US$18 million to US$37 million. The project is sensitive to changes in some of the model’s variables (animal mortality rates and offtake), confirming that sustainable investments in animal nutrition, water access and health are key to project success (tables 10A and 10B).

TABLE 2

Herd modelling (cattle), step 1, setting the age group categories (WOP scenario)

I. Technical performance of ruminant herds (without intervention)

Livestock farming system: B1MR **Race: Bovine** **Mixed rainfed system (MR)** **Size: small**

Model

I. Age groups

		Duration (months)	Exact age (year) from	to
Female	Juvenile	12	0	1
	Sub-adult	36	1	4
	Adult	132	4	15
Male	Juvenile	12	0	1
	Sub-adult	36	1	4
	Adult	72	4	10

Population

Size		No. anim.	% anim.	Size	Structure Global	Intra-sex
Female	Juvenile		11%	0.5	12%	18%
	Sub-adult		9%	0.5	11%	15%
	Adult		40%	2.0	47%	67%
Male	Juvenile		11%	0.5	12%	42%
	Sub-adult		9%	0.5	11%	36%
	Adult		5%	0.3	6%	22%
Total	Female			3.0	70%	100%
	Male			1.2	30%	100%
	Total			**4.2**	**100%**	
	Tot. no. anim.	**5**				

Projection

Report over 20 years

No. years: 20

Summary/synthesis year 20

		Structure	Rate (%) Offtake	Growth	No. prod.
Female	Juvenile	7%			
	Sub-adult	20%			
	Adult	30%			
Male	Juvenile	7%			
	Sub-adult	19%			
	Adult	18%			
Total	Female	56%	12.9%	-16.2%	
	Male	44%	17.0%	-17.6%	
	Total	**100%**	**14.7%**	**-16.8%**	**-3.4%**

How to fill the tables:
1. Age groups table: set the age-class durations by sex class (months).
2. Population table: set the sex-by-age structure (percentages) and the total population size targeted by the project.
3. Projection settings: set the simulation period (from 1 to 20 years).

TABLE 3

Herd modelling (cattle), step 2, setting the demographic parameters (reproduction, mortality, offtake and importation) (WOP scenario)

II. Demography			Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Reproduction										
Parturition rate (/year)			0.57	0.57	0.57	0.57	0.46	0.57	0.57	0.57
Rate of net prolificacy			1	1	1	1	1	1	1	1
% of females at birth			50%	50%	50%	50%	50%	50%	50%	50%
Mortality (%)										
- / age group if duration < 1 year										
- / year if duration >= 1 year	Female	Juvenile	15%	15%	15%	15%	30%	15%	15%	15%
		Sub-adult	7%	7%	7%	7%	14%	7%	7%	7%
		Adult	6%	6%	6%	6%	12%	6%	6%	6%
	Male	Juvenile	15%	15%	15%	15%	30%	15%	15%	15%
		Sub-adult	7%	7%	7%	7%	14%	7%	7%	7%
		Adult	6%	6%	6%	6%	12%	6%	6%	6%
Offtake (%)										
- / age group if duration < 1 year										
- / year if duration >= 1 year	Female	Juvenile	0%	0%	0%	0%	0%	0%	0%	0%
		Sub-adult	0%	0%	0%	0%	0%	0%	0%	0%
		Adult	4%	4%	4%	4%	20%	0%	4%	4%
	Male	Juvenile	0%	0%	0%	0%	0%	0%	0%	0%
		Sub-adult	3%	3%	3%	3%	6%	0%	3%	3%
		Adult	5%	5%	5%	5%	25%	0%	5%	5%

II. Demography			Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Reproduction														
Parturition rate (/year)			0.57	0.46	0.57	0.57	0.57	0.57	0.46	0.57	0.57	0.57	0.57	0.46
Rate of net prolificacy			1	1	1	1	1	1	1	1	1	1	1	1
% of females at birth			50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Mortality (%)														
- / age group if duration < 1 year														
- / year if duration >= 1 year	Female	Juvenile	15%	30%	15%	15%	15%	15%	30%	15%	15%	15%	15%	30%
		Sub-adult	7%	14%	7%	7%	7%	7%	14%	7%	7%	7%	7%	14%
		Adult	6%	12%	6%	6%	6%	6%	12%	6%	6%	6%	6%	12%
	Male	Juvenile	15%	30%	15%	15%	15%	15%	30%	15%	15%	15%	15%	30%
		Sub-adult	7%	14%	7%	7%	7%	7%	14%	7%	7%	7%	7%	14%
		Adult	6%	12%	6%	6%	6%	6%	12%	6%	6%	6%	6%	12%
Offtake (%)														
- / age group if duration < 1 year														
- / year if duration >= 1 year	Female	Juvenile	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Sub-adult	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Adult	4%	20%	0%	4%	4%	4%	20%	0%	4%	4%	4%	20%
	Male	Juvenile	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Sub-adult	3%	6%	0%	3%	3%	3%	6%	0%	3%	3%	3%	6%
		Adult	5%	25%	0%	5%	5%	5%	25%	0%	5%	5%	5%	25%

How to fill the demography tables:
1. Reproduction: set the parturition, net rate of prolificacy and percentage of females at birth.
2. Mortality: set the mortality rates by age and sex class.
3. Offtake: set the offtake by age and sex class.

TABLE 4

Herd modelling (cattle), step 3, setting the production and feeding parameters (live weights, financial prices, milk production, etc.) (WOP scenario)

III. Production			Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Live weight (kg/animal at start of age group)																						
	Female	Juvenile	70	70	70	70	49	70	70	70	70	49	70	70	70	70	49	70	70	70	70	49
		Sub-adult	153	153	153	153	107	153	153	153	153	107	153	153	153	153	107	153	153	153	153	107
		Adult	260	260	260	260	182	260	260	260	260	182	260	260	260	260	182	260	260	260	260	182
	Male	Juvenile	75	75	75	75	53	75	75	75	75	53	75	75	75	75	53	75	75	75	75	53
		Sub-adult	160	160	160	160	112	160	160	160	160	112	160	160	160	160	112	160	160	160	160	112
		Adult	320	320	320	320	224	320	320	320	320	224	320	320	320	320	224	320	320	320	320	224
Meat																						
Dressing percentage (%)			45%	45%	45%	45%	45%	0%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%
Financial price (/animal)																						
Farm	Female	Juvenile	36,000	36,000	36,000	36,000	18,000	36,000	36,000	36,000	36,000	18,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000	18,000
		Sub-adult	90,000	90,000	90,000	90,000	45,000	90,000	90,000	90,000	90,000	45,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000	45,000
		Adult	180,000	180,000	180,000	180,000	90,000	180,000	180,000	180,000	180,000	90,000	180,000	180,000	180,000	180,000	180,000	180,000	180,000	180,000	180,000	90,000
	Male	Juvenile	48,000	48,000	48,000	48,000	24,000	48,000	48,000	48,000	48,000	24,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	24,000
		Sub-adult	120,000	120,000	120,000	120,000	60,000	120,000	120,000	120,000	120,000	60,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000	60,000
		Adult	240,000	240,000	240,000	240,000	120,000	240,000	240,000	240,000	240,000	120,000	240,000	240,000	240,000	240,000	240,000	240,000	240,000	240,000	240,000	120,000
Milk (litre)																						
Duration of lactation (days)			170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170
Milking per day of lactation (litre/reproductive female)			5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Production per lactation (litre)			850	850	850	850	850	850	850	850	850	850	850	850	850	850	850	850	850	850	850	850

IV. Feeding			
Daily dry matter requirement (% per kg live weight)			
	Female	Juvenile	2.5%
		Sub-adult	2.5%
		Adult	2.5%
	Male	Juvenile	2.5%
		Sub-adult	2.5%
		Adult	2.5%

How to fill the production tables:

1. Live weight: set the weight (kg) per animal by age and sex class.
2. Financial prices: set the price per animal by age and sex class in domestic or foreign currency.
3. Milk production: set the duration of lactation (days) and milking days per lactation (litre per reproductive female).
4. Hides/skins, wool, manure: quantities can be entered in kilogram per animal (not displayed on this table, optional).

TABLE 5

Herd modelling (cattle), step 4, using results from the modelling for EFA (WOP scenario)

I. Population	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Average
Growth rate																					
Female	4.3%	3.4%	3.0%	2.8%	-16.2%	4.4%	2.7%	2.7%	2.6%	-16.2%	4.3%	2.7%	2.7%	2.6%	-16.2%	4.3%	2.7%	2.6%	2.6%	-16.2%	-0.7%
Male	26.6%	16.9%	11.9%	9.1%	-14.0%	9.2%	5.2%	4.5%	4.1%	-16.8%	6.7%	3.4%	3.2%	3.1%	-17.5%	6.1%	2.9%	2.9%	2.8%	-17.6%	2.6%
Total	**10.9%**	**8.0%**	**6.3%**	**5.2%**	**-15.3%**	**6.4%**	**3.7%**	**3.5%**	**3.3%**	**-16.5%**	**5.3%**	**3.0%**	**2.9%**	**2.8%**	**-16.7%**	**5.1%**	**2.8%**	**2.7%**	**2.7%**	**-16.8%**	**0.5%**

II. Production	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Average	Total
Financial equivalent																						
Average live stock	589,323	643,316	696,596	746,388	356,515	682,911	724,047	754,060	782,795	365,107	685,286	716,615	738,390	760,312	704,936	658,114	685,809	704,740	724,160	335,184	652,730	13,054,602
Inventory change	53,261	54,725	51,834	47,750	-56,494	51,554	30,718	29,307	28,163	-65,973	40,963	21,695	21,856	21,988	-131,436	36,729	18,659	19,203	19,637	-62,993	11,557	231,146
Farm	46,042	49,922	55,272	60,954	68,803	41,186	62,957	66,573	69,842	74,064	44,259	64,858	67,203	69,424	144,924	43,240	62,700	64,636	66,512	69,146	64,626	1,292,517
Importation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VS + E - I	99,304	104,647	107,106	108,704	12,309	92,740	93,675	95,880	98,005	8,092	85,222	86,553	89,059	91,411	13,487	79,969	81,359	83,838	86,149	6,153	76,183	1,523,663
% change		5.4%	2.4%	1.5%	-88.7%	653.5%	1.0%	2.4%	2.2%	-91.7%	953.2%	1.6%	2.9%	2.6%	-85.2%	492.9%	1.7%	3.0%	2.8%	-92.9%		
Milk (litre)																						
Average per reproductive female	485	485	485	485	388	485	485	485	485	388	485	485	485	485	388	485	485	485	485	388	465	
Total	**936**	**896**	**886**	**891**	**650**	**751**	**784**	**805**	**826**	**608**	**706**	**740**	**761**	**781**	**575**	**668**	**700**	**720**	**739**	**544**	**748**	**14.968**
% change		-4.3%	-1.2%	0.6%	-27.1%	15.5%	4.5%	2.7%	2.6%	-26.4%	16.1%	4.8%	2.8%	2.7%	-26.4%	16.2%	4.8%	2.8%	2.7%	-26.4%		

How to use this table for EFA: in the 'Results' subsection, the line VS + E - I can be used to reflect the stream of financial benefits arising from the livestock activity without the project.

TABLE 6

Herd modelling (cattle), step 1, setting the age group categories (WP scenario)

I. Technical performance of ruminant herds (with intervention)

Livestock farming system: B1MR **Race: Bovine** **Mixed rainfed system (MR)** **Size: small**

Model

I. Age groups

		Duration (months)	Exact age (year) from	to
Female	Juvenile	12	0	1
	Sub-adult	36	1	4
	Adult	132	4	15
Male	Juvenile	12	0	1
	Sub-adult	36	1	4
	Adult	72	4	10

Population

Size		No. anim.	% anim.	Size	Structure Global	Intra-sex
Female	Juvenile		11%	0.6	13%	18%
	Sub-adult		9%	0.5	11%	15%
	Adult		40%	2.0	47%	67%
Male	Juvenile		11%	0.6	13%	44%
	Sub-adult		9%	0.5	11%	36%
	Adult		5%	0.3	6%	20%
Total	Female		60%	3.0	71%	100%
	Male		25%	1.3	29%	100%
	Total		**85%**	**4.3**	**100%**	
	Tot. no. anim.	**5**				

Projection **Summary/synthesis year 20**

Import from projection (without)

No. years: 20

		Structure	Rate (%) Offtake	Growth	No. prod.
Female	Juvenile	7%			
	Sub-adult	20%			
	Adult	30%			
Male	Juvenile	7%			
	Sub-adult	18%			
	Adult	17%			
Total	Female	57%	14.3%	-15.1%	
	Male	43%	19.6%	-17.3%	
	Total	**100%**	**16.6%**	**-16.1%**	**-0.6%**

How to fill the tables:

1. Age groups table: set the age-class durations by sex class (months).
2. Population table: set the sex-by-age structure (percentages) and the total population size targeted by the project.
3. Projection settings: set the simulation period (from 1 to 20 years).

TABLE 7

Herd modelling (cattle), step 2, setting the demographic parameters (reproduction, mortality, offtake and importation) (WP scenario)

II. Demography			Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Reproduction																						
Parturition rate (/year)			0.6	0.6	0.6	0.6	0.5	0. 6	0.6	0.6	0.6	0.5	0.6	0.6	0.6	0.6	0.5	0.6	0.6	0.6	0.6	0.5
Rate of net prolificacy			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
% of females at birth			50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Mortality (%)																						
- / age group if duration < 1 year																						
- / year if duration >= 1 year	Female	Juvenile	14%	14%	14%	14%	28%	14%	14%	14%	14%	28%	14%	14%	14%	14%	14%	14%	14%	14%	14%	28%
		Sub-adult	6%	6%	6%	6%	12%	6%	6%	6%	6%	12%	6%	6%	6%	6%	6%	6%	6%	6%	6%	12%
		Adult	5%	5%	5%	5%	10%	5%	5%	5%	5%	10%	5%	5%	5%	5%	5%	5%	5%	5%	5%	10%
	Male	Juvenile	14%	14%	14%	14%	28%	14%	14%	14%	14%	28%	14%	14%	14%	14%	14%	14%	14%	14%	14%	28%
		Sub-adult	6%	6%	6%	6%	12%	6%	6%	6%	6%	12%	6%	6%	6%	6%	6%	6%	6%	6%	6%	12%
		Adult	5%	5%	5%	5%	10%	5%	5%	5%	5%	10%	5%	5%	5%	5%	5%	5%	5%	5%	5%	10%
Farm (%)																						
- / age group if duration < 1 year																						
- / year if duration >= 1 year	Female	Juvenile	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Sub-adult	2%	2%	2%	2%	4%	0%	2%	2%	2%	4%	0%	2%	2%	2%	4%	0%	2%	2%	2%	4%
		Adult	4%	4%	4%	4%	20%	0%	4%	4%	4%	20%	0%	4%	4%	4%	20%	0%	4%	4%	4%	20%
	Male	Juvenile	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Sub-adult	6%	6%	6%	6%	12%	0%	6%	6%	6%	12%	0%	6%	6%	6%	12%	0%	6%	6%	6%	12%
		Adult	5%	5%	5%	5%	25%	0%	5%	5%	5%	25%	0%	5%	5%	5%	25%	0%	5%	5%	5%	25%

How to fill the demography tables:

1. Reproduction: set the parturition, net rate of prolificacy and percentage of females at birth.
2. Mortality: set the mortality rates by age and sex class.
3. Offtake: set the offtake by age and sex class.

TABLE 8

Herd modelling (cattle), step 3, setting the production and feeding parameters (live weights, financial prices, milk production, etc.) (WP scenario)

III. Production			Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Live weight (kg/animal at start of age group)																						
	Female	Juvenile	77	77	77	77	60	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77
	Female	Sub-adult	168	168	168	168	130	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168
	Female	Adult	286	286	286	286	218	286	286	286	286	286	286	286	286	286	286	286	286	286	286	286
	Male	Juvenile	83	83	83	83	63	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83
	Male	Sub-adult	176	176	176	176	134	176	176	176	176	176	176	176	176	176	176	176	176	176	176	176
	Male	Adult	352	352	352	352	269	352	352	352	352	352	352	352	352	352	352	352	352	352	352	352
Meat																						
Dressing percentage (%)			45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%
Financial price (/animal)																						
Farm	Female	Juvenile	36,000	36,000	36,000	36,000	16,204	36,000	36,000	36,000	36,000	16,204	36,000	36,000	36,000	36,000	16,204	36,000	36,000	36,000	36,000	16,204
Farm	Female	Sub-adult	90,000	90,000	90,000	90,000	40,509	90,000	90,000	90,000	90,000	40,509	90,000	90,000	90,000	90,000	40,509	90,000	90,000	90,000	90,000	40,509
Farm	Female	Adult	180,000	180,000	180,000	180,000	81,018	180,000	180,000	180,000	180,000	81,018	180,000	180,000	180,000	180,000	81,018	180,000	180,000	180,000	180,000	81,018
Farm	Male	Juvenile	48,000	48,000	48,000	48,000	24,929	48,000	48,000	48,000	48,000	24,929	48,000	48,000	48,000	48,000	24,929	48,000	48,000	48,000	48,000	24,929
Farm	Male	Sub-adult	120,000	120,000	120,000	120,000	62,322	120,000	120,000	120,000	120,000	62,322	120,000	120,000	120,000	120,000	62,322	120,000	120,000	120,000	120,000	62,322
Farm	Male	Adult	240,000	240,000	240,000	240,000	124,644	240,000	240,000	240,000	240,000	124,644	240,000	240,000	240,000	240,000	124,644	240,000	240,000	240,000	240,000	124,644
Milk (litre)																						
Duration of lactation (days)			184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184
Milking per day of lactation (litre/reproductive female)			5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
Production per lactation (litre)			966	966	966	966	966	966	966	966	966	966	966	966	966	966	966	966	966	966	966	966

IV. Feeding		
Daily dry matter requirement (% per kg live weight)		
Female	Juvenile	2.5%
Female	Sub-adult	2.5%
Female	Adult	2.5%
Male	Juvenile	2.5%
Male	Sub-adult	2.5%
Male	Adult	2.5%

How to fill the production tables:
1. Live weight: set the weight (kg) per animal by age and sex class.
2. Financial prices: set the price per animal by age and sex class in domestic or foreign currency.
3. Milk production: set the duration of lactation (days) and milking days per lactation (litre per reproductive female).
4. Hides/skins, wool, manure: quantities can be entered in kilogram per animal (not displayed on this table, optional).

TABLE 9

Herd modelling (cattle), step 4, using results from the modelling for EFA (WP scenario)

I. Population	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Average
Growth rate																					
Female	5.0%	4.0%	3.5%	3.3%	-15.1%	5.5%	3.1%	3.1%	3.1%	-15.1%	5.5%	3.1%	3.1%	3.1%	-8.5%	5.4%	3.1%	3.1%	3.1%	-15.1%	0.3%
Male	27.4%	17.2%	12.2%	9.4%	-13.8%	11.3%	5.6%	5.0%	4.5%	-16.5%	8.6%	3.8%	3.7%	3.5%	-10.1%	7.9%	3.3%	3.3%	3.2%	-17.3%	3.6%
Total	**11.6%**	**8.4%**	**6.7%**	**5.6%**	**-14.6%**	**7.8%**	**4.2%**	**3.9%**	**3.7%**	**-15.7%**	**6.8%**	**3.4%**	**3.4%**	**3.3%**	**-9.1%**	**6.5%**	**3.2%**	**3.2%**	**3.2%**	**-16.1%**	**1.5%**

II. Production	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Average	Total
Financial equivalent																						
Average live stock	590,028	648,796	706,025	759,568	349,659	707,206	756,384	790,774	824,276	373,088	735,013	775,489	802,440	829,906	387,698	790,750	831,510	857,996	885,343	398,516	690,023	13,800,464
Inventory change	58,655	58,882	55,576	51,511	-52,102	63,481	34,875	33,905	33,099	-64,243	54,294	26,658	27,243	27,690	-39,235	55,502	26,019	26,953	27,740	-71,628	21,744	434,875
Farm	50,212	55,773	62,342	68,964	73,443	44,179	72,633	76,855	80,801	81,949	49,114	77,004	79,993	82,936	85,937	53,744	83,312	86,146	88,981	88,846	72,158	1,443,165
Importation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VS + E - I	108,867	114,655	117,918	120,475	21,341	107,660	107,508	110,760	113,900	17,706	103,407	103,662	107,236	110,626	46,702	109,246	109,331	113,100	116,721	17,218	93,902	1,878,040
% change		5.3%	2.8%	2.2%	-82.3%	404.5%	-0.1%	3.0%	2.8%	-84.5%	484.0%	0.2%	3.4%	3.2%	-57.8%	133.9%	0.1%	3.4%	3.2%	-85.2%		
Milk (litre)																						
Average per reproductive female	560	560	560	560	454	560	560	560	560	454	560	560	560	560	454	560	560	560	560	454	539	
Total	**1,090**	**1,051**	**1,045**	**1,057**	**789**	**913**	**960**	**989**	**1,020**	**767**	**892**	**940**	**970**	**1,000**	**779**	**942**	**993**	**1,026**	**1,058**	**796**	**954**	**19,076**
% change		-3.6%	-0.6%	1.2%	-25.4%	15.7%	5.1%	3.1%	3.1%	-24.7%	16.2%	5.4%	3.2%	3.1%	-22.1%	20.9%	5.4%	3.3%	3.1%	-24.7%		

How to use this table for EFA: in the 'Results' subsection, the line VS + E - I can be used to reflect the stream of financial benefits arising from the livestock activity with the project.

TABLE 10A

Results of the sensitivity analysis measured by impact on IRR

Scenario	Burkina Faso	Chad	Mali
Baseline	18.9%	21.0%	22.2%
With changes in mortality rates (all other variables being fixed)			
+2% in mortality rates	16.8%	19.3%	20.1%
+5% in mortality rates	13.3%	16.5%	16.7%
With changes in parturition rates (all other variables being fixed)			
-5% in parturition rate	18.0%	20.1%	21.3%
-10% in parturition rate	17.0%	19.1%	20.4%
With changes in offtake rates (all other variables being fixed)			
+2% in offtake rates	16.6%	18.7%	20.6%
+5% in offtake rates	12.1%	14.6%	17.0%
With changes in animal prices during shocks			
-10% in animal prices	15.6%	17.5%	18.8%
-15% in animal prices	13.6%	15.5%	16.8%

TABLE 10B

Results of the sensitivity analysis measured by impact on IRR

Scenario	Mauritania	Niger	Senegal
Baseline	23.5%	21.7%	20.0%
With changes in mortality rates (all other variables being fixed)			
+2% in mortality rates	21.3%	19.5%	17.1%
+5% in mortality rates	17.9%	15.9%	12.4%
With changes in parturition rates (all other variables being fixed)			
-5% in parturition rate	22.5%	20.6%	19.2%
-10% in parturition rate	21.6%	19.6%	18.4%
With changes in offtake rates (all other variables being fixed)			
+2% in offtake rates	21.4%	19.0%	18.8%
+5% in offtake rates	18.0%	14.1%	16.8%
With changes in animal prices during shocks			
-10% in animal prices	21.4%	18.6%	18.5%
-15% in animal prices	20.2%	16.9%	17.8%

EXAMPLE 2

Study on enhancement of the Smallholder Livestock Investment Programme (E-SLIP)

(Zambia, IFAD, 2014)

Programme description

This example on livestock farming and production is based on an EFA undertaken in 2014 in the context of IFAD's Smallholder Livestock Investment Programme in Zambia. The programme's objective is to enhance production and productivity of key livestock systems of targeted smallholder producers through three components: (i) animal disease control improvement; (ii) increased livestock production and productivity; and (iii) programme management. Several models have been developed to represent programme activities to increase the incomes of livestock-sector households (table 11). While analysis of the programme entailed both dynamic and static growth models, the examples used in this note primarily focus on the latter so as to demonstrate the effectiveness and viability of 'pass on the gift' activities[1] in rural communities. More particularly, this example illustrates the static growth model through analysis of poultry restocking and passing on.

Costs and benefits

Activity costs include investment, operating/production and labour costs. No animal costs are included (pass-on scheme). Investment costs comprise: (i) infrastructure costs for housing built with locally made materials; and (ii) a one-time veterinary contribution equal to 10 per cent of total revenues. Operating costs per production cycle include: (i) feed for chicks and broilers; (ii) veterinary costs (external and internal deworming, cleaning and disinfection); and (iii) miscellaneous costs including water provision. Costs for the labour of family members are quantified and valued at 8 Zambian kwacha (K) per day – an average of rural unskilled labour in the area. The programme is expected to deliver substantial tangible and intangible benefits to rural households and to contribute to: (i) reduced livestock mortality; (ii) the adoption of a holistic approach to tick-borne disease control; (iii) expanded forage technologies, while ensuring a reliable future seed supply; and (vi) the establishment of a sustainable government restocking programme, including systems for the procurement of animal health services.

Methodology

The initial livestock packages for poultry will consist of 30 hens and 4 roosters. Pass-on will happen between the second and fourth programme years. Parameters adopted for simulating poultry-keeping are consistent with improved animal practices. Moreover, it is assumed that farmers will have access to water and feed supplies, together with veterinary and technical advisory services provided by the programme. Computation of costs and revenues for these models is based on the technical parameters specified in table 11, while the detailed budget is presented in table 12.

TABLE 11

List of household models

Project component	Model name
Animal disease control improvement	• Cattle keeping, CBPP control • Cattle keeping, ECF control • Stabilize production at CVRI
Livestock production and productivity improved	• Improved forage production • Cattle restocking and pass-on • Goat keeping (improved) • Goat restocking and pass-on • Pig restocking and pass-on • Poultry restocking and pass-on

Note: CBPP = contagious bovine pleuropneumonia; ECF = East Coast fever; CVRI = Central Veterinary Research Institute.

1 'Pass on the gift' models refer to smallholder households receiving livestock 'packages' (cattle, goats, pigs or poultry), which they would pay for through a mechanism of 'pass-on' to fellow poor households.

TABLE 12
Model's assumptions and parameters

	Units	Unit cost
Selling price, hen	K/head	14.0
Selling price, rooster	K/head	17.0
Selling price, broiler	K/head	24.0
Family labour	person-days/year	70.0
Family labour	K/day	8.5
Feed costs for chicks (4 weeks)	K/head	3.0
Feed costs for broilers (12 weeks)	K/head	9.0
Veterinary cost	K/head	4.0
One-time veterinary contribution	% of gross revenue	10%
Housing	K	472.5
Miscellaneous expenditure	% of gross revenue	10%

		Unit	Years		
			1	2	3-20
Technical parameters	Mortality of chicks	%	40%	40%	40%
	Mortality of broilers	%	30%	30%	30%
	Hatched chicks per hen per year	head	150		
Stock (heads)	Chickens	head	2,700	2,700	2,700
	Broilers	head	1,890	1,890	1,890
	Hens	head	30	30	30
	Roosters	head	4	4	4
	Total	**head**	**1,924**	**1,924**	**1,924**
Offtake (heads)	Hens (selling)	head	0	30*	0
	Roosters (selling)	head	0	2	2
	Hens (pass on)	head	0	30	0
	Broilers	head	0	1,828	1,888
	Total	**head**	**0**	**1,890**	**1,890**

* Animal sold every two years.

Annual financial cash flows were calculated to demonstrate the financial viability of the proposed activity. A proxy for WOP foregone income is included in the analysis so as to derive incremental net benefits and avoid optimistic results. Annual cash flows consider all costs and revenues from each year for a period of 20 years. An 8 per cent opportunity cost of capital was assumed, based on the average deposit rates prevailing in Zambia, and IRR and NPV results calculated accordingly.

Results

Table 13 shows that the proposed programme activity is financially desirable, with 12.3 per cent IRR, and NPV averaging K 13,000 (about US$1,300).

TABLE 13

Poultry-keeping costs and revenues

		Unit	WOP	1	2	3	4	5-20
Revenue	Sales (live animals)	K	0	0	44,326	45,346	45,046	45,346
	Total revenues	**K**	**0**	**0**	**44,326**	**45,346**	**45,046**	**45,346**
Investment costs	Housing	K	0	473	0	0	0	0
	One-time veterinary contribution	K	0	4,433	0	0	0	0
	Total investment costs	**K**	**0**	**4,905**	**0**	**0**	**0**	**0**
Operating costs	Feed for chicks	K	0	6,480	6,480	6,480	6,480	6,480
	Feed for broilers	K	0	17,314	17,314	17,314	17,314	17,314
	Animal health care	K	0	7,695	7,695	7,695	7,695	7,695
	Miscellaneous	K	0	4,000	4,433	4,535	4,505	4,535
	Total operating costs	**K**	**0**	**35,489**	**35,921**	**36,023**	**35,993**	**36,023**
Labour costs	Hired labour	K	0	0	0	0	0	0
	Family labour	K	0	595	595	595	595	595
Total costs		**K**		**40,989**	**36,516**	**36,618**	**36,588**	**36,618**
Profitability	Net income	K	2,500*	-40,989	7,810	8,728	8,458	8,728
	Net incremental benefits	K		-43,489	5,310	6,228	5,958	6,228
	FIRR	%		12.3%				
	NPV @ 8%	K		13,280				
	Return to labour	K/day		-586	112	125	121	125
	Benefit/cost ratio			0.0	1.2	1.2	1.2	1.2

* Net income in the WOP situation is an estimate of foregone income related to alternative investment activities.
Note: FIRR = financial internal rate of return.

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CASE STUDY 5

Natural resource management

Conceptual section

Scope of the note

The objective is to highlight the main tangible benefits from natural resource management (NRM) interventions or projects[1] and the related proxies for evaluating them. The examples that follow deal with watershed management, which is one of the main interventions in the area of NRM financed by donors. The note supports economists, natural resource specialists and project design leaders in identifying relevant benefits that can be easily quantified in EFA of NRM projects.

Interventions

Many donor-funded projects are adopting a holistic approach to NRM. The objective is usually to ensure long-term sustainability of the productive capital linked to land, water, soil and plant genetic resources, as well as to foster productive and non-productive local and global benefits. The rationale behind NRM investment is that natural resources are jeopardized by the combined effect of unsustainable productive human use and climate change. This could translate into critical medium- and long-term effects, in particular: (i) lower agricultural production and food security; and (ii) a higher incidence and severity of climate shocks, environmental hazards and disasters. NRM projects thus intend to mitigate and prevent these foreseeable impacts by restoring and preserving the natural resources of key ecosystems and promoting sustainable production practices. As a result, most of the benefits of NRM projects or components are related to *avoided losses* and to *restoration of productive value in degraded areas*.

By definition, NRM interventions target a wide range of interlinked natural resources: land, soils, forests and water. One common project approach is the watershed management approach where NRM is included at the upstream and downstream levels of the various productive systems. This approach integrates technical parameters linked to ecosystem functions, but also production and socio-economic dimensions (human communities). Interventions include both software and hardware investments such as: (i) upper watershed – agroforestry, afforestation and reforestation; and infrastructure and techniques for soil erosion control, sediment retention and rainwater harvesting (terraces, soil fertility management, etc.); and (ii) lower watershed – irrigation and water control infrastructure (dams, dikes, canals, drainage systems, etc.); integrated soil-fertility management techniques; and establishment of groups such as water users' associations. Thus, due to the holistic spatial and economic approach of NRM interventions, this note is closely linked to – complementing but not duplicating – the case studies on irrigation, climate-smart agriculture and livestock discussed in these guidelines.

Benefits

Benefits stemming from NRM interventions include those related to the use and non-use values of natural resources, as well as to on- and off-site benefits. The main benefits are: (i) tangible on-site benefits – those occurring locally, in the same area as project interventions, for private actors, and

1 The proposed EFA guidance case applies to projects that do not, in particular, include NRM as a development objective or a stand-alone component. Sustainable use of the natural resource base is usually mainstreamed in all projects that include production activities dependent on natural resources. Thus EFA should systematically incorporate and reflect ecosystem benefits and trade-offs of NRM interventions.

corresponding to most of the 'direct-use' benefits; (ii) tangible off-site private benefits – those occurring outside the project area for private actors – including other farmers, water treatment companies and hydroelectric plants; and (iii) intangible on-site and global benefits – those corresponding to local and global positive externalities of the ecosystem. All these benefits are presented in table 1.

TABLE 1

Main tangible and intangible benefits of NRM interventions

	On-site tangible benefits	Due to …
1	Increased crop productivity and avoided crop productivity loss	▶ increase in yields through erosion control; conservation measures, intercropping and crop diversification to spread the risk of losses from climate shocks; irrigation development; and complementary activities (improved seed, fertility management, manure, etc.) ▶ avoided yield losses for upstream and downstream crops, through preservation of the nutrient and moisture content of the soil, generated by adoption of sustainable land, water and soil management techniques
2	Avoided cropped area loss and increased cropped area	▶ no loss of productive upstream areas through reversion of land degradation processes, and of downstream irrigated areas through lower siltation of water control facilities, which normally tend to reduce the area under production ▶ additional area under production in upper watershed (agroforestry terraces) and lower watershed (irrigation development) through increased availability of water
3	Increased livestock productivity	▶ increase in livestock outputs through better availability of fodder grown on upper watersheds (afforestation, agroforestry, grassland development)
4	Increased and diversified incomes	▶ some interventions (agroforestry, crop diversification, intercropping, grassland development, reforestation and afforestation) can generate additional revenues: fodder, timber, poles, non-timber forest products, fuelwood, agroforestry products, etc. Other revenues can come from tourism and recreational activities
5	Lower O&M labour and non-labour costs	▶ reduction of O&M costs, paid for by farmers, related to de-siltation of water control facilities through reduced sediment loads in rivers. Costs can include direct labour (salaried or family labour), O&M fees, etc.

	Off-site tangible benefits	Due to …
7	Lower de-siltation and water treatment costs	▶ reduced sediment content of water through upstream interventions, lower siltation and water treatment costs for hydropower and water supply companies or for public institutions
8	Lower capital cost of irrigation schemes	▶ soil erosion control
9	Lower natural-disaster-related capital and O&M costs	▶ erosion control activities increase control of water flow peaks/floods through improved infiltration and slowing of flow through restored vegetation cover, resulting in lower frequency and severity of floods and lower public or private spending for: (i) rehabilitation, reconstruction and repair of irrigation schemes, home repair, etc.; and (ii) O&M of infrastructure.

	Intangible benefits (on-site and global)	Due to …
10	Increased carbon sequestration	▶ increase in biomass (agroforestry, reforestation and afforestation, etc.)
11	Watershed services	▶ natural resource conservation and hydrological services
12	Avoided biodiversity loss of increased biodiversity	▶ avoided biodiversity loss can have: (i) direct-use value by contributing to short- and long-term crop productivity (in which case it is captured indirectly in crop models); and (ii) option value (potential future medicinal or genetic applications), as well as existence and bequest values, which are difficult to estimate
13	Microclimate regulation	▶ activities focusing more particularly on forest and biomass resources (very site-specific benefit)

NRM interventions can also generate negative externalities, whose probability of occurrence and impact has to be identified and analysed. These externalities can generate additional costs and/or limit some benefits previously described. For example, for watershed projects, migration is often highlighted as a potential externality. In this case, the productivity gains and production expansion can make the area more attractive and increase labour requirements. This might generate migration flows, representing a higher pressure on resources, especially water and fuelwood. Sometimes, in the case of in-country migration, it can be considered a zero-sum trend, as it means less pressure on resources in the zone of departure.

Methodologies and tools

The main methodological approaches used to value the above-mentioned benefits (table 1, box 1) are the following:

- *On-site private benefits*. Most of these benefits are captured through crop, livestock or other production models/budgets. Other on-site private benefits are sometimes valued using a simple straightforward approach of estimating incremental volumes produced or costs savings per hectare and valuing those using financial and economic prices (see volume 2 of these guidelines for price conversion). The avoided losses approach is often used in analysing NRM projects that mitigate or prevent negative impacts that would have happened in the without-project scenario. The main avoided loss is usually related to productivity – in livestock or crop yields in particular. In that case, secondary data should be used to establish the counterfactual situation (without project). Empirical data from previous projects, long-term biophysical modelling studies or data from national research institutes should be analysed to establish hypotheses for the baseline, WOP trends, WP trends and adoption rates. The findings can also be summarized through graphs (see figure 1 in example 1).
- *Off-site tangible benefits*. These are quantified using a simplified approach, based on estimation of annual cost savings per unit (hectare, ton). These costs include those that would have occurred in the future (in the absence of NRM practices) for public or private infrastructure replacement, soil fertilization, etc. Annual cost savings are usually drawn from similar projects and/or from technical inputs by engineers or ministries.

BOX 1

Total economic value

Total economic value (TEV) is a concept used in the literature related to environmental economics (forests, in particular) to give economic values to the full range of services people assign to different uses of the environment and the natural resources around them. It is defined as follows:

TEV = {use values} + {non-use values} + {option values}

'Use values' include: (i) *direct-use values:* values related to the direct use of environmental services or outputs (wood products, non-timber forest products, drinking water, irrigation water, land for crop production, grassland for livestock, etc.); and (ii) *indirect-use values:* benefits from the ecological functions of the various natural resources (carbon sequestration, biodiversity conservation, soil fertility, water recycling, climate change mitigation, etc.).

'Non-use values' encompass: (i) *existence value:* – existence of resource such as forest, biodiversity, fauna, valued as such, valued for example through the willingness to pay for biodiversity preservation; and (ii) *bequest value:* willingness to keep the natural resource for future generations.

'Option values' relate to the choice to keep natural resource stocks for future direct or indirect use, that is, the price people are willing to pay to ensure future benefits.

Source: Cavatassi 2004.

- *Global benefits*. The main global benefits that can be quantified are carbon sequestration and avoided emissions using the EX-ACT tool, as presented in the note on 'Climate-smart agriculture'. Other intangible global benefits related to watersheds are sometimes evaluated based on studies using complex modelling exercises.

Other specific aspects need to be taken into account when quantifying NRM-related benefits:

- *Site-specific vs. generic models*. Watershed management projects usually include several watersheds with very specific biophysical characteristics. When data are available and the time allocated for EFA allows, site-specific analysis is preferable. When potential sites are numerous and/or data are parsimonious, the generic approach can be used for the selection and prioritization process, together with other aspects.
- *Aggregation of benefits*. Many cases analysed estimate financial and economic benefits per hectare and in the aggregate based on the project area. Due to the often complex economic and social organization around ecological spaces (watersheds), this approach omits two key elements: (i) integration of crop production, livestock and NRM aspects at the household level (farm or household models), with the risk of overestimating or double-counting benefits; and (ii) allocation of benefits among actors, which can influence the likelihood of project impact and sustainability (among crop producers, herders and agropastoral producers; between upper watershed and lower watershed farmers, etc.).
- *Period of analysis* is usually based on the lifespan of the proposed investments. Many have a total life of over 20 years. NRM projects are often analysed over a 25-to-50-year period to ensure that long-term economic benefits are captured.

Natural resource management

EXAMPLE 1

Land Husbandry, Water Harvesting and Hillside Irrigation Project

(Rwanda, World Bank, 2010)

Project description

The project is based on a watershed approach to implementing sustainable land husbandry measures for hillside agriculture and irrigation. The development objective is to increase agricultural productivity and farmers' incomes from hillside crops through an integrated range of mutually reinforcing activities. To achieve this objective, the project comprises two technical components: (i) capacity development and institutional strengthening for hillside intensification; and (ii) infrastructure development for hillside intensification. The project targets six sites identified by the Government.

Costs and benefits

The following costs have been included in the EFA: (i) investment costs (water harvesting infrastructure such as valley dams and reservoirs, reservoir protection, hillside irrigation infrastructure such as water conveyance structures, capacity development for water users' associations, etc.); (ii) recurrent economic costs, estimated through Costab; (iii) replacement costs for irrigation and water infrastructure in year 25; (iii) annual recurrent costs after the project implementation period, equal to recurrent costs in the last year of the project; and (iv) resettlement costs and costs of new investments in institutional and market development (to be repeated after 10 years). Total project costs were estimated at US$68.9 million.

The project is expected to generate three main benefit streams:

- *On-site private benefits within the project area:* (i) increased value of production in non-irrigated areas; (ii) crop diversification and increased value of production in irrigated areas; (iii) increased income from timber, shrubs and grass grown in downstream reservoir-protection areas; (iv) avoided yield loss from soil fertility degradation and soil erosion; (v) increased value of livestock production; (vi) increased employment opportunities; and (vii) improved access to water.

- *Public benefits in downstream project areas:* (i) cost savings due to decreased sediment load removal; and (ii) reduction of capital costs of irrigation schemes.
- *Global benefits beyond the project area:* carbon sequestration.

Methodology

First, financial analysis was conducted using market prices and calculating direct benefits in project sites. Most on-site private benefits were estimated using crop and livestock models. Second, economic analysis was undertaken using adjusted financial prices with their economic or shadow price and adding externalities beyond the project (see volume 2 of these guidelines for indications on shadow costing techniques). The following methodologies were adopted to quantify each benefit:

- *Increased revenues in non-irrigated areas*. The WP situation is characterized by higher yields as a result of higher soil quality and fertility, obtained through soil conservation measures and continued use of manure (whose availability will be increased through livestock diversification). Based on past studies and literature review, the assumption was that yields of traditional annual crops and perennial crops would increase by 30 per cent and 50 per cent respectively. Crop models were developed to calculate the incremental gross margin per hectare, which was then aggregated to obtain the total annual incremental benefit (3,786 ha of non-irrigated area for the six sites).
- *Increased revenues in irrigated areas*. The WP situation is characterized by higher yields for coffee and plantain (70 per cent increase), a larger area under production (areas previously waterlogged during the rainy season) and high-value crop diversification and intercropping (new cropping patterns). Crop models were developed to calculate the incremental gross margin per hectare, which was then aggregated to obtain the total annual incremental benefit (944 ha of irrigated area for the six sites).
- *Additional productive revenues in downstream reservoir-protection areas*. The WP situation is characterized by the development of 25 ha of forest plantation in each site for timber, poles, charcoal and feed production. An average timber harvest value was established and applied every five years, and annual charcoal and livestock feed production were estimated. Total incremental benefits were aggregated for the six sites.
- *Avoided yield loss*. The WP situation is characterized by constant yields, compared with a WOP situation with yield losses due to soil erosion and nutrient depletion (figure 1). Analysis capitalizes on results of a run-off plot experiment in Rwanda and additional studies on the impact of soil erosion on crop yields. A conservative figure of 2 per cent yield loss per hectare per year was the parameter for estimating the annual value of yield loss in the six sites.
- *Increased revenues from livestock production*. The WP situation is characterized by higher availability of fodder and water for livestock and higher crop revenues, which would enable households to purchase improved breeds. Livestock models were established based on additional milk production.
- *Increased income from greater employment opportunities (economic benefit).*[2] The WP situation is characterized by higher farm labour requirements, which may translate into hiring temporary labour (if the family does not have the capacity to absorb the extra workload). An average labour cost per hectare of plantain and avocado was estimated at US$167/ha and aggregated based on the incremental number of farm labourers.
- *Improved access to water*. The WP situation is characterized by the presence of reservoirs, which will enable communities to save time previously spent fetching distant water and the cost of purchasing borehole water in the WOP situation. The time spent each day in fetching water was estimated at 480 minutes and valued at a wage rate of US$1.8 per eight hours (the labour wage in the area). The cost of water purchased was also estimated. An annual average savings including time and cash was calculated per household.
- *Savings from cost of sediment load removal*. The WP situation is characterized by lower

2 From the financial perspective, however, increased labour demand increases production costs.

sedimentation in rivers and downstream reservoirs, thus decreasing costs associated with sediment load removal. Based on experiences in Kenya and Madagascar,[3] the average cost per ton of sediment is US$14 per ton and the average reduction of sediment load per hectare and per year due to upstream afforestation were estimated at 1.125 tons/ha per year.

- *Reduction of capital cost of irrigation schemes.* The WP situation is characterized by lower capital costs of irrigation schemes due to soil erosion control. Data from Madagascar were used – relevant for the local context – with a cost reduction of US$5/ha in the first year after project completion and annual additional savings of US$1/ha in following years. Care was taken not to double-count costs included in crop models.
- *Carbon sequestration.* Analysis starts from a hypothesis of 0.5 tons of avoided carbon emissions per hectare, based on the experience of similar projects in Rwanda and the region, and converted into CO_2 emissions for a total of 8,607 tons of CO_2 sequestered per year in the project area from year 1 through year 5, and of 12,000 tons CO_2/year for year 6 onwards. A social price of US$20 per ton was used to value CO_2 emissions (see the note on 'Climate-smart agriculture' for guidance on estimating social price).

Results

Economic NPV was estimated at US$73.8 million, at an opportunity cost of capital of 12 per cent,[4] and economic rate of return (ERR) at 29 per cent (table 2). Net economic value per hectare was calculated to estimate the average increase in household income based on average landholding. The increase would be some US$49 per year per household. A sensitivity analysis was conducted to test the robustness of EFA results (table 3). The following scenarios were analysed: higher yield increase, lower yield increase, reduction of farm gate prices and lower livestock-production-value increase. ERR remains high and above the opportunity cost of capital in all scenarios.

TABLE 2

Average annual on-site private benefits and present value (base scenario)

(US$ '000)

Benefit item	Annual financial value	Annual economic value
On-site private benefits		
Increased value of production in non-irrigated areas	6.1	6.5
Increased value of production from irrigated areas	6.5	6.9
Increased value of production from downstream reservoir protection areas	0.2	0.3
Avoided yield loss due to soil fertility degradation and soil erosion	0.2	0.2
Increased value of livestock production	2.2	2.3
Increased employment opportunities	0.2	0.2
Improved access to water	2.1	2.3
Public benefits downstream project areas		
Reduction of sediment load		0.1
Reduction of capital loss of irrigation		0.1
Global public benefits		
Carbon sequestration		0.2
Total benefits	**17.5**	**19.1**
Total costs	**5.6**	**5.7**
IRR	28%	29%

3 The analyst used this assumption owing to data scarcity on sediment load removal costs in Rwanda. The figure was discussed with the NRM expert of the project design team.

4 Choice of the most-appropriate discount rate for NRM projects is often an issue, and lower rates (5-7 per cent) than the usual 12 per cent are often suggested in the literature. See EFA volumes 1 and 2 [in press], EX-ACT handbook, etc.

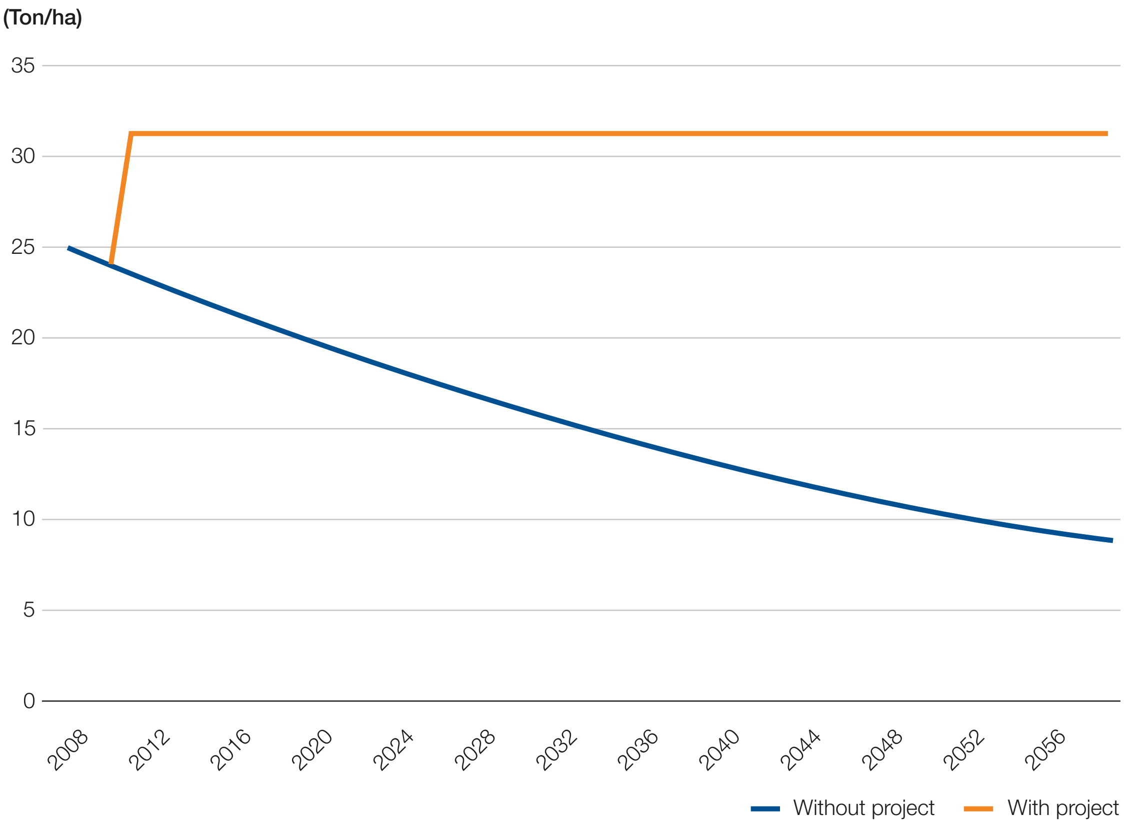
TABLE 3

Sensitivity analysis – results under various scenarios

Scenarios	FRR	ERR
Original scenario		
70% increase in yield for irrigated crops, 30% increase in yields for traditional annual crops, 50% increase in yield for perennial crops	28%	29%
Optimistic scenario		
100% increase in yield for irrigated crops and perennial crops; 60% increase in yield for traditionnal annual crops	33%	34%
Pessimistic scenario		
35% increase in yield for irrigated crops, 15% increase in yield for traditional annual crops, 25% increase in yield for perennial crops	25%	26%
20% reduction in exporters' farm gate prices for irrigated crops compared to the original scenario	24%	25%
20% reduction in local farm gate prices for traditional crops because of more abundant supply compared to original scenario	22%	23%
50% reduction in the original increase in livestock production value	23%	24%

FIGURE 1

Estimated yields with and without project



Note: The graph shows avoided yield losses (i.e. keeping a productivity status quo) attributed to the project.

EXAMPLE 2

Integrated Watershed Development Project

(India, World Bank, 2005)

Project description

The project aimed to improve the agricultural productivity potential of project areas through watershed treatment and a community-based approach that would enable decreased soil erosion and increased water availability. The project had two components: (i) watershed protection and development; and (ii) institutional strengthening. Watershed development mainly consisted of watershed treatment, fodder and livestock development and rural infrastructure.

Costs and benefits

EFA employed economic costs derived from Costab tables, excluding taxes and price contingencies. Incremental economic costs included sub-watershed treatments of US$94 million (vegetative barriers, terrace repairs, pasture development, forest regeneration), fodder and livestock development of US$18 million (veterinary health improvement, fodder production, etc.) and rural infrastructure development of US$27 million (irrigation infrastructure and rural roads). Costs incurred mainly at the farm level are included in the farm models. The main incremental benefits of the project are classified as follows:

- *On-farm benefits:* (i) increase in yields of 43-60 per cent and increase in cropping intensity of 305 per cent for rainfed crops owing to reduced surface run-off and soil erosion and increased soil moisture content; (ii) increase in yields of 80-150 per cent and increase in crop intensity of 30 per cent (percentage points) in rainfed areas with irrigated systems; (iii) increase in horticulture cultivation; (iv) development of farm forestry for fuelwood and construction timber; and (v) higher livestock productivity through better access to forage and improved feeding management.
- *Off-farm benefits:* additional revenues generated by timber, fuelwood and fodder through afforestation. Other benefits are included at this level, but are not analysed in the present example (benefits related to potable water supplies, marketing collection centres and rural road rehabilitation).
- *Environmental and natural resource benefits:* (i) land area saved and reclaimed due to implementation of watershed treatment measures; (ii) value of nutrients added to the soil as a result of the intervention; and (iii) increased soil moisture content and rise of the water table. It is assumed that benefits related to (iii) are captured through yield and cropping intensity increases on farms.
- *Other benefits:* employment generation due to additional economic activity.

Methodology

The first step in analysis was to identify various areas where benefits would occur in relation to the various project interventions in 75 sub-watersheds (table 4). The second step consisted in establishing crop models, using the FARMOD software, for rainfed production, irrigated production, horticulture, farm forestry, afforestation and bamboo production (table 5). A financial analysis of these models was performed, indicating gross margin, labour requirements and return on labour. Two farm models – crop and livestock production – were also analysed (table 6). Economic analysis is based on aggregation of the two farm models through FARMOD for the total project area treated. It was assumed that untreated areas will benefit indirectly from the project through improved soil moisture, resulting in some increases in yields and cropping intensity. The phasing of incremental

TABLE 4

Net area under treatment

Arable land	**87,923**
Rainfed crop	35,514
Horticulture	19,827
Private irrigation	12,362
Fodder production	6,950
Farm forestry	13,270
Non arable land	**66,354**
Afforestation	17,162
Forest augmentation	16,298
Silvipasture	22,939
Pasture development	8,125
Bamboo planting	1,830
Forest land	**45,171**
Afforestation	20,470
Forest augmentation	24,701
Total	**199,448**

production benefits in volumes is presented in table 7. Benefits from incremental milk production (47.3 million litres in year 7), roads, marketing collection centres and potable water supplies have been included, but are not analysed here.

Results

The ERR of the various activities was calculated to compare interventions (table 8). To estimate the overall ERR of the project, two scenarios were used: (i) scenario 1 includes only benefits from increased production; (ii) scenario 2 includes all benefits. The ERR was estimated at 16.6 and 17.3 per cent respectively. A sensitivity analysis was conducted with lower benefits, benefits lag and higher costs. In all scenarios considered, economic results remain robust.

TABLE 5

Yields and cropping intensities without and with project

	Treated areas					Untreated areas				
	Yields (t/ha)			Cropping intensity		Yields (t/ha)			Cropping intensity	
	WOP	WP	% increm.	WOP	WP	WOP	WP	% increm.	WOP	WP
Rainfed crops										
Maize	1.0	1.6	60%	43%	49%	1.0	1.1	10%	43%	45%
Wheat	1.1	1.6	45%	19%	21%	1.1	1.2	10%	19%	19%
Pulses	0.4	0.5	43%	55%	62%	0.4	0.4	11%	55%	55%
Gram	0.4	0.7	63%	23%	15%	0.4	0.4	10%	23%	23%
Total				**140%**	**147%**				**140%**	**142%**
Irrigated crops										
Maize	1.0	2.5	150%	43%	60%					
Wheat	1.1	2.5	127%	19%	8%					
Pulses	0.4	0.6	80%	55%	76%					
Gram	0.4	0.7	80%	23%	15%					
Paddy	n/a	3.0	n/a	0%	8%					
Onion	n/a	20.0	n/a	0%	2%					
Brinjal	n/a	30.0	n/a	0%	2%					
Total				**140%**	**170%**					

TABLE 6

Financial analysis of rainfed and irrigated farms

		WOP	WP		
			Year 4	Year 7	% increm.
Rainfed farm					
Net benefits (Rs) from:	Rainfed crops (1.2 ha)	5,280	8,400	8,400	59%
	Livestock (1.4 cattle)	2,438	2,755	3,073	26%
Total		**7,718**	**11,155**	**11,473**	**49%**
Irrigated farm					
Net benefits (Rs) from:	Rainfed crops (1 ha)	5,280	7,000	7,000	33%
	Irrigated crops (0.2 ha)	-	2,560	2,560	n/a
	Livestock (1.4 cattle)	2,438	2,755	3,073	26%
Total		**7,718**	**12,315**	**12,633**	**64%**

TABLE 7

Phasing of increased crop production

	Unit	Incremental production			
		Year 5	Year 10	Year 20	Year 30
Maize	ton	18,058	33,013	33,013	33,013
Wheat	ton	19,488	36,466	36,466	36,466
Gram	ton	485	1,414	1,414	1,414
Pulses	ton	730	1,746	1,746	1,746
Paddy	ton	2,026	2,781	2,781	2,781
Onion	ton	4,553	5,686	5,686	5,686
Brinjal	ton	5,403	7,416	7,416	7,416
Mango	ton	1,234	90,351	123,812	123,812
Guava	ton	17,349	117,480	158,624	158,624
Timber (kikar)[a]	'000 m^3	-	-	206	-
Bamboo	ton	-	-	-	-
Poplar	'000 m^3	-	2,750	7,320	7,320
Eucalyptus[b]	'000 m^3	-	239	299	239

[a] Production years 21-25, max production 333,000 m^3/p.a.
[b] Production years 11-15, max production 215,000 m^3/p.a.

TABLE 8

Economic rate of return of model activities

Model activities	ERR
Horticulture	
Mango	42%
Guava	43%
Farm forestry	
Poplar	38%
Eucalyptus	16%
Afforestation	
on private land	14%
Bamboo	12%
on public land	12%

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CASE STUDY 6

Nutrition

Conceptual section

Scope of the note

This note is intended for economists and development practitioners dealing with ex ante EFA of nutrition-specific and/or nutrition-sensitive projects.[1] It provides an overview of the diverse methods and tools that can be applied, discusses methodological issues, and presents two case studies with EFA examples.

Interventions

Traditionally, interventions in the area of nutrition and food security have focused on increasing food production and raising incomes. However, it is now recognized that the causal link between higher levels of production and income and improved nutrition is not automatic (IFAD 2014), and a more comprehensive approach is necessary to make agriculture nutrition-sensitive and translate increased incomes into healthier and more diverse diets. This approach involves working at all levels of agricultural value chains, from the farm to the end consumer, taking into account the economic, social and political environment. Acknowledging the need for coordinated, multisectoral action, IFAD's nutrition interventions are often integrated into health, education, water and sanitation.[2] Other IFIs, such as the World Bank (2010), advocate food fortification as the most cost-effective approach to addressing

BOX 1

Economic cost of malnutrition

Malnutrition in all its forms – undernutrition, micronutrient deficiencies, and overweight and obesity[3] – imposes unacceptably high economic and social costs on countries at all income levels. Most countries are burdened by multiple types of malnutrition, which may coexist within the same household or individual. Research shows that investing in improving nutrition is not only a moral imperative, but can also yield high economic benefits. For instance, studies show that investing US$1.2 billion annually in micronutrient supplements, food fortification and biofortification of staple crops for five years would generate annual benefits of US$15.3 billion, a B/C ratio of almost 13 to 1, and better health, fewer deaths and increased future earnings (adapted from FAO (2013a) and the FAO website). At the same time, the social and economic costs of malnutrition are very high. Undernutrition and micronutrient deficiencies are estimated to cost 2-3 per cent of global GDP, equivalent to US$1.4-2.1 trillion per year (FAO 2013a). In some African countries, that percentage can range from 1.9 to 16.5 per cent of GDP.[4] Although no global estimates of the economic costs of overweight and obesity exist, the cumulative cost of all non-communicable diseases, for which overweight and obesity are leading risk factors, were estimated at US$1.4 trillion in 2010 (FAO 2013a, box 2).

1 The Scaling Up Nutrition (SUN) framework [http://scalingupnutrition.org], an initiative guiding collective efforts to improve nutrition worldwide, distinguishes two types of nutrition activities: 'nutrition-specific' (e.g. distribution of health-based nutrition interventions, micronutrient supplementation, dietary supplementation and fortification), which directly address immediate determinants of undernutrition; and 'nutrition-sensitive' (e.g. food-based interventions, integrated homestead farming, social safety nets, women's empowerment), which address underlying determinants of undernutrition through a multisectoral approach.

2 See specific case studies in the note on 'Water and sanitation'.

3 FAO's most recent estimates indicate that 12.5 per cent of the world's population (868 million people) are undernourished in terms of energy intake, 26 per cent of the world's children are stunted, 2 billion people suffer from one or more micronutrient deficiencies and 1.4 billion people are overweight, of whom 500 million are obese.

4 African Union Commission, NEPAD Planning and Coordinating Agency, UN Economic Commission for Africa (UNECA) and World Food Programme 2014.

BOX 2

Economic cost of non-communicable diseases (NCDs)

Inadequate nutrition is one of the underlying causes of the prevalence of NCDs, which are likely to involve particular economic costs for developing countries. Studies on this topic showed that, if nothing was done to reduce the risk of chronic disease, an estimated US$84 billion in economic production would be lost from heart disease, stroke and diabetes, from 2006 to 2015, in the 23 low- and middle-income countries accounting for some 80 per cent of chronic disease mortality (Abegunde et al. 2007).

There are several approaches to estimating the financial and economic costs of NCDs. Direct costs can involve medical care for diagnosis, procedures, drugs and inpatient and outpatient care. Indirect costs include productivity costs related to lost or impaired ability to work. Intangible costs include pain and suffering. Opportunity costs of NCDs involve the opportunities foregone to allocate those resources to other health or other national priorities. There can also be non-market social costs, for example withdrawing of children from school to look after stroke or diabetes patients. Costs can occur at the national (macroeconomic) level, including through reduced labour supply, savings and capital formation, or at the household and individual firm level (loss of income, increased expenditures, etc.).

Source: Adapted from World Bank 2012.

malnutrition issues. FAO (2013a) summarizes options for improving nutrition though agriculture and rural development interventions at each stage of the value chain (table 1). Moreover, it provides a list of recommendations (FAO 2013b) to "make agriculture work for nutrition" that highlight the importance of creating a supportive environment by improving policies (including food price, subsidy, trade and pro-poor policies), governance and capacity-building at all levels.

TABLE 1

Interventions in the food system for better nutrition

Food system elements	Nutrition opportunities
Production 'up to the farm gate'	• Sustainable intensification of production • Nutrition-promoting farming systems, agronomic practices and crops – Micronutrient fertilizers – Biofortified crops – Integrated farming systems, including fisheries and forestry – Crop and livestock diversification • Stability for food security and nutrition – Grain reserves and storage – Crop and livestock insurance • Nutrition education and Behaviour Change Communication* – School and home gardens – Integrated homestead food production • Nutrient-preserving on-farm storage
Post-harvest supply chain 'from the farm gate to retailer' (marketing, storage, trade, processing, retailing)	• Nutrient-preserving processing, packaging, transport and storage • Reduced waste and increased technical and economic efficiency • Food fortification • Reformulation for better nutrition (e.g. elimination of trans fats) • Food safety
Consumers (advertising, labelling, education, safety nets)	• Nutrition information and health claims • Product labelling • Consumer education • Social protection for food security and nutrition – General food assistance programmes and subsidies – Targeted food assistance (prenatal, children, elderly, etc.)

* Behavior Change Communication (BCC) is an interactive process of any programme intervention with individuals, communities and/or societies to develop communication strategies to promote positive behaviours appropriate to their settings. This in turn provides a supportive environment to enable people to initiate, sustain and maintain positive and desirable behaviour outcomes.

Source: Adapted from FAO 2013a.

Positive impact pathways of nutrition-sensitive interventions must be carefully analysed and described when planning nutrition-sensitive interventions. It is also important to identify potential negative impact pathways and develop mitigation plans, in order to avoid negative consequences, following the 'do no harm' approach.

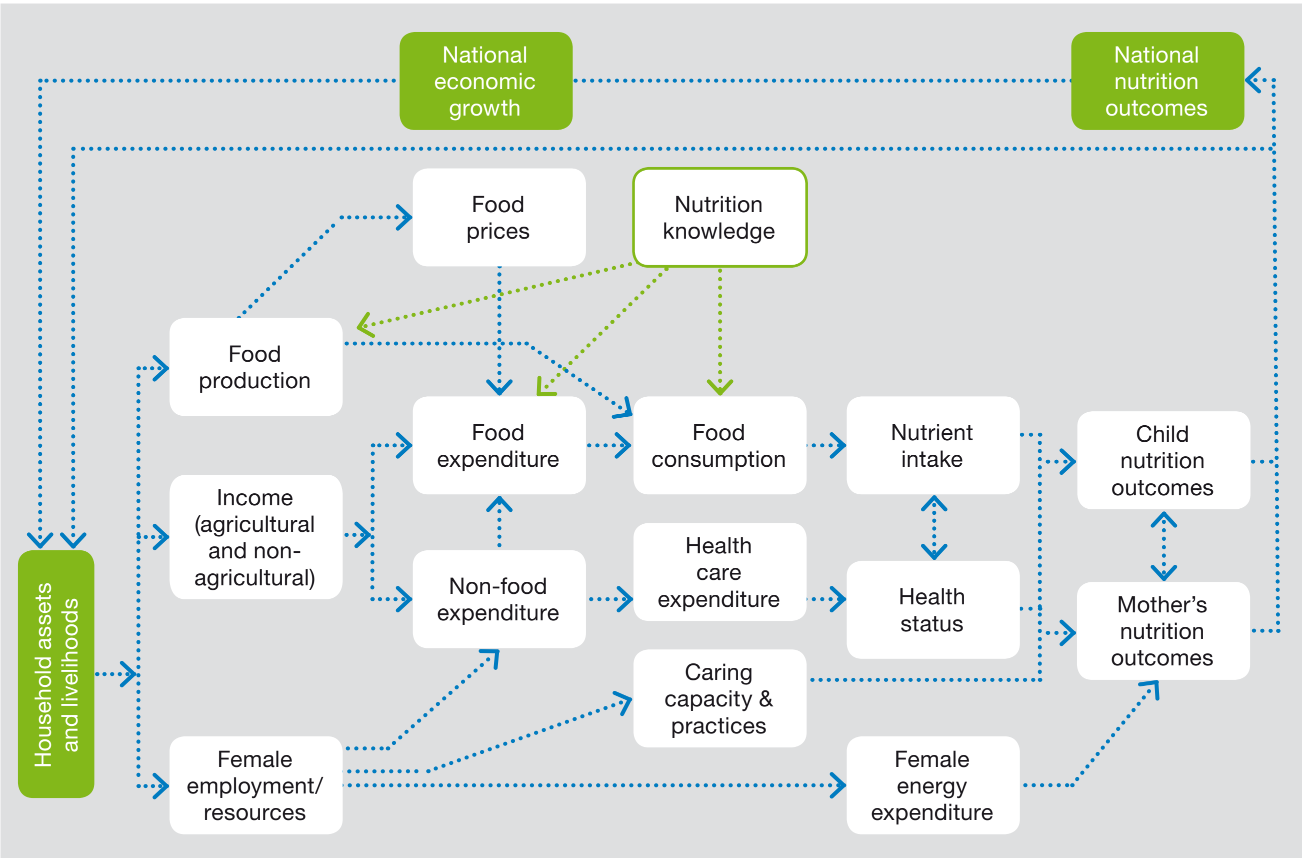
In agriculture projects, potential harm could arise from increased women's workloads, crop choice based on profitability criteria, rather than nutritional value (e.g. cash crops), increased use of agrochemicals, increased agricultural water use and risk of zoonotic diseases (Herforth 2013). Positive and negative impacts of agricultural interventions in nutrition are extensively discussed in World Bank (2007). An example of pathways from agriculture to nutrition adapted from the International Food Policy Research Institute (IFPRI 2012) is presented in figure 1.

Benefits

The benefits of nutrition interventions are tangible and intangible, and accrue both to the public sector and private individuals/households in different time horizons. Social benefits of nutrition-specific projects (heath-based and dietary fortification/supplementation-based) are typically assessed in terms of: (i) reduced expenses for public health systems and savings in out-of-pocket expenses for private individuals; (ii) avoided waste of public and private education expenses; (iii) increased future incomes due to improved physical and cognitive capacity; and (iv) reduced number of unproductive years due to ill-health, disability or early death. This classic approach works for the quantification of benefits at a 'macro' level. However, it does not capture physical, psychological and social dimensions of improved well-being, which are equally important, although by nature difficult to quantify.

FIGURE 1

Pathways from agriculture to nutrition



Source: Adapted from IFPRI 2012.

Nutrition-sensitive projects can simultaneously tackle malnutrition, poverty and remoteness. By increasing food availability and promoting inclusive and nutrition-sensitive value chains, remote rural households – in addition to improving their nutritional status and enhancing their self-reliance – can obtain economic gains from selling produce surpluses, save travel time and accrue intangible benefits linked to empowerment and gender equality. Benefits of nutrition-sensitive projects can also be measured in terms of increased productivity linked to physical and cognitive improvements.

Methodologies and tools

Like any other development project, the nature and scope of nutrition interventions can vary from one project to another. Thus there is not one, single, one-size-fits-all approach to undertaking EFA of nutrition

TABLE 2

Main tangible and intangible benefits of nutrition interventions*

Tangible benefits	Due to …
Income	
Avoided income loss (E)	▶ reduction in days of work lost fully or partially by sufferer or caretaker
Increases in incomes (real wage adjusted to level of education and/ or productivity) (F and E)	▶ improvement in cognitive capacity and school performance, possibly leading to spending more years in school favouring higher future wages ▶ improvement in physical work capacity, resulting in: (i) capacity to work more days; and (ii) real wage adjusted to productivity levels
Increases in incomes (sale of food surpluses) (F and E)	▶ additional income obtained from selling home-gardening produce surpluses
Education	
Reduction in wasted public education expenditures (public cost of schooling per child) (F and E)	▶ improvement in school attendance due to better health
Reduction in wasted private education expenditures (school fees borne by the family) (F and E)	▶ improvement in school attendance due to better health
Time	
Time savings from avoiding frequent travel to markets to purchase food (E)	▶ increased food availability at the household level from home-gardening activities
Health	
Reduction in public health care costs (F and E)	▶ reduction of number of patients with NCDs treated in public hospitals and/or receiving free or subsidized drugs
Reduction in private health care costs (F and E)	▶ reduction of out-of-pocket expenses for NCD-related treatment and/or hospital expenses

Intangible benefits	Due to …
Avoided human capital losses (E)	▶ other non-quantifiable benefits linked to mortality and morbidity, disease and physical and cognitive stunting
Empowerment and gender equality (E)	▶ (i) improvement in nutritional knowledge and dietary, hygiene and sanitation behaviours; (ii) control over resources for home gardening and primary food-processing activities (e.g. sun-drying, fermentation); and (iii) in some countries, gender equality improves when the pressure on women and children to eat smaller and less nutritious portions than adult men household members is reversed through BCC in nutrition and awareness campaigns

* The benefits listed have been extracted from various sources, including World Bank 1996.

projects. However, three generic techniques are frequently applied, as already described in volumes 1 and 2 of these guidelines:[5]

- *Cost-benefit analysis (CBA)* is used when outcomes are expressed in money units. It is the most powerful tool when project benefits can be quantified. It enables comparison between two projects or between a project and other alternatives (including the status quo).
- *Cost-effectiveness analysis (CEA)* is used when the outcome is measured in physical units (e.g. decrease in malnutrition rates). It is a less data-demanding technique and indicates which is the least costly way to achieve a specified objective within a specified level of costs.[6]
- *Cost-utility analysis (CUA)* is used when weighting is incorporated into the CEA – for example, in generating measures such as the disability-adjusted life year (DALY), which measures the burden of disease, expressed as the number of cumulative years lost due to ill-health, disability or early death. A monetary value can be attributed to the DALY for CUA (box 3).

CBA and CEA/CUA are not mutually exclusive and can be applied to the same project to respond to different questions: "should the project be funded, contracted or expanded, i.e. – is it worth it?" and "what is the best way to achieve the stated objectives?" Once a specific public investment in nutrition is justified, based on a sufficiently high B/C ratio (i.e. based on CBA), CEA is used to examine project design options for delivering expected impacts at the lowest cost. Alternative methods have recently been developed and tested, such as the 'Cost of the Diet' methodology software, which can model potential project interventions to estimate their impact on improving the quality and affordability of the diet (box 4).

The main methodological issues encountered in carrying out EFA of nutrition projects are those related to the choice of adoption and discount rates, estimating the opportunity cost of time, and most commonly, assigning value to human life. The latter is addressed in box 3.

- *Adoption rates* are a very sensitive assumption when conducting ex ante EFA. In nutrition projects, adoption may be particularly slow and difficult to predict, given the fact that benefits are not immediate and are difficult to perceive by the beneficiaries. Individuals and households may only adopt the proposed activities when the recognized economic benefits are higher than the expected private cost involved. For instance, in a context where low-nutrient imported foods are cheaper than locally produced vegetables, families would be willing to pay the price premium at the market only if they are aware of the tangible and intangible potential benefits of being healthier. Similarly, these families would take up a project-supported home-gardening activity only if the value they place on being healthier is higher than the cost of inputs and the opportunity costs of the labour invested in growing their own food. Cultural aspects, such as the 'social value' of some foods, should also be taken into consideration.
- *Opportunity costs of time* are used for calculating avoided income loss and time savings. In locations where unemployment rates are very high and households rely completely on subsistence activities, a realistic approach to valuing opportunity costs of time can be to calculate the average return to labour per day from the main subsistence activities and adjust them by the effective number of hours worked per day (example 2).
- *Choice of discount rate.* The choice of a discount rate to value future benefits of avoided mortality and morbidity is very contentious. A discount rate of 5 per cent instead of the usual 10 or 12 per cent rate has been used in many economic studies on health and social policies, and, most recently, academics have argued that a 3 per cent rate for social decisions would be more appropriate.[7] Some academics even look at a zero discount rate scenario[8], on the grounds that discounting benefits the present generation at the expense of future generations: with discounting, saving one life today is considered to be of

5 See also World Bank 1996.

6 Please refer to volume 1 of these guidelines for further information on cost-benefit and cost-effectiveness analysis.

7 The World Bank Disease Control Priorities study used a 3 per cent discount rate, and the United States Panel on Cost-Effectiveness in Health and Medicine recommended that economic analysis of health also use a 3 per cent real discount rate to adjust both costs and health outcomes (Gold et al. 1996).

8 Murray and Lopez (1996).

BOX 3

Disability-adjusted life year (DALY) methodology

Approach. The DALY methodology is frequently used by the World Health Organization (WHO), United Nations Children's Fund (UNICEF), World Bank and other development agencies as an outcome measure of the cost-effectiveness of public health programmes. The methodology has also been used by IFPRI to analyse health benefits of nutrition-specific interventions, such as the development and dissemination of biofortified staple crops (see case study 1). The DALY measures the burden of disease, expressed as the number of cumulative years lost due to ill health, disability or early death. It combines the traditional measure of years of life lost due to premature death with an additional measure of years of 'healthy' life lost due to poor health or disability. Mortality and morbidity are then combined into a single metric, where one DALY is equal to one year of healthy life lost (UNICEF 2012). This methodology can be used in cost-effectiveness and cost-benefit analysis by attributing a monetary value to DALYs and juxtaposing these benefits and the costs of the intervention. Case study 2 presents an example of the use of DALYs in a cost-utility analysis.

Calculation of DALYs. For a disease or health condition, DALYs are calculated as the sum of the 'years of life lost' (YLL) due to premature mortality in the population and the 'years lost due to disability' (YLD) for people living with the health condition or its consequences:

$$DALY = YLL + YLD$$

YLL basically correspond to the number of deaths multiplied by the standard life expectancy at the age at which death occurs. For a given cause, age and sex:

$$YLL = N \times L,$$

where N = number of deaths and L = standard life expectancy at age of death in years. To estimate YLD for a particular cause in a particular time period, the number of incident cases in that period is multiplied by the average duration of the disease and a weighting factor that reflects the severity of the disease on a scale from 0 (perfect health) to 1 (dead):

$$YLL = I \times DW \times L,$$

where I = number of incident cases, DW = disability weight and L = average duration of the case until remission or death (years). Recent studies have based the YLD calculation on prevalence rather than incidence (Stein et al. 2005):

$$YDL = P \times DW,$$

where P = number of prevalent cases.

Details are available at www.who.int/healthinfo/global_burden_disease/metrics_daly/en/.

Value of DALYs. Different approaches are used to attribute a value to a DALY: (i) a standardized international value (usually US$1,000) (Stein et al. 2005); (ii) country-specific annual per capita incomes; or (iii) an approach based on value-of-life estimates.

More information can be consulted at www.harvestplus.org/sites/default/files/tech04.pdf.

Cost per DALY saved. The World Bank and WHO have suggested benchmarks for interpreting costs per DALY saved. For the World Bank, a public health intervention with a cost per DALY of less than US$2,602 is very cost-effective (World Bank 1993); for WHO, a health intervention should be considered cost-effective if its cost per DALY saved is one to three times the per capita income, and very cost-effective if its cost per DALY saved is less than the per capita income (WHO 2003).

Limitations of the approach. The DALY methodology is subject to criticism due to its 'human capital approach' to valuing health and lives. Ethical issues are associated with: (i) valuing lives in terms of a money metric; (ii) age-weighting, or assigning different value to different ages; and (iii) applying discount rates, benefiting present generations at the expense of future generations (see the 'methodological issues' paragraph in the 'Methodology and tools' subsection above). In terms of technical limitations, some authors argue that combining mortality and morbidity in the same indicator produces an important information loss, and they should thus be presented separately. In addition, the methodology does not take into account the 'economic costs' of illness – the burden on caretakers, family and the society at large.[9] Moreover, it builds on national statistics and datasets that are not always available. The applicability of this approach in IFAD-funded projects, more particularly for EFAs that need to be prepared in a relatively short period of time, could be a challenge for the analyst. If more resources are available during project preparation, a more in-depth study (as presented in case study 2) could be commissioned at an early stage of formulation to assess the economic impact of nutrition investments using the DALY approach. That study could strengthen and feed into the more classic EFA prepared during project appraisal.

9 Anand and Hanson 1997.

greater value than saving one life next year (Stein et al. 2005).

- *Impact pathways.* Economic and financial analysis can be a useful tool to identify and avoid some unintended impacts of nutrition-sensitive interventions, for example assessing changes in women's workload by performing a labour analysis of the crop/activity budgets. At the same time, the underlying assumptions of the project's theory of change can help identify potential risks that would in turn inform the sensitivity analysis.

Sometimes, NPV and IRR cannot capture all the benefits of a project dealing with food security and nutrition, which are multidimensional. However, EFA can help in setting baselines and targets for project indicators relevant to household food security and nutritional status (e.g. total value of domestic food production, household dependence on imported foods, expenditure on food relative to total income, etc. – see case studies 1 and 2).

BOX 4

'Cost of the Diet' methodology

Description of the methodology. 'Cost of the Diet' is a method developed by Save the Children (2009) to better understand the extent to which poverty affects nutritional status. This software-based tool can estimate the amount, combination and cost of local foods needed to provide individuals or families with their average needs for energy and their recommended intakes of protein, fat and micronutrients. The tool can also identify periods when households may be most vulnerable to high food prices, and which nutrients are the hardest to obtain from locally available foods. This valuable information can be used to design nutrition and food security interventions aimed at improving the nutrient quality of the diet, promoting the least expensive sources of nutrients, or increasing the availability of the currently expensive food groups, which, in turn, could reduce their market price.

Limitations. The Cost of the Diet method and software can be very powerful tools to design location-specific nutrition interventions. The methodology requires extensive surveys of dietary habits and socio-economic indicators. In addition, detailed market information must be updated regularly, especially on prices. This can be a time-consuming and costly exercise and may render the methodology impractical when beneficiaries are in diverse locations or have diverse profiles.

Further information is available at www.savethechildren.org.uk/resources/online-library/the-cost-of-the-diet.

Nutrition

EXAMPLE 1

Kiribati Outer Island Food and Water Project (OIFWP)

(Kiribati, IFAD, 2015-2019)

Overview

The benefits of improved access to nutritious food are analysed observing changes in the caloric and nutritional intake of beneficiary households, based on a household activity and consumption model. Other indicators relevant to household food security and nutritional status are also calculated (e.g. expenditure on food relative to total income, and household dependence on imported foods). The latter indicator is particularly pertinent for poor rural households in very remote locations, where food supply is inconsistent and unreliable. In addition, the analysis includes a model that illustrates the economic benefits of improved access to clean water.

Project description

The goal is that "people living in the outer islands of Kiribati lead healthier lives with sustainable livelihoods". The development objective is that "Outer Island communities are able to successfully plan and implement activities that result in good nutrition and access to clean water". The project is being implemented in the 43 major communities in four target islands, whose population represents some 25 per cent of the total Outer Island population. The project has three principal components plus support for project management and implementation: (i) community planning and action; (ii) improved household food and nutrition; and (iii) rainwater harvesting for increased household water supply. The OIFWP began in late 2014 and is being implemented over a four-year period. The first batch of interventions promotes improved household food and nutrition. The project helps households sustainably grow and eat more nutritious foods, taking challenging environmental issues and the fragile ecological environment into account. Home gardeners are trained in improved soil and water management and in the use of better planting materials, using a farmer field school approach. This is complemented by participatory research and direct support to improving the poultry, root crops and tree crops that are part of traditional household food production systems, but have low productivity or are compromised by changing climatic conditions. Educational and food-preparation materials and training address issues of behaviour, consumption choices and nutritional awareness. A second set of interventions support rainwater harvesting for increased household water supply. The project aims to provide secure access to a basic minimum quantity of clean drinking water. It is building 278 rainwater-harvesting structures, each with a consensus-based water-user agreement for maintenance of the structures and use of the water.

Costs and benefits

Successful implementation of the project will result in both quantifiable and unquantifiable benefits. The main tangible benefits will accrue from: (i) increased food availability through adoption of home-gardening and poultry activities and establishing of strategic food reserves; (ii) reduced household dependence and overall expenditure on imported foods, as a result of increased availability of local foods and changes in dietary habits introduced by the project; (iii) income generation opportunities for poor households, which will be able to sell occasional production surpluses; (iv) reduced incidence of water-borne diseases through better access to safe water sources, thus avoiding income losses; and (v) time saved from not having to collect water from the previous source. Unquantifiable benefits relate to avoided human capital losses.

Methodology

A CBA was carried out and incremental benefits estimated from a household model that illustrates the potential impact of the project for a typical Outer Island family. The model compiles results from household financial models and incorporates additional information on incomes, labour, self-consumption and food expenditures. It also illustrates differences in overall household caloric intake, as well as in protein, iron and vitamin intake, as a result of adopting the proposed interventions. The CBA provides benchmark values to assess whether project interventions would bring families closer to the recommended average intakes of each nutrient type. A number of indicators for household food security and nutritional status are presented and compared for WOP and WP situations. The bulk of project funding is invested in the second and third components (59 per cent and 22 per cent respectively).

Results

The period of analysis is 20 years to account for the phasing and gestation period of the proposed interventions. Given the benefit and cost streams shown in the following tables, base-case IRR is estimated at 19 per cent. Base case NPV of the project's net benefit stream is US$1,961,261. After adoption of project activities, the model household would have three additional sources of cash income. It would then produce up to 62 per cent of the total value of the food consumed, and reduce dependence on rice, flour and sugar by about 25 per cent, decreasing expenses for imported food items from 61 per cent to only 22 per cent of its cash income. Most importantly, the household would shift from a diet deficient in fibre, vitamins A and C and polyunsaturated acids to an average annual intake above the recommended thresholds for these types of nutrients. In addition, consumption of minerals would increase by about 80 per cent, almost doubling the baseline intake values, although still below the recommended benchmark. The new diet would also maintain consumption of proteins and B vitamins above the desirable values. Further explanations of the household model and food security and nutrition indicators are presented in the tables.

TABLE 3

Financial benefits from home-gardening activities per household

(Australian dollars [$A])

Yields and inputs	Unit	Unit cost ($A)	Without project	With project									
Items				1	2	3	4	5	6	7	8	9	10 to 20
Main production													
Pumpkin	kg		0	640	640	640	640	640	640	640	640	640	640
self-consumption	kg		0	576	576	576	576	576	576	576	576	576	576
for sale	kg	1.3	0	64	64	64	64	64	64	64	64	64	64
Sweet potato	kg		0	144	144	144	144	144	144	144	144	144	144
self-consumption	kg		0	129.6	129.6	129.6	129.6	129.6	129.6	129.6	129.6	129.6	129.6
for sale	kg	1.5	0	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4
Chinese cabbage	plant		0	32	32	32	32	32	32	32	32	32	32
self-consumption	plant		0	29	29	29	29	29	29	29	29	29	29
for sale	plant	2.0	0	3	3	3	3	3	3	3	3	3	3
Tomato	kg		0	77	77	77	77	77	77	77	77	77	77
self-consumption	kg		0	69	69	69	69	69	69	69	69	69	69
for sale	kg	4.0	0	8	8	8	8	8	8	8	8	8	8
Eggplant	kg		0	38	38	38	38	38	38	38	38	38	38
self-consumption	kg		0	35	35	35	35	35	35	35	35	35	35
for sale	kg	3.0	0	4	4	4	4	4	4	4	4	4	4
Investment													
Home-gardening tools	set	300.0	0	1	0	0	0	0	1	0	0	0	0
Equipment for grey water collection	set	300.0	0	1	0	0	0	0	1	0	0	0	0
Operating inputs													
Planting material	seedling	0.1	0	6.4	0	6.4	0	6	0	6	0	6	0
Pumpkin (replant every 2 years)	cutting	0.1	0	48	0	0	0	0	0	0	0	0	0
Sweet potato (2 cycles)	seedling	0.1	0	32	32	32	32	32	32	32	32	32	32
Chinese cabbage	seedling	0.2	0	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
Tomato (1 plant for 2 cycles)	seedling	0.1	0	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Eggplant (1 plant for 2 cycles)	kg/l	0.0	0	400	400	400	400	400	400	400	400	400	400
Compost	kg	0.5	0	2	2	2	2	2	2	2	2	2	2
Organic pesticides (neem)													
Labour	person-days			135	135	135	135	135	135	135	135	135	135

TABLE 3 (CONT.)

Financial budget ($A)	Unit	Unit cost ($A)	Without project	With project			With project						
Items				1	2	3	4	5	6	7	8	9	10 to 20
Revenue from sales													
Local sale													
Pumpkin			0	80	80	80	80	80	80	80	80	80	80
Sweet potato			0	22	22	22	22	22	22	22	22	22	22
Chinese cabbage			0	6	6	6	6	6	6	6	6	6	6
Tomato			0	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7
Eggplant			0	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5
Total revenues			0	150	150	150	150	150	150	150	150	150	150
Value of self-consumption													
Pumpkin			0	720	720	720	720	720	720	720	720	720	720
Sweet potato			0	194	194	194	194	194	194	194	194	194	194
Chinese cabbage			0	58	58	58	58	58	58	58	58	58	58
Tomato			0	276	276	276	276	276	276	276	276	276	276
Eggplant			0	104	104	104	104	104	104	104	104	104	104
Total value of self-consumption			0	1,352	1,352	1,352	1,352	1,352	1,352	1,352	1,352	1,352	1,352
Total gross benefits			**0**	**1,502**	**1,502**	**1,502**	**1,502**	**1,502**	**1,502**	**1,502**	**1,502**	**1,502**	**1,502**
Investment costs													
Tools			0	300	0	0	0	0	300	0	0	0	0
Tanks for collection of grey water				300	0	0	0	0	300	0	0	0	0
Total investments			0	600	0	0	0	0	600	0	0	0	0
Operating costs													
Planting material													
Pumpkin			0.0	0.0	0.0	0.3	0.0	0.6	0.0	0.6	0.0	0.6	0.0
Sweet potato			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chinese cabbage			0.0	0.0	0.8	1.6	2.4	3.2	3.2	3.2	3.2	3.2	3.2
Tomato			0.0	0.0	0.2	0.5	0.7	1.0	1.0	1.0	1.0	1.0	1.0
Eggplant			0.0	0.0	0.1	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3
Compost			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Organic pesticides (neem)			0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Family labour			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total operating costs			0.0	1.0	2.0	4.0	4.0	6.0	5.0	6.0	5.0	6.0	5.0
Total costs			**0.0**	**601.0**	**2.0**	**4.0**	**4.0**	**6.0**	**605.0**	**6.0**	**5.0**	**6.0**	**5.0**
Net benefits/net incremental benefits			0	901	1,500	1,499	1,498	1,496	897	1,496	1,497	1,496	1,497
Return to family labour ($A)			0	7	11	11	11	11	7	11	11	11	11

TABLE 4

Financial benefits from tree-crop replanting activities per household

(Australian dollars)

Yields and inputs Items	Unit	Unit cost ($A)	Without project	With project 1	2	3	4	5	6	7	8	9	10 to 20
Main production													
Coconut – old trees	trees		100	0	0	0	0	0	0	0	0	0	0
Coconut – new trees	trees		180	240	240	240	240	240	240	240	240	240	240
Copra output from old coconuts	trees		300	0	0	0	0	0	0	0	0	0	0
Copra output from new coconuts	trees		2,700	2,700	2,700	2,925	3,150	3,375	3,600	3,600	3,600	3,600	3,600
Total copra output			**3,000**	**2,700**	**2,700**	**2,925**	**3,150**	**3,375**	**3,600**	**3,600**	**3,600**	**3,600**	**3,600**
self-consumption	kg		300	300	300	300	300	300	300	300	300	300	300
for sale	kg	0.8	2,700	2,400	2,400	2,625	2,850	3,075	3,300	3,300	3,300	3,300	3,300
Pawpaw old trees	trees		3	3	3	0	0	0	0	0	0	0	0
Pawpaw new trees	trees		0	6	6	6	6	6	6	6	6	6	6
Production old trees	trees		15	15	15	0	0	0	0	0	0	0	0
Production new trees	trees		0	0	36	72	72	72	72	72	72	72	72
Total pawpaw			**15**	**15**	**51**	**72**	**72**	**72**	**72**	**72**	**72**	**72**	**72**
Self-consumption	kg		15	15	51	58	58	58	58	58	58	58	58
For sale	kg	1.2	0	0	0	14	14	14	14	14	14	14	14
Breadfruit old trees	trees		4	4	4	0	0	0	0	0	0	0	0
Breadfruit new trees	trees		0	8	8	8	8	8	8	8	8	8	8
Production old trees	trees		32	32	32	0	0	0	0	0	0	0	0
Production new trees	trees		0	0	0	80	120	160	160	160	160	160	160
Total breadfruit			**32**	**32**	**32**	**80**	**120**	**160**	**160**	**160**	**160**	**160**	**160**
Self-consumption	kg		32	32	32	80	120	128	128	128	128	128	128
For sale	kg	1.5	0	0	0	0	0	32	32	32	32	32	32
Investments													
Coconut seedlings	seedling	0.5	0	50	0	0	0	0	0	0	0	0	0
Pawpaw seedlings	seedling	1.0	0	6	0	0	0	0	0	0	0	0	0
Breadfruit seedlings	seedling	1.0	0	6	0	0	0	0	0	0	0	0	0
Labour: clearing	person-days		0	25	0	0	0	0	0	0	0	0	0
Labour: land preparation and replanting	person-days	0	0	30	0	0	0	0	0	0	0	0	0
Operating costs													
Labour													
Coconut: harvesting, cutting and transport	person-days		135.0	121.5	121.5	131.6	141.8	151.9	162.0	162.0	162.0	162.0	162.0
Breadfruit and pawpaw: harvesting and transport	person-days		5.0	8.0	8.0	9.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Total family labour	person-days	0	140.0	129.5	129.5	140.6	151.8	161.9	172.0	172.0	172.0	172.0	172.0

TABLE 4 (CONT.)

Financial budget ($A) Items	Unit	Unit cost ($A)	Without project	With project 1	2	3	With project 4	5	6	7	8	9	10 to 20
Revenues from local sales													
Copra			2,160.0	1,920.0	1,920.0	2,100.0	2,280.0	2,460.0	2,640.0	2,640.0	2,640	2,640.0	2,640.0
Pawpaw			0.0	0.0	0.0	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3
Breadfruit			0.0	0.0	0.0	0.0	0	48.0	48.0	48.0	48.0	48.0	48.0
Total revenue			2,160.0	1,920.0	1,920.0	2,117.3	2,297.3	2,525.3	2,705.3	2,705.3	2,705.3	2,705.3	2,705.3
Value of self-consumption													
Copra			240.0	240.0	240.0	240.0	240.0	240.0	240.0	240.0	240.0	240.0	240.0
Pawpaw			18.0	18.0	61.2	69.1	69.1	69.1	69.1	69.1	69.1	69.1	69.1
Breadfruit			48.0	48.0	48.0	120.0	180	192.0	192.0	192.0	192.0	192.0	192.0
Total value of self-consumption			30.06	30.06	349.2	429.1	489.1	501.1	501.1	501.1	501.1	501.1	501.1
Total gross benefits			**2,466**	**2,226**	**2,269.2**	**2,546.4**	**2,786.4**	**3,026.4**	**3,206.4**	**3,206.4**	**3,206.4**	**3,206.4**	**3,206.4**
Investments													
Coconut seedlings			0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pawpaw seedlings			0.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Breadfruit seedlings			0.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Labour: clearing			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Labour: land preparation and replanting			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total investment costs			0.0	37.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Operating costs													
Total family labour			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total operating costs			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total costs			0.0	37.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Net benefits			**2,466**.0	**2,189**.0	**2,269.0**	**2,546.0**	**2,786.0**	**3,026.0**	**3,206.0**	**3,206.0**	**3,206.0**	**3,206.0**	**3,206.0**
Incremental net benefits				-277.0	-197.0	80.0	320.0	560.0	740.0	740.0	740.0	740.0	740.0
Return to family labour ($A)			18.0	14.0	18.0	18.0	18.0	19.0	19.0	19.0	19.0	19.0	19.0

TABLE 5

Financial benefits from poultry production per household

(Australian dollars)

Yields and inputs Items	Unit	Unit cost ($A)	Without project	With project 1	With project 2 to 20
Sales					
Roosters (free-range)	head	10.0	2	0	0
Cull hens (free-range)	head	9.0	1	0	0
Roosters (housed)	head	13.0	0	6	6
Cull hens (housed)	head	10.0	0	3	3
Eggs	unit	0.2	0	438	438
Self-consumption					
Roosters (free-range)	head	10.0	2	0	0
Pullets – 1 yr (free-range)	head	10.0	2	0	0
Cull hens (free-range)	head	9.0	2	0	0
Roosters (housed)	head	13.0	0	6	6
Pullets – 1 yr (housed)	head	13.0	0	6	6
Cull hens (housed)	head	10.0	0	3	3
Eggs	unit	0.1	47	438	438
Investment					
Chicken sheds	unit	100.0	0	1	0
Labour (shed construction)	person-days	0.0	0	3	0
Operating costs					
Local feeds		0.3	0	50	50
Family labour	person-days	0.0	7	16	16

TABLE 5 (CONT.)

Financial budget ($A)	Without project	With project	
Items		1	2 to 20
Revenue from local sales			
Roosters (free-range)	20.0	0.0	0.0
Cull hens (free-range)	9.0	0.0	0.0
Roosters (housed)	0.0	78.0	78.0
Cull hens (housed)	0.0	30.0	30.0
Eggs	0.0	65.7	65.7
Total revenues	0.0	95.7	95.7
Value of self-consumption			
Roosters (free-range)	20.0	0.0	0.0
Pullets – 1 yr (free-range)	20.0	0.0	0.0
Cull hens (free-range)	18.0	0.0	0.0
Roosters (housed)	0.0	78.0	78.0
Pullets – 1 yr (housed)	0.0	78.0	78.0
Cull hens (housed)	0.0	30.0	30.0
Eggs	7.0	65.7	65.7
Total value of self-consumption	65.0	251.7	251.7
Total gross benefits	**65.0**	**347.4**	**347.4**
Investment costs			
Chicken sheds	0.0	10.0	0.0
Family labour (shed construction)	0.0	0.0	0.0
Total investment costs	0.0	10.0	0.0
Operating costs			
Local feed (50%)	0.0	147.0	147.0
Family labour	0.0	0.0	0.0
Total costs	0.0	247.0	147.0
Total net benefits	**65.0**	**10.0**	**20.0**
Incremental net benefits		36.0	136.0
Return to family labour	10.0	6.0	13.0

TABLE 6

Financial benefits from tree school nurseries per nursery

(Australian dollars)

Yields and inputs	Unit	Unit cost ($A)	Without project	With project		With project							
Items				1	2	3	4	5	6	7	8	9	10 to 20
Main production													
Pumpkin	seedling	0.1	0	667	33	33	33	33	33	33	33	33	33
Chinese cabbage	seedling	0.1	0	6,667	6,667	6,667	6,667	6,667	6,667	6,667	6,667	6,667	6,667
Tomato	seedling	0.2	0	6,667	6,667	6,667	6,667	6,667	6,667	6,667	6,667	6,667	6,667
Eggplant	seedling	0.1	0	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Pawpaw	seedling	1.0	0	667	33	33	33	33	33	33	33	33	33
Breadfruit	seedling	1.0	0	1,000	50	50	50	50	50	50	50	50	50
Coconut	seedling	0.5	0	1,000	50	50	50	50	50	50	50	50	50
Revenues													
Pumpkin	$A		0	0	1	2	3	3	3	3	3	3	3
Chinese cabbage	$A		0	0	167	333	500	667	667	667	667	667	667
Tomato	$A		0	0	333	667	1,000	1,333	1,333	1,333	1,333	1,333	1,333
Eggplant	$A		0	0	25	50	75	100	100	100	100	100	100
Pawpaw	$A		0	0	8	17	25	33	33	33	33	33	33
Breadfruit	$A		0	0	13	25	38	50	50	50	50	50	50
Coconut	$A		0	0	8	17	25	33	33	33	33	33	33
Subtotal revenues			0	0	555	1,110	1,665	2,220	2,220	2,220	2,220	2,220	2,220
Investment inputs													
Materials for nursery construction	set	3,200	0	1	0	0	0	0	0	0	0	0	0
Materials for compost shed	set	1,800	0	1	0	0	0	0	0	0	0	0	0
Labour (beneficiaries' contribution)	person-days	0	0	45	0	0	0	0	0	0	0	0	0
Investment costs													
Materials for nursery construction	$A		0	3,200	0	0	0	0	0	0	0	0	0
Materials for compost shed	$A		0	1,800	0	0	0	0	0	0	0	0	0
Labour	$A		0	0	0	0	0	0	0	0	0	0	0
Subtotal investments			0	5,000	0	0	0	0	0	0	0	0	0
Operating inputs													
Pumpkin	seed	0.0010	0	667	33	33	33	33	33	33	33	33	33
Chinese cabbage (34,000 seeds/can @ $A34)	seed	0.0010	0	6,667	6,667	6,667	6,667	6,667	6,667	6,667	6,667	6,667	6,667
Tomato (3,800 seeds/pack @ $A22.5)	seed	0.0059	0	6,667	6,667	6,667	6,667	6,667	6,667	6,667	6,667	6,667	6,667
Eggplant (2,600 seeds/pack @ $A4.5)	seed	0.0017	0	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Pawpaw (385 seeds/pack @ $A22.5)	seed	0.0584	0	667	33	33	33	33	33	33	33	33	33
Plastic trays	units	0.2000	0	180	180	180	180	180	180	180	180	180	180
Soil	20 kg bag	1.0000	0	9	9	9	9	9	9	9	9	9	9
O&M	lump sum	2%	of investment	1	1	1	1	1	1	1	1	1	1
Labour: production and sale (2 people part-time)	person-days	4	365	365	365	365	365	365	365	365	365	365	365

TABLE 6 (CONT.)

Yields and inputs				With project		With project							
Items	Unit	Unit cost ($A)	Without project	1	2	3	4	5	6	7	8	9	10 to 20
Operating costs													
Pumpkin	$A		0	1	0	0	0	0	0	0	0	0	0
Chinese cabbage (34,000 seeds/can @ $A34)	$A		0	7	7	7	7	7	7	7	7	7	7
Tomato (3,800 seeds/pack@ $A22.5)	$A		0	39	39	39	39	39	39	39	39	39	39
Eggplant (2,600 seeds/pack @ $A4.5)	$A		0	2	2	2	2	2	2	2	2	2	2
Pawpaw (385 seeds/pack @ $A22.5)	$A		0	39	2	2	2	2	2	2	2	2	2
Plastic trays	$A		0	36	36	36	36	36	36	36	36	36	36
Soil	$A		0	9	9	9	9	9	9	9	9	9	9
Subtotal input costs			0	133	95	95	95	95	95	95	95	95	95
O&M	$A		0	100	100	100	100	100	100	100	100	100	100
Labour: production and sale (2 people part-time)	$A		0	1,460	1,460	1,460	1,460	1,460	1,460	1,460	1,460	1,460	1,460
Subtotal operating costs			0	1,693	1,655	1,655	1,655	1,655	1,655	1,655	1,655	1,655	1,655
Total costs	**$A**		**0**	**6,693**	**1,655**	**1,655**	**1,655**	**1,655**	**1,655**	**1,655**	**1,655**	**1,655**	**1,655**
Net revenue	$A		0	-11,693	-1,100	-545	10	565	565	565	565	565	565
Incremental net revenue (before financing)	$A			-11,693	-1,100	-545	10	565	565	565	565	565	565
Benefit/cost ratio			0.0	0.0	0.3	0.7	1.0	1.3	1.3	1.3	1.3	1.3	1.3

Financing analysis ($A)	Unit	
Investments	$A	5,000
Subsidized operating inputs in PY 1	%	100%
Subsidized operating inputs in PY 2	%	75%
Subsidized operating inputs in PY 3	%	50%
Subsidized operating inputs in PY 4	%	25%

Yields and inputs				With project		With project							
Items	Unit	Unit cost ($A)	Without project	1	2	3	4	5	6	7	8	9	10 to 20
Subtotal revenues			0	0	555	1,110	1,665	2,220	2,220	2,220	2,220	2,220	2,220
Subtotal investments			0	0	0	0	0	0	0	0	0	0	0
Subtotal operating costs			0	0	414	827	1,241	1,655	1,655	1,655	1,655	1,655	1,655
Total costs			0	0	414	827	1,241	1,655	1,655	1,655	1,655	1,655	1,655
Net revenue			0	0	141	283	424	565	565	565	565	565	565
Incremental net revenue				0	141	283	424	565	565	565	565	565	565

Note: economic prices closely mirror financial prices, particularly for agricultural produce, with the exception of the heavily subsidized copra industry and items for which VAT is anticipated to apply – mainly tools and equipment. Financial benefit streams have been converted into economic ones by:

- Applying a 0.78 conversion factor to equipment and materials;
- Valuing labour at $A2.70/day (estimated as the average return to labour/day from island households' four main sources of income ($A18 per day), and adjusted by the effective number of hours worked per day – about 15% of an 8-hour labour/day);
- Calculating import-export parity prices for tradable goods. Conversion factors are 0.32 for copra, 0.96 for rice and 0.7 for sugar.

TABLE 7

Economic benefits from household-water-supply systems per group of households

(Australian and United States dollars)

Assumptions		
Average number of people per family	6	
Economically active people per family	4	
Economic unskilled shadow wage = average return to labour/day from four main sources of income (from household model)* effective hours per workday (15% of an 8-hour labour day)	2.70	
WOP		
Original source of water 1 (8 months a year)	120	minutes/day
Original source of water 2 (4 months a year)	160	minutes/day
Total hours per family per year	811	
Total days per family per year	101	
Average days of water-borne illnesses per family member per year	3	
Total days of illnesses per year of economically active members	12	

Assumptions (cont.)		
WP		
New source of water (8 months)	40	minutes/day
Original source of water 2 (4 months a year)	160	minutes/day
Total hours per family per year	486	
Total days per family per year	61	
Days saved per family per year	**41**	
Reduction in water borne illnesses	90%	
Days saved per family per year	**36**	
Total days saved per family per year	**77**	

* From household consumption in Abemama.

Items		Without project	With project									
			1	2	3	4	5	6	7	8	9	10 to 20
Number of families per group	6											
Benefit stream												
Time saved from getting water (days)		0	243	243	243	243	243	243	243	243	243	243
Time saved from illness (days)		0	219	219	219	219	219	219	219	219	219	219
Total days saved		0	462	462	462	462	462	462	462	462	462	462
Economic value ($A)		0	1,248	1,248	1,248	1,248	1,248	1,248	1,248	1,248	1,248	1,248
NPV @ 12% ($A)	7,049.31											
NPV @ 12% (US$)	6,656.57											
Costs												
Household-water-supply system in the southern islands (without VAT)			3,199									
Installation (one member of each household, 5 days)			81									
O&M (5% of investment costs)				160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0
Total costs ($A)			**3,280.2**	**160.0**	**160.0**	**160.0**	**160.0**	**160.0**	**160.0**	**160.0**	**160.0**	**160.0**
NPV @ 12% ($A)	3,689.74											
NPV @ 12% (US$)	3,484.17											
Net Incremental benefits			**-2,033**	**1,088**	**1,088**	**1,088**	**1,088**	**1,088**	**1,088**	**1,088**	**1,088**	**1,088**

	$A	US$
NPV @ 12%	3,360	3,172
IRR	52%	52%
Switching values		
NPV incremental benefits ($A)	7,049	45%
NPV incremental investment cost ($A)	3,690	86%

TABLE 8

Beneficiary phasing assumptions

Home gardening and replanting	889 households				
Phasing of households	**Year 1**	**Year 2**	**Year 3**	**Year 4**	
Total		889			
Adoption rate	40%				
Generation of benefits from year of adoption (net incremental incomes from crop models)	**1**	**2**	**3**	**4**	**5-20**
Incremental net benefits home gardening (per household) ($A)	672	1,137	1,137	1,130	1,123
Incremental net benefits replanting ($A)	-234	-5	120	207	297
Total incremental net benefits home gardening + replanting	438	1,132	1,256	1,337	1,420
Phasing of benefits (year +1)					
Total incremental net benefits ($A)	0	0	389,338	1,006,037	1,116,951
Total incremental net benefits (US$)	**0**	**0**	**367,646**	**949,988**	**1,054,722**

Poultry and egg production	889 households				
Phasing of households (one shed per household)	**Year 1**	**Year 2**	**Year 3**	**Year 4**	
Number of sheds		889	0	0	
Generation of benefits from year of adoption (net incremental incomes from livestock models)	**1**	**2**	**3**	**4**	**5-20**
Incremental net benefits (per group of households)	-116	100	100	100	100
Phasing of benefits (year +1)					
Total incremental net benefits ($A)	0	0	-103,181	89,127	89,127
Total incremental net benefits (US$)	**0**	**0**	**-97,433**	**84,162**	**84,162**

School nurseries	6 nurseries				
Phasing of beneficiaries	**Year 1**	**Year 2**	**Year 3**	**Year 4**	
Total	0	6	0	0	
Generation of benefits from year of establishment (from nursery model)	**1**	**2**	**3**	**4**	**5-20**
Incremental net benefits per nursery ($A)	-9,211	-625	-70	485	1,040
Total incremental net benefits ($A)	-55,266	-3,752	-422	2,909	6,239
Phasing of benefits (year +1)					
Total incremental net benefits ($A)	0	0	-55,266	-3,752	-422
Total incremental net benefits (US$)	**0**	**0**	**-52,187**	**-3,543**	**-398**

Household water supply	278 systems		1,668 households		
Phasing of households (tanks)	**Year 1**	**Year 2**	**Year 3**	**Year 4**	
Northern islands	0	73	0	0	
Southern islands	0	0	205	0	
Generation of benefits from year of aestablishment (from water supply model)	**1**	**2**	**3**	**4**	**5-20**
Net incremental benefits per household	-2,033	1,088	1,088	1,088	1,088
Phasing of benefits (year +1)					
Abemama			-148,379	79,399	79,399
Southern islands				-416,680	222,969
Total incremental net benefits ($A)	0	0	-148,379	-337,281	302,368
Total incremental net benefits (US$)	**0**	**0**	**-140,112**	**-318,490**	**285,523**

TABLE 9

Economic analysis

(United States dollars)

Project economic analysis	1	2	3	4	5	6	7	8	9	10-20
Incremental benefits (US$)*										
Home gardening and replanting	0	0	367,646	949,988	1,054,722	1,122,772	1,192,248	828,138	1,217,653	1,218,492
Poultry and egg production	0	0	-97,433	84,162	84,162	84,162	84,162	84,162	84,162	84,162
School nurseries	0	0	-52,187	-3,543	-398	2,747	5,892	5,892	5,892	5,892
Household water supply	0	0	-140,112	-318,490	285,523	285,523	285,523	285,523	285,523	285,523
Total project incremental benefits (US$)	**0**	**0**	**77,914**	**712,116**	**1,424,008**	**1,495,203**	**1,567,824**	**1,203,714**	**1,593,229**	**1,594,068**
Success rate	0.7									
Incremental benefits after success rate	0	0	58,436	534,087	1,068,006	1,121,402	1,175,868	902,785	1,194,921	1,195,551
Total project costs (US$)	**1,221,018**	**1,203,719**	**1,225,045**	**880,073**						
Total project incremental net benefits	**-1,221,018**	**-1,203,719**	**-1,166,609**	**-345,986**	**1,068,006**	**1,121,402**	**1,175,868**	**902,785**	**1,194,921**	**1,195,551**

NPV (US$)	1,961,261
IRR	19%

* Exchange rate: US$:$A = 0.94.

TABLE 10
Sensitivity analysis
(United States dollars)

Sensitivity analysis	Base case	Costs increase			Increase of benefits		Decrease of benefits			Delay of benefits	
		+10%	+20%	+30%	+10%	+20%	-10%	-20%	- 30%	1 year	2 years
IRR	**19.3%**	18.0%	16.0%	15.0%	21.0%	23.0%	17.0%	15.0%	13.0%	16.0%	14.0%
NPV (US$)	**1,961,261**	1,613,155	1,265,049	916,944	2,505,492	3,049,724	1,417,029	872,797	328,566	1,267,496	648,062
Discount rate	12.0%										

Switching values			
NPV incremental benefits	6,529,141	4,567,880	-30.0%
NPV incremental investment cost	3,626,321	5,587,582	54.0%

Source: Author's calculations.

TABLE 11
Household model* 'without project' – low incomes, high dependence on imported foodstuffs and poor nutrition

Sources of income ($A)	Copra	Fishing	Mat weaving	Poultry (birds and eggs)	Tree crops (breadfruit and pawpaw)	Total
Net benefit per month ($A)	206	92	150	5	6.0	453.0
Net benefit per year ($A)	2,466	1,109	1,800	65	66.0	5,440.0
Labour per month (person-days)	11	6	8	1	0.4	26.0
Labour per year (person-days)	135	72	96	7	5.0	310.0
Return to labour per year ($A/day)	18	15	19	10	13.0	17.6

Food production for self-consumption (year)	Kg	Price per unit	Value ($A)	Kcal value per 100 g	Total Kcal/ year
Breadfruit	32	1.5	48	130	41,600
Pawpaw	15	1.2	18	51	7,650
Copra	300	0.8	240	283	849,000
Fish	504	0.3	166	130	655,200

Poultry	Units	Price per unit	Value ($A)	Kcal value per 100 g	Total Kcal/ year
Roosters – 1 yr	2.0	10.0	20	231	6,930
Pullets – 1 yr	2.0	10.0	20	231	6,930
Cull hens	2.0	9.0	18	231	11,550
Eggs (30 grams)	46.4	0.1	7	147	2,046

Purchased foods (year)	Kg	Price	Total cost ($A)	Kcal value per 100 g	Total Kcal/ year
Rice	733	1.3	929	123	901,234
Flour	262	1.3	335	349	913,271
Sugar	327	1.6	523	394	1,288,785
Other	-	-	1,197	-	n/a

* From household consumption in Abemama.
Source: Author's calculations based on field research.

An average household of six people, with four economically active members, would generate a monthly income of about $A453 (including the value of self-consumption) from the five most common economic activities in the Outer Islands: copra cutting, fishing, mat weaving, poultry and fruit production, the last two being mainly carried out for household consumption. The return to family labour of these activities ranges from $A15 to $A19/person/day ($A17 on average), and working days total 26 per household per month, or 6.5 days per economically active person.

Excluding the value of self-consumption, the model household generates a monthly average of $A408 in cash, or $A4,902 annually, which is used for food and non-food expenditures (mainly education and church donations). Total household expenditure on food items is 65 per cent (including self-consumption), while total annual consumption of imported food items (rice, flour, sugar and others) represents at least 61 per cent of household cash income. The family produces only 15 per cent of the total value of food consumed.

The analysis demonstrates not only an extraordinarily high dependence on imported foods, but also a very imbalanced diet, high in sugar and fat and low in iron, vitamins and fibre. This dietary issue is the major factor underlying the increasing prevalence of non-communicable diseases in Kiribati, especially diabetes and heart diseases.

After adoption of project activities, the household would have three additional sources of cash income. Proceeds from the sale of surplus production of vegetables and tree crops and from market-oriented poultry production (mainly for eggs) can generate about $A1,109/year incremental cash income for the family. Total number of labour days per year will increase greatly – from 310 to 491.

The household is now able to produce up to 62 per cent of the total value of food consumed, and to reduce dependence on rice, flour and sugar by about 25 per cent, decreasing expenditure on imported food items to only 22 per cent of household cash income.

Most importantly, the household would shift from a diet deficient in fibre, vitamins A and C and polyunsaturated acids to an average annual intake above recommended thresholds for these types of nutrients. In addition, consumption of minerals would increase by about 80 per cent, almost doubling the baseline intake values, although still below the recommended benchmark. The new diet would also maintain consumption of proteins and B vitamins above desirable values.

TABLE 12

Household model 'with project' – higher incomes, less imported foodstuffs, improved nutrition

Sources of income ($A)	Copra	Fishing	Mat weaving	Poultry (birds and eggs)	Home garden	Tree crops (breadfruit and pawpaw)	Total/year
Net benefit per month ($A)	240	92	150	17	125	27	651
Net benefit per year ($A)	2,880	1,109	1,800	201	1,496	326	7,812
Labour per month (person-days)	14	6	8	1	11	1	41
Labour per year (person-days)	162	72	96	16	135	10	491
Return to labour per year ($A/day)	18	15	19	13	11	33	16

Food production for self-consumption (year)	Kg	Price	Value ($A)	Kcal value per 100 g	Total Kcal/year
Breadfruit	128	1.5	192.0	130	166,400
Pawpaw	58	1.2	69.1	51	29,376
Copra	300	0.8	240.0	283	849,000
Fish	504	0.2	75.6	130	655,200
Vegetables					
Pumpkin	576	1.3	720.0	44	253,440
Chinese cabbage	29	2.0	57.6	65	18,720
Sweet potato	130	1.5	194.4	86	111,456
Tomato	69	4.0	276.5	18	12,442
Eggplant	35	3.0	103.7	35	12,096

Poultry	Units	Price per unit	Value ($A)	Kcal value per 100 g	Total Kcal/year
Roosters – 1 yr	6	13.0	78.0	231	34,650
Pullets – 1 yr	6	13.0	78.0	231	34,650
Cull hens	3	10.0	30.0	231	20,790
Eggs (30 grams)	438	0.2	65.7	147	25,754

Purchased foods (year)	Kg	Price	Total cost ($A)	Kcal value per 100 g	Total Kcal/year
Rice (-25%)	550	1.3	697.0	123	675,925
Flour (-25%)	196	1.3	251.0	349	684,953
Sugar (-25%)	245	1.6	393.0	394	966,589

Source: Author's calculations based on field research.

TABLE 13

Summary table – main indicators 'with' and 'without project'

Indicator summary	WOP	WP
A - Household cash income per year ($A)*	4,902	6,012
B - Total value of produced food per year ($A)	537	2,181
C - Total value of income + produced foods ($A) (A+B)	5,440	8,193
D - Total cost of purchased foods per year ($A)	2,985	1,340
E - Total value of food consumption per year ($A) (B+D)	3,522	3,521
F - Food produced/total food consumed (B/E)	15%	62%
G - Purchased food/total food consumed (D/E)	85%	38%
H - Household expenditure on food items (E/C)	65%	43%
I - Expenditure on imported foods (D/A)	61%	22%
J - Total labour days/year	310	491

* Excluding self-consumption.

Source: Author's calculations based on field research.

TABLE 14

Changes in nutritional intake 'with' and 'without project'

Nutrient type	WOP	WP	% change	Recommended average intake per household per year*
Protein (g)	193,600	225,595	17%	101,488
Fibre (g)	65,223	79,348	22%	73,365
Total proximates	**258,823**	**304,943**	**18%**	**174,853**
Calcium (mg)	343,240	640,510	87%	2,199,125
Iron (mg)	28,497	37,238	31%	48,271
Zinc (mg)	15,667	19,967	27%	28,470
Total minerals	**387,405**	**697,714**	**80%**	**2,275,866**
Provitamin A (RAE)	609,134	2,479,972	307%	1,819,525
Riboflavin (mg)	2,737	4,178	53%	2,616
Niacin (mg)	62,731	63,583	1%	31,938
B-6 (mg)	3,744	4,978	33%	2,995
Vitamin C (mg)	15,747	112,049	612%	106,763
Total vitamins	**694,093**	**2,664,760**	**284%**	**1,963,836**
Fatty acids, total polyunsaturated (mg)	14,592	23,733	63%	17,319
Total lipids	**14,592**	**23,733**	**63%**	**17,319**

* Recommended intake for an average household of six members, composed of one infant (0-11 months), one young child (1-6 years), one child (1-18 years), one adult man (18-65+ years), one adult woman (18-65+ years) and one pregnant adult woman.

Source: Author's calculations based on field research.

TABLE 15

Recommended daily nutrient intake by age group

Recommended daily nutrient intake	Children 0-11 months	Children 1-6 years	Children 7-18 years	Men 18-65 years	Women 18-65 years	Pregnancy/ lactation
Protein (g)	5	19	43	55	45	56
Fibre (g)	15	22	35	38	25	29
Total proximates	**20**	**41**	**78**	**93**	**70**	**85**
Calcium (mg)	375	550	1,000	1,000	1,000	1,100
Iron (mg)	6	8	32	18	30	20
Zinc (mg)	5	6	20	13	10	12
Total minerals	**386**	**564**	**1,052**	**1,031**	**1,039**	**1,132**
Provitamin A (RAE)	375	425	550	900	800	1,035
Riboflavin (mg)	0	1	1	1	1	2
Niacin (mg)	3	7	14	16	14	18
B-6 (mg)	0	1	1	1	1	2
Vitamin C (mg)	28	30	38	45	45	63
Total vitamins	**406**	**463**	**604**	**964**	**861**	**1,118**
Fatty acids, total polyunsaturated (mg)	3	5	8	9	7	7
Total lipids	**3**	**5**	**8**	**9**	**7**	**7**

Source: Author's calculations based on FAO 2004.

TABLE 16

Nutritive value of food items

Food item	Nutritive value per 100 g
Vegetables	
Pumpkin	0.72 g protein 1.1 g fibre 15 mg calcium 0.57 mg iron 0.23 mg zinc 248 RAE provitamin A 0.078 mg vitamin B riboflavin 0.413 mg vitamin B niacin 0.044 mg vitamin B-6 4.7 mg vitamin C 0.040 mg fatty acids
Cabbage	1.28 g protein 2.5 g fibre 40 mg calcium 0.47 mg iron 0.18 mg zinc 3 RAE provitamin A 0.040 mg riboflavin 0.234 mg niacin 0.124 mg vitamin B-6 36.6 mg vitamin C 0.017 mg fatty acids
Sweet potato	1.37 g protein 2.5 g fibre 27 mg calcium 0.72 mg iron 0.20 mg zinc 59 RAE provitamin A 0.047 mg vitamin B riboflavin 0.538 mg vitamin B niacin 0.165 mg vitamin B-6 12.8 mg vitamin C 0.080 mg fatty acids
Tomato	0.88 g protein 1.2 g fibre 10 mg calcium 0.27 mg iron 0.17 mg zinc 42 RAE provitamin A 0.019 mg vitamin B riboflavin 0.594 mg vitamin B niacin 0.080 mg vitamin B-6 13.7 mg vitamin C 0.083 mg fatty acids
Eggplant	0.90 g protein 2.5 g fibre 25 mg calcium 0.77 mg iron 0.23 mg zinc 3 RAE provitamin A 0.070 mg vitamin B riboflavin 0.660 mg vitamin B niacin 0.140 mg vitamin B-6 0 mg vitamin C 0.294 mg fatty acids

Food item	Nutritive value per 100 g
Poultry	
Rooster – 1 yr	27.30 g protein 0 g fibre 15 mg calcium 1.26 mg iron 1.94 mg zinc 48 RAE provitamin A 0.168 mg vitamin B riboflavin 8.487 mg vitamin B niacin 0.400 mg vitamin B-6 0 mg vitamin C 2.970 mg fatty acids
Pullet – 1 yr	27.30 g protein 0 g fibre 15 mg calcium 1.26 mg iron 1.94 mg zinc 48 RAE provitamin A 0.168 mg vitamin B riboflavin 8.487 mg vitamin B niacin 0.400 mg vitamin B-6 0 mg vitamin C 2.970 mg fatty acids
Cull hen	27.30 g protein 0 g fibre 15 mg calcium 1.26 mg iron 1.94 mg zinc 48 RAE provitamin A 0.168 mg vitamin B riboflavin 8.487 mg vitamin B niacin 0.400 mg vitamin B-6 0 mg vitamin C 2.970 mg fatty acids
Egg (46 grams)	6.26 g protein 0 g fibre 29 mg calcium 0.87 mg iron 0.64 mg zinc 75 RAE provitamin A 0.228 mg vitamin B riboflavin 0.038 mg vitamin B niacin 0.085 mg vitamin B-6 0 mg vitamin C 1.495 mg fatty acids

Food item	Nutritive value per 100 g
Fruit	**Fruit**
Breadfruit	7.4 g protein 5.2 g fibre 36 mg calcium 3.67 mg iron 0.9 mg zinc 13 RAE provitamin A 0.3015 mg vitamin B riboflavin 0.438 mg vitamin B niacin 0.320 mg vitamin B-6 6.6 mg vitamin C 2.977 mg fatty acids
Pawpaw	0.47 g protein 1.7 g fibre 20 mg calcium 0.25 mg iron 0.08 mg zinc 47 RAE provitamin A 0.027 mg vitamin B riboflavin 0.357 mg vitamin B niacin 0.038 mg vitamin B-6 60.9 mg vitamin C 0.084 mg fatty acids
Copra	6.88 g protein 16.3 g fibre 26 mg calcium 3.32 mg iron 2.01 mg zinc 0 RAE provitamin A 0.100 mg vitamin B riboflavin 0.603 mg vitamin B niacin 0.300 mg vitamin B-6 1.5 mg vitamin C 0.706 mg fatty acids

Food item	Nutritive value per 100 g
Imported foods	
Rice	2.02 g protein 1.0 g fibre 2 mg calcium 0.14 mg iron 0.41 mg zinc 0 RAE provitamin A 0.013 mg vitamin B riboflavin 0.290 mg vitamin B niacin 0.026 mg vitamin B-6 0 mg vitamin C 0.069 mg fatty acids
Flour	10.33 g protein 2.7 g fibre 15 mg calcium 4.64 mg iron 0.70 mg zinc 0 RAE provitamin A 0.494 mg vitamin B Riboflavin 5.904 mg vitamin B niacin 0.044 mg vitamin B-6 0 mg vitamin C 0.413 mg fatty acids
Sugar	0 g protein 0 g fibre 1 mg calcium 0.06 mg iron 0.01 mg zinc 0 RAE provitamin A 0.019 mg vitamin B riboflavin 0 mg vitamin B niacin 0 mg vitamin B-6 0 mg vitamin C 0 mg fatty acids

Food item	Nutritive value per 100 g
Fish and seafood	
Fish (milkfish, tuna, shellfish)	24.825 g protein 0 g fibre 36.5 mg calcium 0.715 mg iron 0.825 mg zinc 112 RAE provitamin A 0.16 mg vitamin B riboflavin 8.455 mg vitamin B niacin 0.4715 mg vitamin B-6 0 mg vitamin C 1.844 mg fatty acids

Source: Author's calculations based on FAO 2004.

EXAMPLE 2

Ex ante economic analysis of biofortified high-provitamin A and high-iron banana

(Uganda, IFPRI, 2013)

Description

This example illustrates the potential contribution of genetically modified, high-provitamin A and high-iron banana (HPVAHIB) to reducing vitamin A deficiency and anaemia.[1] The purpose of biofortifying staple crops is to improve human health and well-being by reducing the burden of disease caused by micronutrient deficiency. The ex ante economic analysis of the costs and nutritional benefits of HPVAHIB presented below was conducted by IFPRI, using DALY methodology adapted by HarvestPlus[2] for the study of biofortified crops.

IFPRI's High-Provitamin A, High-Iron Banana (HPVAHIB) Project is being implemented in four phases: phase I consists of basic research, applied research and technology development; phase II continues and completes the applied research and technology development phase and begins the regulatory approval process in Uganda; in phase III, HPVAHIB varieties will be released and promotional campaigns undertaken, and in phase IV, long-term government regulatory supervision and maintenance-breeding activities will begin.

Costs and benefits

Costs comprise: (i) research and development (R&D) costs incurred when adding one more trait to regular breeding efforts for the staple crop in question; (ii) country-specific adaptive breeding and dissemination costs; and (iii) maintenance costs. R&D and adaptive costs are incurred from project inception until HPVAHIB is released in year 8 (calendar year 2019). Release and dissemination costs are incurred over the following two years, and maintenance costs from then onwards. The benefit to public health is stated as the number of DALYs gained through introduction of the technology. The project will not produce benefits, however, until HPVAHIB varieties are released and adopted by farmers and the output is consumed, starting in calendar year 2019. Total health benefits produced each year by HPVAHIB depend on the number of HPVAHIB adopters, area cultivated, amount produced, number of HPVAHIB consumers, amount consumed, amount of vitamin A lost during processing, other foods consumed with HPVAHIB, and consumers' health status, among others.

Methodology

The method is based on a paper by Zimmermann and Qaim (2004), in which the concept of DALYs was first used to measure potential health benefits of a biofortified staple crop. HaverstPlus introduced some modifications to counter some of the limitations of the original methodology, such as eliminating the very controversial age-weighting factor (that places more value on the lives of young, productive adults) and using national average life expectancy rather than a standard life table.

To measure the economic impact of biofortified staple crops on public health, both the number of DALYs lost under the status quo and the number of DALYs lost under a hypothetical scenario, in which people consume biofortified crops, were calculated. Presumably, less DALYs are lost in the scenario with biofortified crops; the difference between WP and WOP scenarios corresponds to the impact of biofortification. A monetary value is then attributed to a DALY to carry out a cost-benefit analysis (see box 3 in the conceptual section of this note). By juxtaposing cost and benefit streams, and taking into account the research lag, IRRs and other measures can be calculated.

1 According to WHO, Uganda has made notable progress in reducing micronutrient deficiencies in recent years, but the prevalence of vitamin A deficiency and anaemia among children under five remains unacceptably high.

2 HarvestPlus is part of the CGIAR Research Program on Agriculture for Nutrition and Health (A4NH), which helps realize the potential of agricultural development to deliver gender-equitable health and nutritional benefits to poor people. It is coordinated by CIAT and IFPRI and seeks to improve the nutrition and health status of undernourished people in developing countries by breeding staple crops to enhance the content of essential micronutrients, such as iron, zinc and provitamin A.

DALYs are generated annually in direct proportion to the quantity of HPVAHIB produced and consumed, as the difference between the baseline and endline scenarios, and valued at a standard rate of US$1,000.[3] Estimated project costs and benefits are compared over a period of 32 years and discounted at a 3 per cent rate. A number of indicators are calculated, including: (i) the cost per DALY saved;[4] (ii) the present value of the B/C ratio; and (iii) EIRR. A comparative analysis is conducted to assess the differences of six vitamin A and iron scenarios.

Results

The base scenario[5] shows the following results: HPVAHIB generates a total savings of more than 400,000 DALYs, with a total present value of approximately US$210,000 million and a cost of US$62 per DALY saved. It has a B/C ratio of 16 and EIRR of approximately 31 per cent. According to criteria established by WHO and the World Bank, the HPVAHIB project would be a very cost-effective health intervention.[6] Calculations are shown in table 20. Table 21 provides a comparative analysis of alternative HPVAHIB packages, with different assumptions used for iron and vitamin A content, adoption rates and release dates. The comparative tables show that, at a higher provitamin A content, HPVAHIB would substantially improve its performance on all three of these measures (cost per DALY saved, present value of B/C ratio and EIRR). This implies that biofortifying banana, especially cooking banana, results in huge health benefits and has positive impacts on household well-being in both highland and lowland regions of Uganda.

Further information on methodology, assumptions and results can be consulted in www.harvestplus.org/sites/default/files/tech04.pdf and www.ifpri.org/sites/default/files/publications/ifpridp01277.pdf.

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3 See box 3 for a discussion of the value of DALYs.

4 See box 3 for estimates of costs of DALYs saved.

5 The base scenario includes the biofortification of cooking banana with provitamin A at a level equal to 400 per cent of its intrinsic provitamin A content.

6 According to WHO criteria, if the cost per DALY saved is less than US$1,380, high-provitamin A banana can be considered a cost-effective intervention, and if it is less than US$460 it can be considered “very cost-effective” (World Bank 2012; WHO 2003).

TABLE 17

Estimated costs of development, release and promotion for HPVAHIB Package 2 (vitamin A and iron costs, cooking banana only) in highland and lowland regions

in (US$ '000)

									Release						Total costs		
	Calendar year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2012-24	2012-44	%
	Project year	7	8	9	10	11	12	13	14	15	16	17	18	19			
1	Development costs: breeding	1,625	1,625	1,625	1,400	1,000	900	900	900	500	500	0	0	0	10,975	10,975	48.2%
2	Development costs: on-farm trials and promotion	0	0	0	100	300	300	300	250	200	200	0	0	0	1,650	1,650	7.3%
3	Dissemination costs	0	0	0	0	0	0	0	500	250	200	700	350	300	2,300	2,300	10.1%
4	Bio-regulatory related costs	0	0	278	278	278	278	150	150	150	150	0	0	0	2,116	2,116	9.2%
5	Education and promotion campaign	0	0	0	0	0	0	200	200	100	200	200	100	100	1,100	1,100	5.0%
6	Maintenance and monitoring	0	0	0	0	0	0	0	0	0	0	200	200	200	0,600	4,600	20.2%
	Total	**1,625**	**1,625**	**1,903**	**1,778**	**1,578**	**1,478**	**1,550**	**2,000**	**1,200**	**1,250**	**1,100**	**0,650**	**0,600**	**18,337**	**22,741**	**100.0%**

Notes: Post-2024 costs: US$0.2 million per year for monitoring. Total costs cover the 20-year period 2025-2044. In 2019, release of cooking banana only (nakinyika and M9) with high-provitamin A. In 2022, release of cooking banana only (nakinyika and M9) with high-provitamin A and high Iron.
Source: IFPRI calculations.

TABLE 18

DALYs lost in Uganda due to iron-deficiency anaemia and vitamin A deficiency

Deficiency	Number of deaths	Discounted YLLs[a]	Discounted YLDs[b]	DALYs
Iron-deficiency anemia	518	11,831	82,444	94,276
Vitamin A	4,857	127,011	39,060	166,070
Total	**5,375**	**138,842**	**121,504**	**260,346**
Percentage				
Iron-deficiency anemia	10	9	68	36
Vitamin A	90	91	32	64
Total	**100**	**100**	**100**	**100**

[a] YLLs = years of life lost.
[b] YLDs = years of living with disability.
Note: DALYs are the sum of YLLs and YLDs.
Source: IFPRI calculations based on the HarvestPlus methodology (Stein et al. 2005).

TABLE 19

DALYs lost due to inadequate vitamin A intake, DALYs saved due to biofortification, and impact of lives and DALYs saved by region

Region	Number of deaths	Discounted YLLs[a]	Discounted YLDs[b]	DALYs
Baseline				
Lowlands	1,461	38,206	11,434	49,640
Highlands	835	21,838	6,467	28,305
Both regions	2,292	60,044	17,895	77,939
Endline: 400% inrease in vitamin A content *(pessimistic scenario)*				
Lowlands	1,226	32,067	8,075	40,142
Highlands	623	16,291	3,722	20,013
Both regions	1,857	48,555	11,921	60,476
Endline: 600% inrease in vitamin A content *(optimistic scenario)*				
Lowlands	1,175	30,717	7,325	38,043
Highlands	573	14,995	2,806	17,802
Both regions	1,757	45,953	10,338	56,291
Biofortification impact (baseline–endline)				
Endline: 400% inrease in vitamin A content *(pessimistic scenario)*				
Lowlands	235	6,138	3,359	9,497
Highlands	212	5,547	2,745	8,292
Both regions	439	11,488	5,975	5,975
Endline: 600% inrease in vitamin A content *(optimistic scenario)*				
Lowlands	286	7,488	4,109	11,597
Highlands	262	6,843	3,661	10,503
Both regions	539	14,090	7,557	21,648

[a] YLLs = years of life lost.

[b] YLDs = years of living with disability.

Note: DALYs are the sum of YLLs and YLDs.

Source: IFPRI calculations based on the HarvestPlus methodology (Stein et al. 2005).

TABLE 20

Economic analysis, base-case scenario

(United States dollars)

Pessimistic base package #1: 400% increase in vitamin A content Lowlands & highlands banana-growing regions of Uganda					
Years	Type of cost/ project phase	Annual costs (US$ '000)	Valuation of benefit: US$1,000 per DALY	Net benefits (US$ '000)	DALYs saved
2012	R&D, adaptive	1,625	0	-1,625	0
2013	R&D, adaptive	1,625	0	-1,625	0
2014	R&D, adaptive	1,852	0	-1,852	0
2015	R&D, adaptive	1,227	0	-1,227	0
2016	R&D, adaptive	1,027	0	-1,027	0
2017	Adaptive	1,027	0	-1,027	0
2018	Adaptive	1,454	0	-1,454	0
2019	HPVAHIB release	1,450	1,847,403	397	1,847
2020	Dissem. & maintenance	648	4,018,432	3,371	4,018
2021	Dissem. & maintenance	548	7,500,274	6,952	7,500
2022	Maintenance	200	11,402,111	11,202	11,402
2023	Maintenance	200	14,378,683	14,179	14,379
2024	Maintenance	200	16,065,522	15,866	16,066
2025	Maintenance	200	16,866,684	16,667	16,867
2026	Maintenance	200	17,215,240	17,015	17,215
2027	Maintenance	200	17,361,143	17,161	17,361
2028	Maintenance	200	17,421,296	17,221	17,421
2029	Maintenance	200	17,445,978	17,246	17,446
2030	Maintenance	200	17,456,101	17,256	17,456
2031	Maintenance	200	17,460,259	17,260	17,460
2032	Maintenance	200	17,461,971	17,262	17,462
2033	Maintenance	200	17,462,677	17,263	17,463
2034	Maintenance	200	17,462,969	17,263	17,463
2035	Maintenance	200	17,463,090	17,263	17,463
2036	Maintenance	200	17,463,140	17,263	17,463
2037	Maintenance	200	17,463,161	17,263	17,463
2038	Maintenance	200	17,463,161	17,263	17,463
2039	Maintenance	200	17,463,161	17,263	17,463
2040	Maintenance	200	17,463,161	17,263	17,463
2041	Maintenance	200	17,463,161	17,263	17,463
2042	Maintenance	200	17,463,161	17,263	17,463
2043	Maintenance	200	17,463,161	17,263	17,463
2044	Maintenance	200	17,463,161	17,263	17,463
Undiscounted total values		17,083	403,458,262	386,375	403,456
Present values (in base year @ 3%)		13,319	215,638,236	202,319	215,638
Net present cost per DALY saved		0.1			
Benefit-cost ratio (present values)			16,190		
Internal rate of return				30.8%	
Average annual cost (undiscounted)		517.7			

Note: DALYs are generated annually in direct proportion to the quantity of HPVAHIB produced and consumed in both regions, and as the difference between the baseline and endline scenarios.

Source: IFPRI calculations.

TABLE 21

Comparative analysis of alternative HPVAHIB packages and scenarios comparing cost-effectiveness, B/C ratio and IRR

#	Package/ banana type	Increase in content %		Net present cost per DALY saved (US$)	Benefit-cost ratio (present values)	Internal rate of return (%)	Total cost (undis-counted x10^6)	Total cost (present value x10^6)	Total DALY saved (present value x10^6)
		Vitamin A	Iron						
1	A.1/cooking banana only	400%	0%	62	16.2	30.8%	17.1	13.3	251,638
2	A.1/cooking banana only	600%	0%	50	20.1	33.6%	17.1	13.3	267,309
3	B.2/cooking banana only	400%	300%	70	14.4	30.0%	22.7	17.7	254,919
4	B.2/cooking banana only	600%	400%	55	18.1	32.9%	22.7	17.7	320,433
5	C.3/cooking and sweet banana	400%	300%	77	13.0	29.2%	25.3	19.7	256,897
6	C.3/cooking and sweet banana	600%	400%	61	16.4	32.2%	25.3	19.7	323,267

Source: IFPRI calculations.

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CASE STUDY 7

Probabilistic risk analysis

Conceptual section

Scope of the note

This section offers guidance on how to integrate probabilistic risk analysis into project economic and financial analysis. The main limitation of methodologies of deterministic sensitivity analysis (i.e. without randomness) and switching values – as described in volume 2 of these guidelines – is their lack of consideration of the *probability* of the occurrence of, and possible *correlation* between, the uncertain variables of a cost-benefit model. Risk analysis, when performed under a stochastic setting (i.e. probabilistic), has the advantage of overcoming these shortcomings and offers a probabilistic framework in which different possible project scenarios can be assessed and their potential benefits quantified. Simple methods, requiring minimum time[1] and expertise in statistics and probabilities, together with user-friendly software, are available for modelling risk. In practice, quantitative risk analysis complements the scope of qualitative risk assessment and classic EFA by providing a more thorough understanding of project dynamics and uncertainties. The insights gained through quantitative risk analysis may be useful for project design, implementation and ex post evaluation.

Rationale for risk analysis

Uncertainty about price volatility (e.g. resulting in the 2008 food price crisis) and adverse weather events (e.g. droughts in the Horn of Africa and the Sahel in 2011) highlight the need to pay more attention to risks in agriculture. A satisfactory return on investment in agriculture is subject to a number of these risks. Thus they should be assessed at all steps of the project cycle, and risk analysis should inform decision-making, both when it is a 'go ahead' or 'don't go ahead' choice and when it is a matter of choosing between alternative design options.

TABLE 1

Qualitative risk analysis

Risk category	Risks
Project stakeholders	▶ Donor relations, borrower relations, general public perception risk
Operating environment	▶ Country risks (enabling environment, systemic fraud and corruption, fiduciary management, civil society capacity, politics and governance, security) and institutional risks (ownership and commitment, accountability and oversight, institutional capacity)
Implementing agency	▶ Governance risks (decision-making, behaviour and norms, accountability and oversight, ownership), capacity risks (resources, processes) and fraud and corruption risks (prevalence of fraud and corruption, transparency and controls)
Project risks	▶ Design risks (technical complexity, scope/coverage complexity, arrangement complexity, design flexibility), safeguards risks (environmental and social), programme and donor risks (programme dependencies, donor collaboration, donor delivery) and delivery quality risks (sustainability, measurability, contract management)

Source: ORAF, World Bank.

1 A few hours (less than one working day) is generally needed to prepare a risk-based EFA if the software is known by the consultant.

Qualitative risk assessment

The World Bank has developed a qualitative risk assessment framework to assess its operations ex ante, as have many other IFIs. The Systematic Operations Risk-Rating Tool (SORT) considers eight risk categories: political and governance, macroeconomic, sector strategies and policies, technical design of the project, institutional capacity, fiduciary, environmental and social risks, and stakeholders. In a more synthetic way, the former Operational Risk Assessment Framework (ORAF) reckoned project stakeholder, operating environment, implementing agency and project risks as the four most common risks to be considered when designing a project[2] (table 1). These risks must be complemented by those related to climate that affect productivity, natural resources and infrastructure.

Quantifying all these intangible risks and assessing their impact on the return on investment is very difficult. A suggested practice is to assess the impact of project risks for which it is possible *to assume numeric projection values about the future and/or make probability estimations*. Typical factors found in agriculture and rural development projects subject to risk analysis are summarized in table 2.

Quantitative risk assessment

This type of risk analysis aids response to the following questions: "How likely is the project to achieve the expected results (or the best possible returns), and if it does not, by which probability is it likely to over- or underperform? How does this change if we adapt the project design?" When performed through a random sampling experiment (usually the Monte Carlo method), risk analysis helps with these questions. Requiring only a basic knowledge of statistics and one of the available, user-friendly software products (such as @RISK, Risk Solver or Crystal Ball), risk analysis is a concrete and time-efficient tool that can enhance the quality of EFAs. The analysis considers the following question: "If we had the possibility of running the calculation of the project's IRR and NPV 100, 500, 1,000 or 10,000 times, with random changes in the value of key project variables (e.g. yields, prices, etc.), what would be the distribution, mean value and standard deviation of project IRR and NPV?"

Methodology

The methodology for preparing an EFA with a probabilistic risk analysis is well detailed in the literature, for example the *Handbook for Integrating*

TABLE 2

Typical factors found in agriculture projects subject to risk analysis

Sector	Factors affecting estimates of economic outcomes
Rainfed agriculture	▶ Yields, due to the negative effects of climate change (more frequent droughts, rain failures, adverse weather events)
Irrigation and rural development	▶ Cost overruns, implementation delays, untested technologies, cropping intensities, poor water management ▶ Water availability due to extreme weather events
Livestock	▶ Animal mortality rates, parturition rates, offtake rates, price trends
Rural finance	▶ Repayment rates, debt amnesties, rates of interest, government commitment
Fisheries	▶ Price trends, numbers of vessels, fish stock composition
Industrial crops	▶ Yields (impacted by adverse weather events) and prices, cost overruns, mill capacity and throughput
Health and education	▶ Morbidity and mortality levels, cost of services (participation rates and demand)
Transport	▶ Implementation delays, cost overruns, traffic flows, savings in vehicle operating costs (VOC) and passenger travel time costs (TTC)

Source: Extracted and adapted from AsDB 2002.

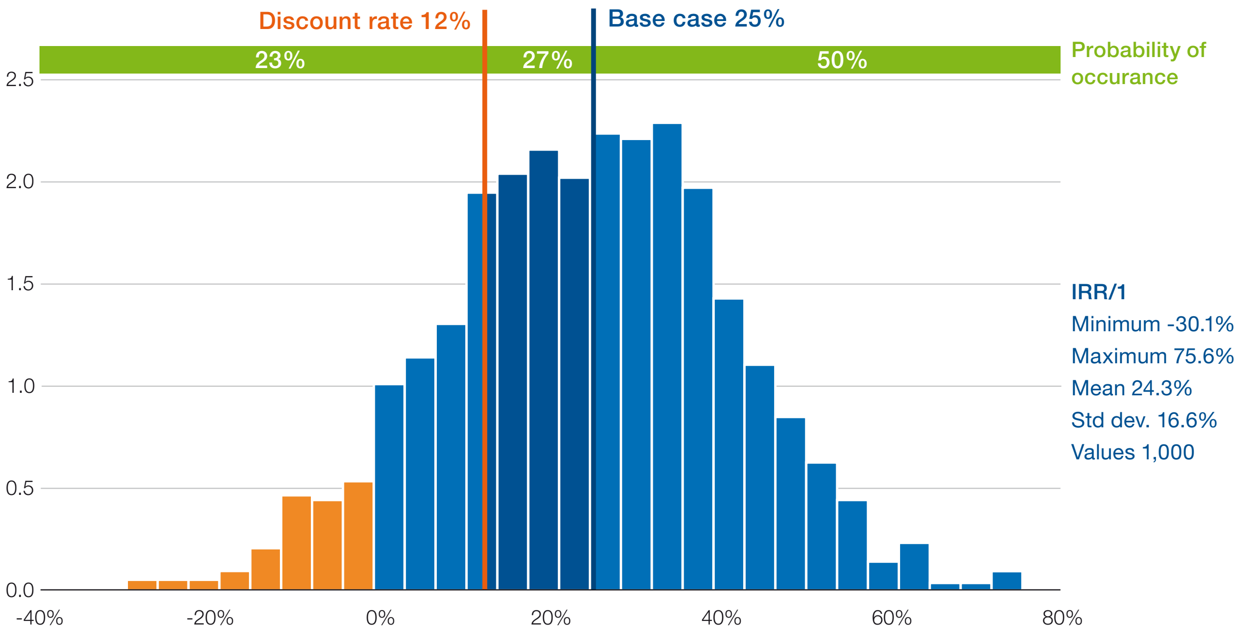
2 Extracted from the World Bank guidelines for preparing the former Operational and Risk Analysis Framework. http://siteresources.worldbank.org/EXTGOVANTICORR/Resources/30358631285875404494/100501_QRC_ORAF_FM.pdf

Risk Analysis in the Economic Analysis of Projects (AsDB 2002). Risk analysis software developers offer online tutorials, webinars and ready-to-use templates (see the links in the bibliography). The methodological steps consist in:

- *Step 1. Preparing an EFA following recommendations provided in volumes 1 and 2 of these guidelines.* Stages to observe are: (i) calculation of project IRR and NPV; (ii) identification of the most uncertain variables of EFA (table 1); and (iii) preparation of the sensitivity analysis (calculation of IRR and NPV by varying singularly, either 'optimistically' or 'pessimistically', the most critical variables of the project) and calculation of the switching values.[3]
- *Step 2. Undertaking risk analysis with a risk-modelling programme.* Use of the risk analysis programme requires formatted Excel spreadsheets in which highly sensitive parameters can be tested. In using the software, key steps to follow are: (i) specification of probability distributions (normal/Gaussian,[4] uniform discrete, triangular, etc.) that the software asks the user to define for the important sources of project uncertainty;[5] (ii) set-up of correlations among these factors (e.g. between input prices and crop price); and (iii) running the simulation through a Monte Carlo methodology. During the simulation, the programme will randomly generate scenarios (either 100, 500, 1,000 or 10,000 iterations, according to the user's choice) following the probability distributions for uncertain input factors and will recalculate the IRR and NPV (100, 500, 1,000 or 10,000 IRRs/NPVs can be calculated).
- *Step 3. Interpreting results.* The main output of the risk analysis (figure 1) is a distribution graph (in the form of a probability density chart or a relative frequency histogram)[6] that plots the

FIGURE 1

@RISK output: probability density chart of IRR for a fictive project



3 According to the definition provided in volume 1 of these guidelines, the 'switching value' is defined as: the maximum reduction in benefits and increase in costs that would result in an NPV equal to zero.

4 More widely known as the 'bell-curve' distribution.

5 The design of distribution curves (i.e. choosing the standard deviation, mean, max. or min. values, etc.) is based on historical data, the opinion of project experts, the analyst's own subjective estimations about the future, etc.

6 Depending on the user's selection. See Figure 6 for an histogram example.

probability of ERR or NPV (and their average value). The obtained distribution, mean value and deviations will then be used to quantify how likely the project will be to not achieve its intended economic results. An example of results, as given by the @RISK software for a fictive project, is provided in figure 1. In this example, generated by our Monte Carlo simulation, the mean ERR will be 24.29 per cent (as shown in the quick statistics box), and it will certainly fall between 12 and 25 per cent with 27.6 probability of occurrence[7].

How to use the results of the analysis?

Risk analysis significantly strengthens the robustness of EFA, but the absence of reliable data cannot be substituted for by risk analysis. Particular caution is needed when choosing and configuring distribution functions. Wrong assumptions can generate bias in results and make the risk-based exercise a profitless effort. When data are unavailable to set a probability density function, the analyst can follow the advice of Belli and Anderson (2013): (i) to use, as default, triangular distributions (see example 2); and (ii) to conduct a sensitivity analysis to test the robustness of findings with various probability distributions.

The results of EFA are particularly critical at the design stage. While it should already be done at the identification/project concept stage, quantitative risk analysis is most valuable during design, when sufficiently detailed information and data should be available. In other phases of the investment cycle, during implementation for example, it should be possible to rerun the EFA and the accompanying risk analysis and to adjust project focus and approaches accordingly. These results, which potentially take into account risks that were not identified at appraisal, can thus be used to improve project implementation.

7 Is an estimate of the degree of confidence one may have in the occurrence of an event, measured on a scale from zero (impossible) to 100 (certain).

Probabilistic risk analysis

EXAMPLE 1

Wool and Mohair Promotion Programme (WAMPP)

(Lesotho, IFAD, 2014)

Programme description

The goal of the WAMPP is to increase the economic and climate resilience of poor smallholder wool and mohair producers to adverse effects of climate change in the mountain and foothill regions of Lesotho. The programme development objectives are to: (i) enable smallholder livestock producers to generate higher incomes and more sustainable livelihoods; and (ii) increase their ability to cope with and recover from natural shocks. The programme will implement three technical components: (i) climate-smart rangeland management; (ii) improved livestock production and management; and (iii) wool and mohair processing and marketing.

Costs and benefits

The WAMPP is expected to lead to increased incomes for smallholder farmers, households and rural entrepreneurs. Such tangible benefits have been calculated through a standard CBA within an EFA, using illustrative models for sheep and goat rearing, shearing sheds, livestock breeding centres and early warning systems – representing the main activities of the programme. All financial and economic costs were extracted from the Costab database developed during programme preparation.

Methodology

Programme and activity NPVs and IRRs were calculated using the recommended methodology described in volumes 1 and 2 of these guidelines. In addition, the EFA included a probabilistic risk analysis, carried out with the Oracle Crystal Ball software. Risk analysis accounted for uncertainty concerning programme variables and aimed to measure variations due to unforeseen factors. Each EFA model was tested through a Monte Carlo random sampling simulation to verify the robustness and sensitivity of the models' assumptions (i.e. yields, price levels and random risks such as weather events). One important feature of this approach is the association of a probability distribution to each variable considering its specific nature: (i) quantities (yields) were combined with Gaussian functions; (ii) prices and costs were mainly associated with triangular, lognormal or beta distributions; and (iii) weather events considered beta and beta-PERT functions.

The selection of a probability distribution for each variable is substantially simplified when historical data are available (e.g. prices or production quantities over past years). Crystal Ball, as with many other Monte Carlo simulation packages, will employ these data using the distribution-fitting features.[8] Thus the software will elaborate the data and find the best-fitting probability distribution, and at the same time determine correlations between variables. In the WAMPP, most programme probability functions on yields and prices were estimated through this procedure. Conversely, in the case of weather events, screening of statistics on natural hazards in Lesotho identified the frequency of the most likely circumstances over the minimum and maximum estimates. These data were then used as parameters of the beta and beta-PERT functions, which better suited natural hazard volatility.

Results

The overall EIRR of the WAMPP is estimated at 21 per cent for the base case. The NPV of the net benefit stream, discounted at 10 per cent, is US$41.3 million. A Monte Carlo simulation was carried out on individual productive models and on the programme as a whole. Figures 2 and 3 present results of the NPV calculation and sensitivity analysis. After 3,000 trials, the software determined that the average value of the shearing shed NPV (609,000 Lesotho maloti [LSL]) was lower than the NPV originally calculated (M 870,000). Nonetheless, the simulation reports almost a 93 per cent probability of exceeding the zero NPV threshold. The software is also able to report those assumptions that concur the most with positive or negative NPV variations – information that programme managers should keep under close control (figure 3). For instance, animal sales have a significant positive impact on the model NPV, while animal acquisition costs will pull down NPV more than any other labour or operating cost.

A similar procedure has been followed in the sensitivity analysis of the programme as a whole (figure 4). Benefit streams of the WAMPP programme are associated with a minimum extreme function, while costs are linked to a triangular distribution. The results in figure 4 show that the programme remains economically viable after costs and benefits variations, and that mean values for both indicators diverge from the base case although remaining positive.

The EFA was tested for another scenario (figure 5) with a benefits underestimation (minimum extreme distribution) and a delay of two years in the implementation of production activities. Simultaneously, costs are overestimated (maximum extreme distribution). The profitability indicators drop significantly with respect to the baseline scenario of figure 4, presenting an average IRR of 15 per cent and an expected NPV of M 162,755. Notwithstanding this, the economic viability of the programme remains unaffected, preserving a positive NPV.

8 With a Chi-squared test.

FIGURE 2
NPV probabilistic profile of the shearing shed model

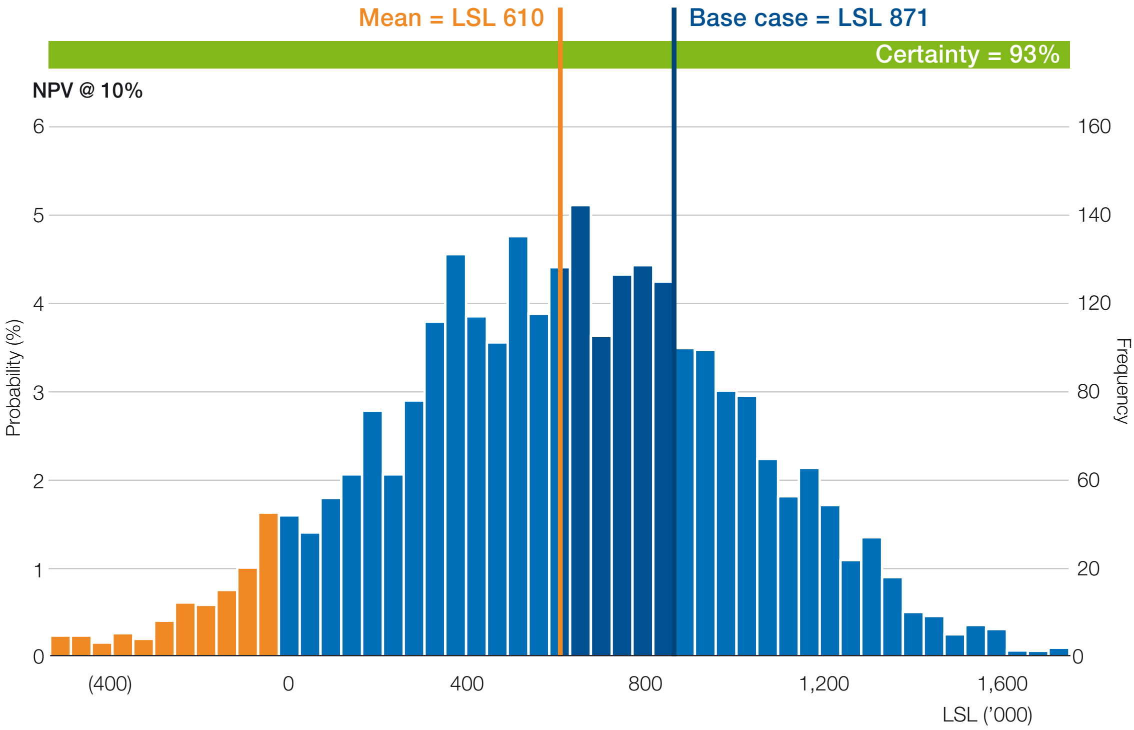
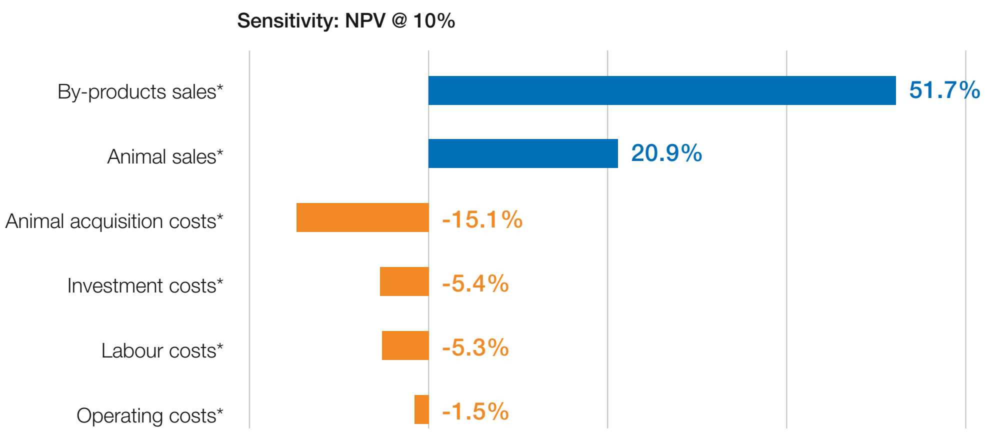


FIGURE 3
Sensitivity profile of the shearing shed model

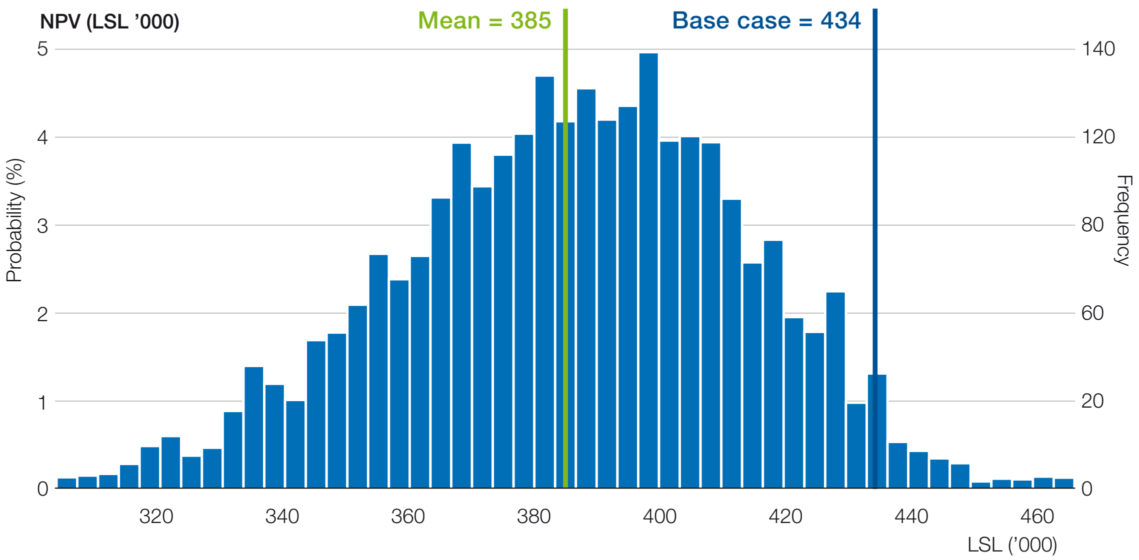


* Grouped assumptions.

FIGURE 4

Sensitivity analysis on the baseline of the WAMPP

Year	Total incremental benefits (LSL '000)	Incremental costs (LSL '000)	Cash flow (LSL '000)
1	0	21,554	-21,554
2	-10,628	33,078	-43,705
3	-26,300	32,573	-58,872
4	-39,209	36,823	-76,032
5	-46,370	32,840	-79,210
6	-44,946	22,472	-67,418
7	-20,295	13,180	-33,475
8	18,538	15,035	3,503
9	61,370	15,035	46,335
10	181,929	15,035	166,894
11	143,960	15,035	128,925
12	182,145	15,035	167,110
13	213,136	15,035	198,101
14	244,373	15,035	229,338
15	273,644	15,035	258,609
16	304,931	15,035	289,896
17	335,139	15,035	320,104
18	367,380	15,035	352,345
19	400,469	15,035	385,434
20	508,913	15,035	493,878
NPV @ 10% (LSL '000)		**433,679**	
NPV @ 10% (US$ '000)		**41,303**	
IRR		**21%**	



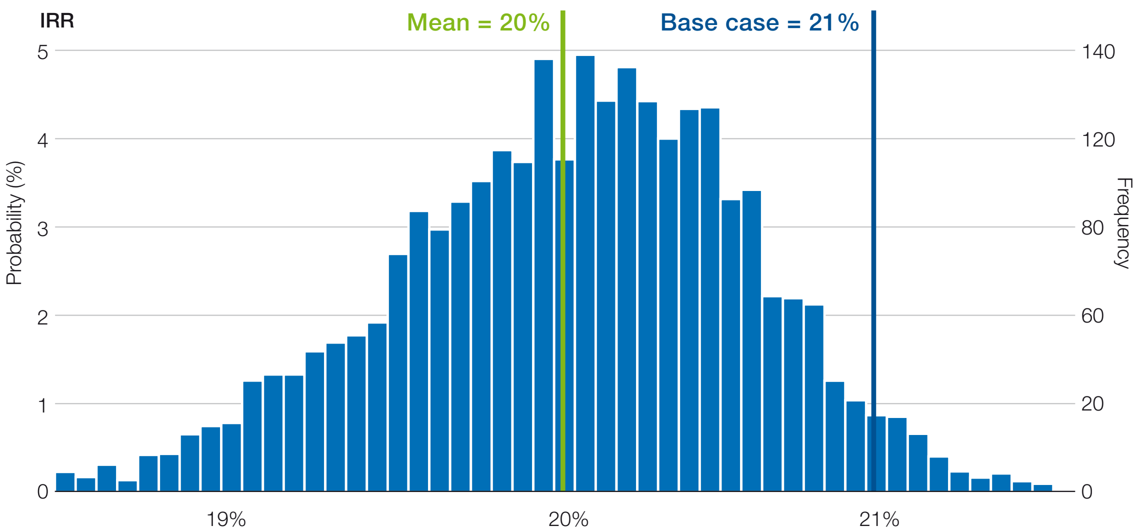
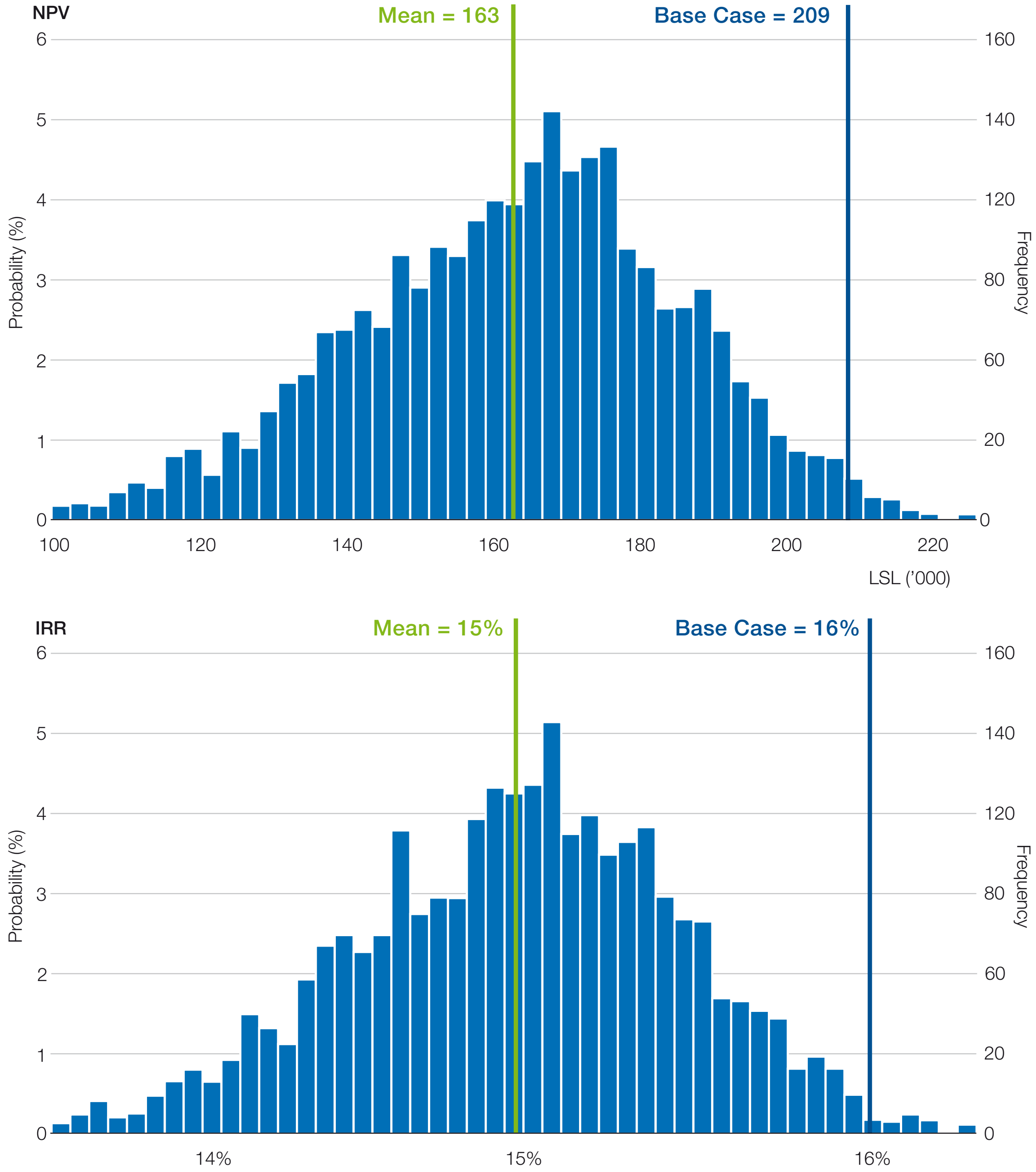


FIGURE 5

Sensitivity analysis on two-year delay and extreme costs and benefits variation



EXAMPLE 2

Agriculture Rehabilitation and Recovery Support Project (ARRSP)

(Democratic Republic of the Congo, World Bank, 2010-2016)

Project description

The development objective is to increase agricultural productivity and improve the marketing of crops and animal products by smallholder farmers in the Equateur Province and Kinshasa area (Pool Malebo) of the Democratic Republic of the Congo. The project is implemented through two investment components: (i) increased access to improved production, support to agro-industries and irrigation infrastructure improvement; and (ii) rural transport and market improvement. The primary beneficiaries of the project are smallholder farmers, while secondary beneficiaries include service providers active in the project areas (NGOs, small businesses, transporters, etc.), producers able to access improved seed from project participants and consumers.

Costs and benefits

Key quantifiable benefits of the ARRSP are: (i) increased yields (cassava, maize and rice) due to better planting materials, improved agronomic techniques, better extension services, rehabilitated irrigation infrastructure and adoption of improved seed and cassava cuttings; (ii) increased seasonal production of livestock due to dissemination of improved breeding stock, provision of veterinary services and use of improved animal feeding; and (iii) savings in VOC and increases in traffic due to road reopening. Although more indirect and more difficult to quantify, benefits are also expected to come from: (i) welfare at the household level, with decreasing poverty, malnutrition and food insecurity; and (ii) institutional benefits, such as improved efficiency of public services through capacity-building support to the Ministry of Agriculture and the Ministry of Rural Development. All economic costs were extracted from the Costab database developed during project preparation.

Methodology

The EFA used a standard CBA to calculate the project's IRR and NPV. In addition to performing a 'classic' sensitivity analysis (deterministic modelling), a probabilistic risk analysis was done using the @RISK software package. The selected variables subject to risk are: (i) prices for main crops (maize, rice and cassava); (ii) yield levels; (iii) road traffic; and (iv) project implementation delays. Assumptions for risk modelling are presented in table 3. Probability distributions (triangular) were specified for these

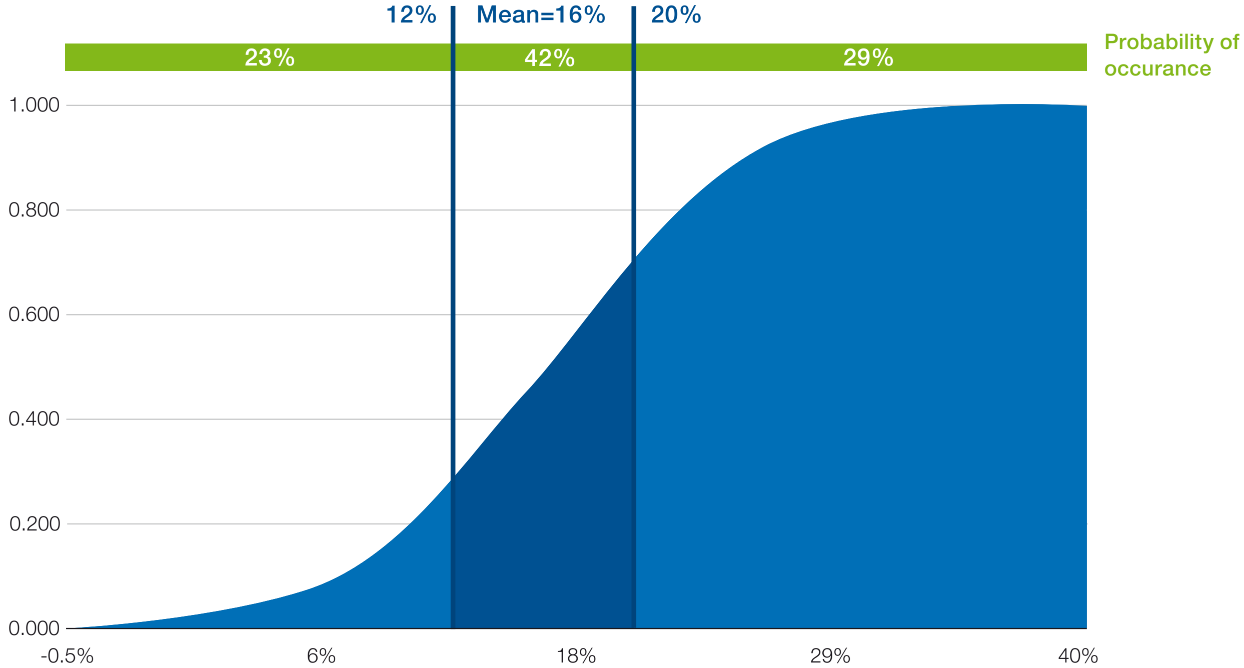
TABLE 3

Main assumptions of risk analysis

Distribution assumptions for uncertain variables under the ARRSP					
Risk variables	Original point value (baseline)	Type of substituted distribution	Change minimum value	Change most likely value	Change maximum value
Output price level (average)	100%	Triangular	-30%	-15%	+20%
Input price level (average)	100%	Triangular	-5%	+5%	+10%
Crop yield level (average)	100%	Triangular	-50%	0%	+10%
Traffic volume increase	6%	Triangular	-6%	0%	+3%
Cumulative benefits year 1	15%	Triangular	-15%	0%	+5%
Cumulative benefits year 2	25%	Triangular	-25%	0%	+5%
Cumulative benefits year 3	45%	Triangular	-30%	0%	+5%
Cumulative benefits year 4	60%	Triangular	-30%	0%	+5%
Cumulative benefits year 5	75%	Triangular	-30%	0%	+5%

FIGURE 6

Results of risk analysis: probability of ERR considering uncertainty for yields, prices, traffic and net benefit-stream phasing



uncertain variables. This probability distribution was chosen due to data scarcity.[9] Possible values for these variables were randomly sampled 1,000 times using a Monte Carlo simulation technique.

Results

Under the presented assumptions, average ERR is 31 per cent (base-case scenario assuming a 12 per cent country social discount rate). Corresponding NPV is positive and on the order of US$77 million for a 15-year project life cycle. Risk analysis showed that the project's returns are sensitive to several scenarios. Considering the uncertainty of key parameters, the stochastic model was used and demonstrated that, in the most likely scenario, ERR will be in the range of 12-20 per cent, with an overall probability of 42 per cent. However, there is a significant probability (29 per cent) that ERR could be below the 12 per cent threshold. While the most likely outcome is an acceptable ERR, the project appears sensitive to changes in price levels, actual yield improvements and, in particular, the phasing of net project benefits. The main output is a cumulative distribution function that plots the probability of ERR (figure 6).

9 Because this is a parametrically parsimonious probability distribution (i.e. a distribution that does not require much data to be defined), 'only' the mean, maximum and minimum values are needed to set the distribution.

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Web pages

Free trial version of @RISK is available at: www.palisade.com/trials.asp

Training modules (basic and advanced tutorials) on the @RISK website:

- Basic training: www.palisade.com/quickstart/en/risk/
- Guided tour of the software: www.palisade.com/GuidedTour/EN/RISK/
- Advanced webinars: www.palisade.com/risk/5/tips/en/gs/default.asp

Free trial version of Crystal Ball is available at: www.oracle.com/us/products/applications/crystalball/overview/index.html

Training modules (basic and advanced tutorials) on the Crystal Ball website: www.oracle.com/us/products/applications/crystalball/resources/index.html

Free trial version of Risk Solver is available at: www.solver.com/#tab3

Training modules on the Risk Solver website: www.solver.com/#Simulation_Tutorial

CASE STUDY 8

Rural finance

Conceptual section

Scope of the note

The present EFA guidance note, built on IFAD experience, aims to support economists, rural finance specialists and project design teams in analysing returns on rural finance investments. More particularly, this note illustrates consideration of benefits accruing to households and financial institutions, bearing in mind that IFAD rural finance projects have two key objectives: (i) facilitate access of poor rural people to rural financial services; and (ii) make this access sustainable.

Interventions

Development projects in rural finance aim to increase access to and use of financial services by smallholder farmers, their families and other off-farm rural small and microentrepreneurs. Financial services include medium-to-long-term and short-term productive loans, consumption loans, savings and longer-term deposits, insurance, money transfers and remittances. IFAD's interventions in rural finance mostly seek to enhance access by poor rural people to such services to improve livelihoods and to foster local economic development. IFAD's rural finance portfolio is comprised of stand-alone rural finance projects or broader projects that include a rural finance component. Interventions include, among others, client capability and institutional capacity development, wholesale financing mechanisms, financial sector support infrastructure, policy and legislation, regulation and supervision. At the micro level, the most common interventions include strengthening existing financial institutions, promoting community-based credit and savings mechanisms and matching grant schemes for public goods. At macro and meso levels, projects focus on strengthening rural financial system development.

Benefits

Benefits related to rural finance interventions can accrue at several levels. Empirical results are sometimes mixed and country specific. At the household level, access to formal rural financial services can enable target groups to: (i) increase and/or diversify their income through higher agricultural productivity, expansion of productive activities or enterprise creation;[1] (ii) accumulate assets including productive (land, equipment, livestock), non-productive (electricity, water, consumption goods)[2] and human assets (investment in health and education[3]); and (iii) smooth consumption and maintain their asset base in the case of shocks (resilience). At the individual level, intangible benefits such as women's empowerment can also occur, through greater control over resources and participation in decision-making at household and community levels. At the enterprise level, empirical evidence finds that project benefits mainly occur through: (i) higher financial performance, including higher revenues and fixed assets;[4] and (ii) job creation.[5] At the financial institution level, the main objective is to ensure

1 Alam (1988, p. 41) showed that microfinance clients allocate a higher percentage of their land to high-yielding varieties.

2 In Sri Lanka, Hulme, Montgomery and Bhattarchaya (1996) found that 82 per cent of clients increased their assets (running water, electricity, etc.).

3 In India, Chen and Snodgrass (2001) found evidence of improvement of boys' enrolment in secondary school.

4 In Peru, Dunn and Gordon (2001) found an additional US$1,000 in net revenue for the treatment group and US$500 in fixed assets for primary enterprises.

5 In the same study in Peru, it was estimated that one full-time job was created for every 2.3 loans outstanding.

that the system is sustainable in the long run, both commercially and institutionally. Specific indicators – including IFAD's Results and Impact Management System (RIMS) indicators – are integrated into the project's M&E system to capture financial performance, together with indicators related to sustainability (portfolio-at-risk, operational self-sufficiency, etc.). At the level of public finances, rural finance interventions can generate benefits in terms of: (i) incremental taxation revenues from financial institutions, productive activities and employees;[6] and (ii) additional inflows to the capital account through increased remittances as a result of lower transaction costs.[7]

TABLE 1

Main tangible and intangible benefits of rural finance interventions

Tangible benefits	Due to ...
Increased incomes	▶ increase in agricultural incomes: new and/or increased profitability of production through financing of inputs (chemicals, improved seed, labour), land acquisition, materials and equipment, etc. – case study 2 ▶ increase in incomes from micro, small and medium enterprises (MSME) or income-generating activities: newly created or expanded through access to working capital or investment – case studies 1 and 2
Increased assets and avoided asset loss	▶ increase in assets through access to credit and/or savings ▶ avoided asset loss through access to emergency loans, savings or insurance to cope with shocks – preventing 'decapitalization'
Increased lifetime earnings	▶ increase in health and education expenditures, through access to loans or savings, to complete education and access to employment opportunities in other sectors (income differential)* – case study 2
Reduction of financial services expenditures	▶ reduced opportunity costs of financial products through new technology applications, mobile phone services, agent banking schemes, etc. (compared with moneylenders) ▶ access time: increased proximity to access services
Job creation	▶ employment generated by the expansion of on- and off-farm activities, including self-employment
Increased financial institution self-sustainability	▶ operational self-sufficiency of financial institutions – case study 2
Increased public taxation revenues	▶ fiscal impact due to increased volume of taxable production and income (for formal activities), increased volume of financial services and new formal employment

Intangible benefits	Due to ...
Increased consumption smoothing	▶ access to emergency loans or savings to cope with external shocks
Increased human capital investments	▶ cognitive development through nutrition-sensitive production, awareness-raising and education, improved school attendance and health status (access to cash lump sums for health care or school fees)
Increased social capital	▶ greater participation in community-based organizational and decision-making meetings and in elections; greater network density, etc.
Gender empowerment	▶ more balanced decision-making In domestic and social spheres – within the household and in the community
Macroeconomic	▶ improved stability of the financial sector and facilitated access to capital, which leads to greater robustness of the private sector and contributes to economic growth ▶ capital inflows into the national capital account through remittances

* Nutrition status can also be improved due to higher expenses in food and health (see the note on 'Nutrition').

6 There is evidence of higher formalization of entrepreneurs accessing formal financial services (Dunn and Gordon, 2001)

7 Gibson, McKenzie and Rohorua (2006) estimated that a 10 per cent reduction in costs would increase remittances by 2 per cent.

Methodologies and tools

In many cases, benefits stemming from rural finance interventions are not directly valued for IFAD's and other donor-supported projects. This is mainly because: (i) the project often provides financing (credit lines, guarantee schemes, matching grants[8]) through a demand-based approach, so activities to be financed cannot be easily pre-identified; and (ii) rural finance interventions generally complement agricultural development and off-farm business activities. Thus benefits are often indirectly captured within the production models.[9]

IFAD's main objective when including rural finance in a project is to ensure sustainable access to financial services by poor rural people. It can do so through targeting IFAD project beneficiaries or targeting financial institutions. The ideal approach would be a combined approach, but this is not always the case. EFA can be a powerful tool in shaping the type of financial services needed (credits, insurance, savings schemes) through a financing sustainability analysis (liquidity cash-flow analysis) and, at the same time, highlighting the importance of making these services sustainable and identifying the type of support local institutions may need. When conducting financing analyses, all sources of cash at the household level should be considered, including off-farm incomes, rural wages and remittances.

In that vein, financial analysis is a key step for rural finance projects. The objectives are two-fold:

(i) From an end-user's perspective (rural household, farmer groups, enterprise), financial cash-flow analysis should indicate the affordability of financial services and tools for target groups – through financial analysis of productive activities, before and after financing, and credit analysis taking into account overall household cash flows; and

(ii) From a financial institution's perspective, financial analysis aims at analysing the sustainability of the institution through the establishment of profit and loss statements, as well as balance sheets.

For the overall project's financial and economic analysis, two methodologies are commonly used depending on the resources and data available at the project design stage. The first methodology (see example 1) focuses on the increase in agricultural and MSME incomes. The steps include:

- *Step 1.* Identifying and undertaking financial analysis of typical economic activities (by type and/or financing needs) that may be financed through rural financial services, based on the main investment options in the project areas and previous experiences;
- *Step 2.* Aggregation of benefits based on phasing and repartition of loans by type/size of activity; and
- *Step 3.* Application of a failure rate obtained from observed failure rates for similar loans in the country (the source of information should be specified by the analyst).

The second methodology focuses on the increase in revenues of the financial institutions (example 2). It consists of three steps:

- *Step 1.* Calculation of the average return by type of activity financed for each financial institution;
- *Step 2.* Aggregation of incremental benefits based on the phasing of loan volumes; and
- *Step 3.* Application of a loan failure rate reflecting investment failure for end-users and/or financial institution failure (here again, the source of information should be specified by the analyst).

Benefits related to increases in lifetime earnings (see example 2) and employment creation are estimated using incremental economic revenues and incremental jobs directly generated through the project.

8 A matching grant is a one-off, non-reimbursable transfer to project beneficiaries. It is based on a specific project rationale for particular purposes and on the condition that the recipient makes a specified contribution for the same purpose or subproject. Matching contributions can be either in cash or in kind, or a combination of both. They may or may not be provided together with other financial services, such as loans, or belinked to them. As one-off transfers, matching grants differ from permanent public transfers, such as subsidies for inputs and services (e.g. fertilizer or interest rate subsidies) or safety nets (e.g. cash transfers, food for work).

9 One usual assumption of production models is that improved access to financial services results in farmers investing in improved seed, chemical inputs or technologies, whereas existing market conditions or self-financing capacities may limit such investments.

BOX 1

Key methodological issues when performing EFA for rural finance interventions

Assumptions on benefits. When identifying benefits, EFA should provide a strong rationale for expected benefits based on existing literature and empirical results, preferably country-specific, and especially for average return on investment for productive activities financed through loans, and loan failure and dropout rates.

Double-counting. In projects where rural finance is a complementary intervention, most benefits are usually indirectly included in farm and MSME/income-generating models. Matching grants should also be deducted from total project costs (as contained in Costab) if they are included in individual models (see case study 1). This important issue, leading often to mistakes, is discussed in volumes 1 and 2 of these guidelines.

Loan failure/dropout/success rates. Not all productive investments financed through rural finance interventions will be successful. Loan failure rates and/or dropout rates should be applied for each type of investment so as not to overestimate benefits (see case studies 1 and 2). They mainly refer to the unsuccessful short-term use and long-term profitability and survival of productive activities. From the farmer's perspective, EFA must assess the risks of taking out a loan, while the financing institution must calibrate the interest levels vis-à-vis its operating costs.

Sensitivity analysis. In projects where generic models are built for the main economic activities or average profits estimated, sensitivity analysis should be conducted (on specific variables such as loan failure rates, dropout/success rates, etc.)

Credit risk analysis. As part of financial analysis at the client level, this analysis is even more relevant to rural finance projects to ensure that the cash revenues generated by these activities are adequate for loan repayment, without undue financial hardship. A best practice is to conduct cash-flow analysis at the household level, covering most incomes and expenses, in order to analyse repayment capacity.

Fiscal impact is sometimes used as a proxy for the overall project's economic impact on society. Fiscal analysis is not common practice in IFAD-supported projects (from IFAD's perspective, development impact is more important than fiscal impact). But when quantifiable benefits are difficult to measure – rendering a traditional economic analysis difficult – analysis of fiscal impact may provide an indication of overall project impact on government revenues. Analysing fiscal impact could provide an idea of how these actions will affect public resources, but does little to inform project design.

BOX 2

Fiscal impact of a project

Fiscal impact analysis of a project is conducted in parallel with economic analysis and complements it.

Estimating government fiscal revenues from the project. Calculating fiscal revenues from a project means assessing incremental short-to-long-term tax and duties revenues generated for central and local governments through project interventions. From a government's perspective, it is relevant to estimate these fiscal revenues, especially in countries where central and local governments are financially constrained. The first step is to identify the various taxes occurring at central and decentralized levels and the economic activities that will generate additional taxes as a result of the project. Activities likely to be subject to taxes are transactions of goods and services (VAT, duties, etc.) and jobs (income taxes, etc.). Many IFAD projects work with the informal sector and with economic agents that are not paying taxes, so both theoretical and actual incremental tax revenues can be estimated. The project itself sometimes pays taxes and duties and these can be included. The second step is to aggregate and phase these benefits.

Estimating project net fiscal impact. As stated by Belli and Anderson (2013), "with the exception of lump-sum taxes, all taxes impose a cost to society that exceeds the amount of funds actually raised and used." Analysis of the net fiscal impact of a project aims to estimate if the project is a net user or a net provider of public funds. A project is a net user of funds if "the total cost of taxation to society is greater than the amount of funds actually raised and used". In addition to the fiscal revenues estimated above, an analysis of net fiscal impact takes into account government expenditures related to the project. Expenditures mainly relate to the cost of borrowing when the project is financed through a loan (debt service).

Rural finance

EXAMPLE 1

Rural Enterprises and Remittances Project

(Nepal, IFAD, 2014)

Project description

The development objective is that viable rural micro and small enterprises (RMSEs), in both on- and off-farm sectors, provide sustainable sources of income to poor households, migrant families and returnees. Component 1 focuses on business development services and skills development. Rural finance interventions feature in component 2, which aims to support access to financial services by RMSEs, migrants and remittance recipient households. Rural finance activities develop innovative financial instruments such as: a risk-sharing scheme to address RMSEs' lack of collateral; a performance-based matching grant scheme for family and microenterprises with insufficient cash flow for borrowing money in the initial stages of microenterprise development; and a savings-linked credit scheme particularly targeting migrants. Capacity-building is provided to financial institutions in the target districts, and in particular to savings and credit cooperatives, to deliver responsive services to the target population. The project improves financial institutions' outreach in target districts by cofinancing investment in innovative ways of reaching rural populations. It also supports creation of a multi-stakeholder working group to propose measures for integrating remittances into the formal financial sector and for developing financial services adapted to migrants' needs.

Costs and benefits

Benefits identified for EFA are not specific to financial services access, but rather result from overall project interventions. They would accrue from: (i) enterprise creation and expansion; (ii) increased employability of vocational trainees and apprentices, coupled with job placement services; (iii) greater labour demand from project-supported enterprises; (iv) enhanced access to finance; (v) better access to markets; and (vi) access to affordable and reliable power supplies. Benefits not included in EFA would derive from: (i) productive use of remittances – by migrants, returnees and remittance recipient households – that can provide an alternative to foreign employment; and (ii) incremental tax revenues resulting from a greater number of registered enterprises and an increased volume of taxable production. Total economic costs of the project have been estimated at US$45.5 million. Matching grants (both project and beneficiary contributions) have been deducted from the overall costs, as they were captured in the financial models.

Methodology

The EFA was conducted following these steps: (i) financial analysis of various enterprise models (table 2), including estimation of incremental net benefits, and conversion into economic prices in accordance with the recommendations in volume 2 of these guidelines; (ii) phasing of total number of enterprises throughout the life of the project; and (iii) aggregation of total incremental benefits for each type of enterprise, taking into account a failure rate based on actual business start-ups, a phasing for incremental benefits and a long-term business success rate (table 3). To avoid double-counting, benefits from vocational training, apprenticeships and infrastructure works have been excluded from the overall benefits stream.

Results

The ERR was estimated at 26 per cent in the base-case scenario for an NPV of US$37.7 million, discounted at 12 per cent over 20 years (table 4). A sensitivity analysis was conducted to assess the effect of variations in benefits and costs (up to a 30 per cent cost increase or benefit decrease) and for various lags in the realization of benefits (table 5). All scenarios generated IRRs above 19 per cent and positive NPVs.

TABLE 2

Rural Enterprises and Remittances Project – enterprise models and incremental benefits (economic prices)

Enterprise type	Activity	Investments in NRs: Investment	IFAD	Benef.	MFIs loan	Annual net benefits* in NRs: WOP	WP	Increm.	Incremental net benefits per NRs of investment
New – farm	Off-season vegetable production	394	110	44	240	0	257	257	0.7
New – off-farm	Communications shop	1,434	110	44	1,280	0	271	271	0.2
New – farm	Fish farming	12,088	330	220	9,890	0	5,179	5,179	0.4
New – off-farm	Bakery	6,549	330	4,426	1,793	0	772	772	0.1
Expansion – farm	Cardamom production	382	88	44	251	956	1,323	367	1.0
Expansion – off-farm	Pottery workshop	631	88	44	499	234	1,027	792	1.3
Expansion – farm	Ginger processing	4,398	440	440	3,519	2,712	4,130	1,418	0.3
Expansion – off-farm	Sweets production	1,759	440	440	880	3,757	4,447	691	0.4
Voc. training	Carpentry workshop	4,514	-	1,978	2,536	0	3,770	3,770	0.8
								(1)	(2)

* At full development.

Note: NR = Nepalese rupee. MFI = microfinance institution.

TABLE 3

Rural Enterprises and Remittances Project – aggregation and phasing of benefits (economic prices)

Direct beneficiaries		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Total	
New enterprises type A – farm		0	1,703	3,747	5,450	3,747	1,703	0	16,350	
New enterprises type A – off-farm		0	1,703	3,747	5,450	3,747	1,703	0	16,350	
New enterprises type B – farm		0	380	837	1,217	837	380	0	3,650	
New enterprises type B – off-farm		0	380	837	1,217	837	380	0	3,650	
Existing enterprises type A – farm		0	745	1,639	2,384	1,639	745	0	7,151	(3)
Existing enterprises type A – off-farm		0	745	1,639	2,384	1,639	745	0	7,151	
Existing enterprises type B – farm		0	167	367	534	367	167	0	1,600	
Existing enterprises type B – off-farm		0	167	367	534	367	167	0	1,600	
Total		**0**	**5,989**	**13,177**	**19,167**	**13,177**	**5,989**	**0**	**57,499**	
Failure rate	53%	(A)								

Incremental benefits		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8-20	
Phasing of incremental benefits	(B)	50%	75%	100%	100%	100%	100%	100%	100%	
New enterprises type A – farm year 1				115,949	255,114	371,063	255,114	115,949		(4) = (1)*(B)*(3)*(A)
Year 2					173,923	382,671	556,594	382,671	173,923	
Year 3						231,897	510,228	742,125	510,228	
Year 4							231,897	510,228	742,125	
Year 5								231,897	510,228	
Year 6									231,897	
Year 7-20										
Subtotal Year 1-20				115,949	429,037	985,631	1,299,969	1,982,870	2,226,376	Same logic as above
New enterprises type A – off-farm					122,129	451,907	1,038,170	1,369,211	2,088,568	
New enterprises type B – farm				521,484	1,930,176	4,434,327	5,848,419	8,921,145	10,016,603	
New enterprises type B – off-farm					77,726	287,689	660,929	871,886	1,329,682	
Existing enterprises type A – farm				72,429	267,938	615,524	811,835	1,238,268	1,390,344	
Existing enterprises type A – off-farm					156,408	578,604	1,329,205	1,752,628	2,673,998	
Existing enterprises type B – farm				62,547	231,498	532,023	702,583	1,070,338	1,201,724	
Existing enterprises type B – off-farm					30,478	112,805	259,244	342,405	521,555	
Total		**0**	**0**	**772,408**	**3,245,390**	**7,998,510**	**11,950,354**	**17,548,750**	**21,448,849**	(5) = sum (4)
Success rate	80%	(C)								
Total incremental net benefits		**0**	**0**	**617,926**	**2,596,312**	**6,398,808**	**9,560,283**	**14,039,000**	**17,159,079**	(6) = (5)*(C)

TABLE 4

Rural Enterprises and Remittances Project – economic analysis

(Thousands of United States dollars)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8-20
Project economic benefits (US$ '000) (6)	0	0	618	2,596	6,399	9,560	14,039	17,159
Project economic costs (US$ '000)	3,448	7,539	11,047	11,243	7,037	3,457	1,777	0
Total project incremental net benefits	**-3,448**	**-7,539**	**-10,429**	**-8,646**	**-638**	**6,103**	**12,262**	**17,159**

IRR	26%
NPV @ 12% (US$ '000)	37,754

	Appraisal value	Switching value	% change
NPV incremental benefits	83,424,139	45,669,797	-45%
NPV incremental investment cost	32,576,535	70,330,878	116%

TABLE 5

Rural Enterprises and Remittances Project – sensitivity analysis

	Base case	Costs increase			Increase of benefits		Decrease of benefits			Delay of benefits	
		+10%	+20%	+30%	+10%	+20%	-10%	-20%	- 30%	1 year	2 years
IRR	26%	24%	23%	21%	29%	31%	24%	22%	19%	22%	19%
NPV @ 12%	37,754,342	34,689,855	31,625,367	28,560,880	44,594,264	51,434,186	30,914,421	24,074,499	17,234,577	28,777,476	20,762,418

EXAMPLE 2

Financial Inclusion in Rural Areas Project

(Uganda, IFAD, 2013)

Project description

The development objective is to sustainably increase access to, and use of, financial services by the rural population in the target area. The first component aims to promote a dynamic and financially sound savings and credit cooperative (SACCO) system in Uganda, and the second supports expansion of community-based savings and credit groups (CSCGs), which provide access to financial services for poor rural communities. The third component promotes an enabling policy and institutional environment for community-based financial institutions.

Costs and benefits

Project benefits would derive mainly from expanded outreach through improved financial services and more diversified financial products in the target area. Benefits quantified in the EFA are: (i) productive investments, including crop and livestock production, as well as income-generating activities financed through CSCGs; (ii) education benefits, resulting from increases in lifetime earnings for those able to complete their education owing to savings and loans; and (iii) increased returns on SACCO portfolios. Other benefits were identified but not quantified:[1] (i) improved consumer protection related to financial services; (ii) incremental tax revenues as a result of increased volume of taxable income; (iii) improved consumption smoothing; and (iv) women's empowerment and improved diet. Economic costs have been included (investment costs, replacement of equipment and recurrent costs provided by Costab), as well as replacement costs during the remaining eight years of the 15-year period of analysis. For the period after project implementation, recurrent costs have been estimated at 4 per cent of implementation-period recurrent costs.

Methodology

- *Financial analysis*. This includes: (i) 10 illustrative production and trade models that estimate incremental net benefits (financing flows corresponding to loans have been subtracted to avoid double-counting); and (ii) income statements and balance sheets of CSCGs and SACCOs to assess their profitability and sustainability.
- *Economic analysis*. To estimate the benefit stream of CSCGs, the following steps were followed: (i) conversion of production and trade models into economic models – making use of economic prices – to obtain the average incremental economic income per type of activity financed (table 7); (ii) distribution of loans over the portfolio of CSCGs (table 6); (iii) aggregation and phasing of total incremental benefits based

Benefits	Costs
▶ Incremental benefits from CSCGs ▶ Incremental benefits from education ▶ Incremental benefits from SACCOs	▶ Investment costs: US$23 million for 7 years ▶ Replacement costs every 5 years: US$108,000 ▶ Recurrent costs: US$2.8 million for 7 years and 4 per cent applied after project implementation

1 These could all have been translated into higher success/ repayment and adoption rates.

on the number of CSCG beneficiaries following a gradual increase over seven years (table 8); and (iv) economic analysis of the CSCG intervention (table 9). The analysis captures direct benefits to the cooperatives of the target groups.

Benefits generated through SACCOs were calculated using another methodology: (i) hypothesis regarding the average profit rate for two types of SACCOs and average success rate (table 10); (ii) phasing of SACCOs by type, including dropout rate; (iii) calculation of net return generated per year for each type of SACCO based on the number of SACCOs, average loan size, incremental number of loans and average portfolio profit rate; and (iv) aggregation and phasing of incremental economic benefits from SACCOs based on phasing rate and success rate (table 11). The analysis highlights direct benefits to local groups in the target population.

Education benefits were quantified through an economic model using the following steps (table 12): (i) estimation of number of CSCG members borrowing money for education; (ii) estimation of net incremental benefit per person based on income differential, phasing and investment cost; and (iii) aggregation and phasing of total incremental benefits.

Results

Base-case NPV of the project was estimated at US$12.9 million, with an ERR of 15 per cent at a 10 per cent discount rate (table 13). A sensitivity analysis was conducted based on various scenarios with regard to cost and benefit streams (table 14). Economic viability of the project would be jeopardised only in the case of a 40 per cent decline in project benefits (negative NPV).

TABLE 6

Financial Inclusion in Rural Areas Project – number and phasing of CSCG members per type

			Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Total
Number and phasing of CSCGs										
Formation of new CSCGs	15,000	CSCGs	750	3,000	4,500	3,750	3,000			15,000
Graduation & linkage of existing CSCGs	3,000	CSCGs		600	600	600	600	600		3,000
Members covered										
Formation of new CSCGs	25	members	18,750	75,000	112,500	93,750	75,000			375,000
Graduation & linkage of existing CSCGs	25	members		15,000	15,000	15,000	15,000	15,000		75,000
Households covered*										
Formation of new CSCGs	0.8	HHs	15,000	60,000	90,000	75,000	60,000			300,000
Graduation & linkage of existing CSCGs	0.6	HHs		9,000	9,000	9,000	9,000	9,000		45,000
										345,000
Number of members in CSCGs	18,750		75,000	112,500	93,750	75,000	375,000			
* Deducting those benefiting twice	(1a)		(1b)	(1c)	(1d)	(1e)	(1f)			

	% of investment	Year 1	Year 2	Year 3	Year 4	Year 5	Total
	(2)	(3) = (1a)*(2)	(3) = (1b)*(2)	(3) = (1c)*(2)	(3) = (1d)*(2)	(3) = (1e)*(2)	(3) = (1f)*(2)
Agriculture	20%	3,750	15,000	22,500	18,750	15,000	75,000
Acquisition of new land	5%	938	3,750	5,625	4,688	3,750	18,750
Livestock	20%	3,750	15,000	22,500	18,750	15,000	75,000
Fish trading	5%	938	3,750	5,625	4,688	3,750	18,750
Second hand clothes	3%	563	2,250	3,375	2,813	2,250	11,250
Grocery stores	5%	938	3,750	5,625	4,688	3,750	18,750
Education expenditures	25%	4,688	18,750	28,125	23,438	18,750	93,750
Health	2%	375	1,500	2,250	1,875	1,500	7,500
Consumption	15%	2,813	11,250	16,875	14,063	11,250	56,250
Total	**100%**	**18,750**	**75,000**	**112,500**	**93,750**	**75,000**	**375,000**

TABLE 7

Financial Inclusion in Rural Areas Project – average incremental income per activity (economic prices)

Annual net benefits after financing (US$)	WOP	WP full devel.	Incremental	% invest.	Average increm. (US$)	
Groundnut land acquisition	20	48	28	5%	57	(4a)
Purchase land (maize, g/nut and cassava)	100	187	87	5%	51	(4b)
Improved seed maize	49	100	51	20%		
Milk cow model	0	34	34	20%	20	(4c)
Goat model	0	6	6	20%		
Sewing machine	6	22	16	5%	32	(4d)
Second hand clothes trading (Kenya)	0	48	48	3%		
Fish mongering	0	11	11	5%	11	(4e)

TABLE 8

Financial Inclusion in Rural Areas Project – phasing and aggregation of CSCG incremental benefits per activity

		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	
Agricultural members	(3)	3,750	15,000	22,500	18,750	15,000											
Incremental average annual income	(4b)	51															
Phasing of development	(5)	0%	10%	20%	30%	40%	60%	80%	100%	100%	100%	100%	100%	100%	100%	100%	
Incremental average income per year	(6) = (4b)*(5)	0	5	10	15	20	31	41	51	51	51	51	51	51	51	51	
	(3)																
Year 1	3,750	0	19,125	38,250	57,375	76,500	114,750	153,000	191,250	191,250	191,250	191,250	191,250	191,250	191,250	191,250	
Year 2	15,000		0	76,500	153,000	229,500	306,000	459,000	612,000	765,000	765,000	765,000	765,000	765,000	765,000	765,000	
Year 3	22,500			0	114,750	229,500	344,250	459,000	688,500	918,000	1,147,500	1,147,500	1,147,500	1,147,500	1,147,500	1,147,500	(7) = (3)*(6)
Year 4	18,750				0	95,625	191,250	286,875	382,500	573,750	765,000	956,250	956,250	956,250	956,250	956,250	
Year 5	15,000					0	76,500	153,000	229,500	306,000	459,000	612,000	765,000	765,000	765,000	765,000	
Total incremental benefits – agriculture	(7)	**0**	**19,125**	**114,750**	**325,125**	**631,125**	**1,032,750**	**1,510,875**	**2,103,750**	**2,754,000**	**3,327,750**	**3,672,000**	**3,825,000**	**3,825,000**	**3,825,000**	**3,825,000**	

TABLE 9

Financial Inclusion in Rural Areas Project – economic benefits of CSCGs

Economic analysis CSCGs		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Aggregated incremental benefits																
Agriculture	(7)		19,125	114,750	325,125	631,125	1,032,750	1,510,875	2,103,750	2,754,000	3,327,750	3,672,000	3,825,000	3,825,000	3,825,000	3,825,000
Acquisition of new land			26,860	112,814	231,000	376,046	526,465	762,837	1,031,442	1,074,418	1,074,418	1,074,418	1,074,418	1,074,418	1,074,418	1,074,418
Livestock			37,613	157,973	323,468	526,575	737,205	1,068,195	1,444,320	1,504,500	1,504,500	1,504,500	1,504,500	1,504,500	1,504,500	1,504,500
Fish mongering			15,497	65,087	121,909	185,963	206,625	206,625	206,625	206,625	206,625	206,625	206,625	206,625	206,625	206,625
Second hand clothes/sewing machine			45,000	189,000	354,000	540,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000
Total incremental benefits	(8)		144,095	639,623	1,355,501	2,259,709	3,103,045	4,148,532	5,386,137	6,139,543	6,713,293	7,057,543	7,210,543	7,210,543	7,210,543	7,210,543
Programme costs																
Investment costs		371,231	1,626,591	2,431,699	2,183,701	1,746,875	294,027	227,202								
Net economic benefits CSCGs		-371,231	-1,482,497	-1,792,076	-828,200	512,834	2,809,018	3,921,330	5,386,137	6,139,543	6,713,293	7,057,543	7,210,543	7,210,543	7,210,543	7,210,543
IRR		**44%**														

TABLE 10

Financial Inclusion in Rural Areas Project – distribution of loans across SACCOs and average profit rates

	Total no. of incremental loans	Average loan size (US$)	Distribution of new loans / Cumulative no. of loans: PY1 0%	PY2 10%	PY3 20%	PY4 35%	PY5 15%	PY6 10%	PY7 10%	Distribution of loans over portfolio: Agriculture	Trade	Other business	Education	Consump-tion	Total	Productive loans	Profit rate: Agriculture	Trade	Other business	Education	average	Rate of failure	
SACCOs type A	3,800	180	0	380	760	1,330	570	380	380	35%	30%	5%	15%	15%	100%	70%	39%	77%	40%	0%	39%	20%	
Average		174																			(A)		
SACCOs type B	200		0	20	40	70	30	20	20	35%	30%	5%	15%	15%	100%	70%	39%	77%	40%	0%	39%	20%	
Average		102																			(A)		
Total	**4,000**		**0**	**400**	**800**	**1,400**	**600**	**400**	**380**	**35%**	**30%**	**5%**	**15%**	**15%**	**100%**	**70%**					**Average success rate**	**80%**	(D)
																(C)							

TABLE 11

Financial Inclusion in Rural Areas Project – aggregation and phasing of SACCO benefits (economic prices)

Phasing SACCOs		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6-15	
Drop out rate of SACCOs*							10%	
SACCOs type A			20	40	40			
	Cumulative	0	20	60	100	100	90	(9a)
SACCOs type B			60	120	120			
	Cumulative	0	60	180	300	300	270	(9b)

* A dropout rate of 10% of all SACCOs supported by the end of year 5.

			Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7-15	
SACCO – type A										
No. supported				20	60	100	100	90	90	(9a)
Average loan size (US$)				180	200	220	230	240	240	(10)
Incremental no. of loans				7,600	45,600	133,000	57,000	57,000	57,000	(11)
Total volume of loans disbursed p.a. (US$)				1,368,000	9,120,000	29,260,000	13,110,000	13,680,000	13,680,000	(12) = (10)*(11)
Return on investment	(A)	39%		1,900,576	12,670,508	40,651,213	18,213,855	19,005,762	19,005,762	(13) = (12)*(A)
Net return generated (US$)				532,576	3,550,508	11,391,213	5,103,855	5,325,762	5,325,762	(14a) = (13) - (12)
SACCO – type B										
No. supported				60	180	300	300	270	270	(9b)
Average loan size (US$)				100	120	130	140	140	140	(10)
Incremental no. of loans				1,200	7,200	21,000	9,000	9,000	9,000	(11)
Total volume of loans disbursed p.a. (US$)				120,000	864,000	2,730,000	1,260,000	1,260,000	1,260,000	(12) = (10)*(11)
Return on investment	(A)	39%		166,717	1,200,364	3,792,817	1,750,531	1,750,531	1,750,531	(13) = (12)*(A)
Net return generated (US$)				46,717	336,364	1,062,817	490,531	490,531	490,531	(14b) = (13) - (12)
Total net return generated (US$)				**579,293**	**3,886,872**	**12,454,030**	**5,594,386**	**5,816,293**	**5,816,293**	(15) = (14a) + (14b)
Phasing and aggregation										
Phasing of SACCOs development			0%	20%	30%	40%	60%	75%	75%	(B)
Average share of productive loans		70%								(C)
Average success rate of loans		80%								(D)
Total benefit stream (US$)			**0**	**64,881**	**652,994**	**2,789,703**	**1,879,714**	**2,442,843**	**2,442,843**	(16) = (15)*(B)*(C)*(D)

TABLE 12

Financial Inclusion in Rural Areas Project – incremental education benefits (economic prices)

Education expeditures			Year 1	Year 2	Year 3	Year 4	Year 5	
Total CSCG members			15,000	60,000	90,000	75,000	60,000	(17)
CSCGs members borrowing money for education	(E)	25%	3,750	15,000	22,500	18,750	15,000	(18) = (17)*(E)

Education benefits per member (US$)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10-15	
Income differential phasing						10%	20%	40%	60%	60%	(19)
Investment costs	120.0	120.0	120.0	120.0	120.0						(20)
Revenues from income differential per person (US$)*						25.0	49.9	99.8	149.8	149.8	(21)
Total incremental benefits per person (US$)	**-120.0**	**-120.0**	**-120.0**	**-120.0**	**-120.0**	**25.0**	**49.9**	**99.8**	**149.8**	**149.8**	(22) = (21) - (20)

IRR 9%

Aggregated benefits (US$)	(18)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10-20	
Number of members year 1	3,750	-450,000	-450,000	-450,000	-450,000	-450,000	93,600	187,200	374,400	561,600	561,600	
2	15,000		-1,800,000	-1,800,000	-1,800,000	-1,800,000	-1,800,000	374,400	748,800	1,497,600	2,246,400	
3	22,500			-2,700,000	-2,700,000	-2,700,000	-2,700,000	-2,700,000	561,600	1,123,200	2,246,400	(23) = (18)*(22)
4	18,750				-2,250,000	-2,250,000	-2,250,000	-2,250,000	-2,250,000	468,000	936,000	
5	15,000					-1,800,000	-1,800,000	-1,800,000	-1,800,000	-1,800,000	374,400	
Total net economic benefits (US$)		**-450,000**	**-2,250,000**	**-4,950,000**	**-7,200,000**	**-9,000,000**	**-8,456,400**	**-6,188,400**	**-2,365,200**	**1,850,400**	**6,364,800**	(24) = sum (23)

IRR	5%
NPV @ 3%	US$6,917,338

* Based on the Employment and Earnings Survey by the Uganda Bureau of Statistics. Monthly income differential between those working in the agriculture sector compared to the median salary in other sectors.

TABLE 13

Financial Inclusion in Rural Areas Project – economic analysis

Economic analysis of the project (US$ '000)			PY1	PY2	PY3	PY4	PY5	PY6	PY7	PY8	PY9	PY10-15
Project economic benefits (US$ '000)												
Incremental benefits from CSCGs	(8)		0	144	640	1,356	2,260	3,103	4,148	5,386	6,140	6,713
Incremental benefits from SACCOs	(16)		0	65	653	2,790	1,880	2,443	2,443	2,443	2,443	2,443
Incremental benefits from education	(26)		-450	-2,250	-4,950	-7,200	-9,000	-8,456	-6,188	-2,365	1,850	6,365
Total project benefits			-450	-2,041	-3,657	-3,054	-4,860	-2,911	402	5,464	10,433	15,521
Project economic costs (US$ '000)												
Investment costs			2,004	4,991	6,287	5,687	3,371	441	261	0	0	0
Replacement of equipment			0	0	0	0	108		0	0	0	108
Recurrent costs			325	390	432	432	432	432	387	155	155	155
Total project costs			2,329	5,381	6,720	6,119	3,911	873	648	155	155	263
Total project incremental net benefits			**-2,779**	**-7,422**	**-10,377**	**-9,174**	**-8,772**	**-3,784**	**-246**	**5,309**	**10,278**	**15,257**
IRR			**15%**									
NPV @ 10% (US$ '000)			**12,862**									
Project benefit stream			-450	-2.041	-3.657	-3.054	-4.860	-2.911	402	5.464	10.433	15.521
	NPV @ 10%	32,401										
Project cost stream			2.329	5.381	6.720	6.119	3.911	873	648	155	155	263
	NPV @ 10%	19,539										
Project net incremental benefits			-2.779	-7.422	-10.377	-9.174	-8.772	-3.784	-246	5.309	10.278	15.257
	NPV @ 10%	12,862										

	Appraisal value	Switching values	% change
Incremental benefits	32,401	19,539	-40%
Incremental costs	19,539	6,678	66%

TABLE 14

Financial Inclusion in Rural Areas Project – sensitivity analysis

Sensitivity analysis (15-year period)	Base case	Costs increase			Increase of benefits		Decrease of benefits			Delay of benefits	
		+10%	+20%	+50%	+10%	+20%	-10%	-20%	-30%	1 year	2 years
IRR @ 10%	15%	14%	13%	11%	16%	17%	14%	13%	2%	14%	13%
NPV (US$ '000)	12,862	10,908	8,954	3,092	16,102	19,342	9,621	6,381	-9,819	9,916	7,238

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CASE STUDY 9

Rural roads

Conceptual section

Scope of the note

Built on an example from IFAD's experience, this note aims to support economists, rural infrastructure specialists and project design teams in analysing return on rural roads investments. It offers some methodological guidance on quantifying and including tangible benefits in analysis and on identifying intangible benefits – through general advice and a practical example from Bangladesh.

Interventions

Most donor-funded investment projects in the agriculture sector include a mix of interventions aiming at directly improving agricultural production and productivity. For most of these interventions, an EFA can be performed through a classic CBA, as the stream of annual costs and benefits is easily quantifiable. Projects can also include interventions whose effects indirectly result in productivity increases and other social and economic benefits. This is often the case for rural road construction and rehabilitation in remote areas, for which the streams of socio-economic benefits are generally difficult to quantify, and are thus sometimes omitted from a standard CBA.

Costs and benefits (table 1)

The main objective of rural roads investments is to address structural constraints such as poor accessibility of agricultural production basins and insufficient connectivity between secondary and main roads, as well as between production basins, villages and markets. Roads investments provide benefits to farmers, local communities and other users: (i) increased agricultural productivity and production (e.g. improved access to markets, inputs and extension services; increased cultivated land; introduction or expansion of higher-value crops; and reduced losses); (ii) increased volumes of marketed outputs (reduced post-harvest losses during transport); (iii) reduction in VOC; (iv) savings in TTC; (v) increased traffic flow and commerce along the roads, also resulting in employment opportunities; and (vi) broader socio-economic opportunities for the rural population (e.g. improved access to schools and health centres). Related direct costs of maintenance should also be considered in analyses, as well as indirect costs such as health and undesirable environmental impacts[1] (negative externalities).

Methodologies and tools

Depending on the availability of data on WOP traffic flows, type of traffic, transport costs, and agricultural production and marketing, the following methodologies can be used:

- *In areas where traffic flow information is available*, VOC and TTC approaches can be applied to both passenger and cargo traffic to calculate benefits. Those two benefits are generally directly attributable to rural roads investments. VOC are calculated by multiplying traffic volumes by vehicle transport cost savings. VOC methods are based on survey work and statistical analysis. TTC are measured by multiplying the time delay by the total TTC per minute. For rural roads where traffic flow is significant, it is advisable to use the Road Costs Knowledge System (ROCKS) and the Road Network Evaluation Tools (RONET) – tools developed by the World Bank to calculate construction, operational and maintenance costs (see box 2 in example 1). This case, gives an example of VOC in the context of an EFA performed for an IFAD-funded project in Bangladesh (union road model, table 3).

1 Some required mitigation measures must be included in initial investment costs. This is particularly relevant under the recent Social, Environmental and Climate Assessment Procedures (SECAP) approach in IFAD.

- *For estimation of other benefits as presented in table 1 – and in areas without sufficient traffic flow information* – additional parameters should be used as applicable. Some IFAD and World Bank cases have estimated benefits from road improvements in terms of: (i) increased volume of transported agricultural products from farm gate to markets (5-40 per cent);[2] (ii) reduced post-harvest losses due to improved road network quality and faster access to warehouses and sale points (10-50 per cent, depending on the type of commodity and remoteness of the area); (iii) increased producer prices; (iv) increased commerce along the roads; (v) increases in land areas under cultivation near the roads (2-5 per cent, depending on different IFAD and World Bank cases); and (vi) introduction/expansion of higher-value crops, which become financially viable.

To estimate the economic viability of rural roads investments (measured by IRR and NPV), annual cash-flow analyses should include annual economic outflows (i.e. total investment costs, including their physical contingencies, and annual operating costs during the lifetime of the road (period of analysis)). Sensitivity analysis should test the impact of changes in the main variables of the model (VOC, TTC, volumes of goods transported, traffic flows, etc., as well as increased costs of construction and maintenance) on project returns.

TABLE 1
Tangible and intangible benefits from investments in rural roads

Tangible benefits	Due to …
Savings in VOC and TTC	▶ reduced fuel, oil consumption, maintenance and repairs, tire wear and roadway-related vehicle depreciation ▶ reduced travel time of passengers in vehicle
Increased traffic (passenger and cargo)	▶ rehabilitation and construction of new roads, attracting new users ▶ improved road surfaces resistant to climatic conditions (e.g. rainy seasons)
Increased cultivated land/changed pattern of production	▶ improved access to markets – including introduction/expansion of higher-value crops (e.g. fruits, vegetables) that become financially viable
Increased agricultural productivity (crop and livestock)	▶ increased availability and reduced costs of inputs ▶ increased access to support services, including extension
Increased producer prices	▶ reduced transport costs ▶ higher quality of produce due to timely transportation and reduced quality losses during transport ▶ better access to markets
Increased volumes of transported products from farm gate to markets	▶ improved access of vehicles (light trucks, pick-ups, motorcycles) from/to the farm gate and from/to the market (primary, secondary or retail)
Reduced post-harvest losses (more particularly for perishable crops)	▶ faster access to warehouses and markets/sale points ▶ accessibility in all seasons ▶ improved road network quality

Intangible benefits	Due to …
Reduced market distortions and increased producer prices	▶ physical access to market information system (MIS) ▶ improved power relations between value chain actors ▶ more balanced relationship between farmers and traders, reduced monopsonistic power of brokers
Incremental employment opportunities	▶ temporary jobs created in civil works ▶ easier access to job opportunities close to/along roads ▶ increased petty commerce along roads
Improved human health	▶ easier access to health-care centres ▶ improved access to potable water, sanitation facilities, health-care centres, schools and information
Increased school enrolment levels	▶ improved access to schools with possibility of school bus services

2 ProDAF in the Niger.

Rural roads

EXAMPLE 1

Sustainable Market Infrastructure for Livelihood Enhancement Project (SMILE)

(Bangladesh, IFAD, 2012)

Project description

The SMILE project[3] in Bangladesh aimed to achieve improved road connectivity for men and women to facilitate their access to markets and social services. The main focus of the SMILE was to improve communication and market infrastructure – critical for rural economic growth – in selected districts of the country. The project funded construction of transport infrastructures (village and union roads) and the related small bridges and culverts.

Benefits

Incremental benefits from roads investments quantified in the analysis include increased volume of transported products and traffic and reduced transportation costs for goods and passengers. Farmers living within the road catchment area would be able to increase the volume of production sold and to fetch higher selling prices due to better access to markets. Farmers would also enjoy improved access to inputs, contributing to higher productivity. Construction of village and union roads would also impact small private entrepreneurs and vehicle owners. Vehicles operating on these roads include motorized vehicles and non-motorized types such as rickshaws. Owners of motorized vehicles would benefit from increased fuel efficiency and reduced costs of maintenance, while for non-motorized vehicles, the improved road surface would reduce the pain and difficulties of rickshaw driving.

Methodology

Incremental benefits were computed for village and union roads following two methodological approaches: (i) increased volume of transported goods (using the village road model); and (ii) the VOC method (using the union road model). Construction costs and routine and periodic maintenance costs of village and union roads were estimated on the basis of information from the civil engineers involved in project design.

- *Village road model*. This model illustrates the possible incremental benefits of rehabilitation of 4 kilometres (km) of village road. A 5 per cent increase in the volume of transported products for sale (rice and vegetables) was assumed. The estimated investment cost for a 4-km road is 17 million Bangladesh taka (BDT) (US$210,000 equivalent). Annual costs of road O&M are assumed to be 5 per cent of investment costs, starting two years after the investment.
- *Union road model*. This model uses the VOC methodology. Benefits are estimated by computing the probable vehicle and passenger operating costs per kilometre for both existing and incremental traffic and the resulting savings from road investment. WOP traffic is based on traffic counts (cargo and passenger) undertaken on existing roads. WP traffic is estimated using data from the M&E system of another project in Bangladesh.[4] WP VOC are assumed at 80 per cent of those prevailing without the project. The existing annual traffic growth rate is assumed to be 5 per cent (based on likely annual population growth). The volume of WP traffic is assumed to double (compared with the WOP situation). This analysis was carried out for a 5-km union road connecting a small town to a market. Road investment is assumed to take place in year 1, with a one-year lag for the first benefits to accrue. Annual costs for road O&M are assumed to be 5 per cent of total investment costs, starting one year after the investment.

Results

Village road model: the model results in an economic IRR of 10.2 per cent and an economic NPV of 281,427 BDT at 10 per cent opportunity cost of capital. The model is presented in table 2. *Union road model*: after computing economic cash flows, the model shows a desirable economic IRR of 28 per cent, well above the opportunity cost of capital (10 per cent) and a positive NPV of 66.93 million BDT (table 3).

3 The SMILE project was merged in 2013 with the Climate Resilient Infrastructure Improvement in Coastal Zone Project (CRIICZP) of AsDB and Kreditanstalt für Wiederaufbau (KfW) to create the joint Coastal Climate Resilient Infrastructure Project (CCRIP).

4 Rural Infrastructure Improvement Project (RIIP).

BOX 1

Traffic assessment tips

Traffic counts for the EFA were undertaken on subproject roads over a 12-hour period (6 a.m. to 6 p.m.) on a market and a non-market day to capture the variation in traffic volume. Traffic was counted according to six categories of motorized traffic and four categories of non-motorized traffic, plus pedestrian traffic. For each day, 12-hour traffic counts were converted into 24-hour traffic volumes by a multiplier of 1.45 for market days and 1.30 for non-market days. Daily traffic counts were converted into weekly average daily traffic (WADT) on the assumption that, on average, there are two market and five non-market days per week. On this basis:

$$WADT = ((Tmx\ 2) + (Tnx\ 5)) / 7, \text{ where}$$

Tm = 24-hour traffic volume on market day

Tn = 24-hour traffic volume on non-market day

Traffic volumes vary on a seasonal basis, with the dry season traffic exceeding that in the wet season. In order to derive the annual average daily traffic (AADT), which is the basis for estimating VOC savings, WADT volumes have been adjusted to account for seasonal variation. Following the Local Government Engineering Department (LGED) methodology prevailing in Bangladesh, each season is assumed to last for six months and the dry season traffic to be 20 per cent higher than the wet season traffic. The traffic counted in April 2012 was assumed to be representative of dry season traffic volume. The AADT is estimated as the average of dry and wet season traffic, as follows:

$$AADT = (Td + Tw) / 2 = ((Td + (Td/1.2)) / 2 = ((Td) \times (1 + 0.83)) / 2$$

where

Td = 24-hour traffic volume during the dry season

Tw = 24-hour traffic volume during the wet season

Estimates of VOC savings accrue from improvements in road surface. In accordance with LGED's evaluation of IFAD's Rural Infrastructure Improvement Project, improvement in road surface is based on a reduction in the international roughness index (IRI) from 14 to 6 for the Upazila road subproject. For the village road subproject, visual inspection indicates that its current condition equates to an IRI of 16. For the improved village road, an IRI of 8 was assumed. VOC for each level of IRI are derived from the latest available (2008) VOC estimates.

Road costs comprise construction and maintenance costs. Unit rates for construction costs are based on the latest LGED unit rates, adjusted upwards both for cost escalation and to take into account the difficulty of access and working conditions in the project area. Maintenance costs are at 5 per cent of road construction costs. The conversion of these financial unit costs into economic costs is discussed in the context of overall project costs.

Source: Extracted from the EFA of the Hoar Infrastructure and Livelihood Improvement Project, Bangladesh, carried out by Lisa Paglietti, Economist, FAO-TCIA.

TABLE 2

SMILE project, Bangladesh, economic analysis for village roads

Economic analysis – village road (BDT)			
Description	Beneficiaries	Cropping pattern (acres)	Production (kg/acre)
Number of beneficiaries	200		
Rice production		1	1,000
Vegetables production (tomato)		1	950
Subtotal production	200		1,950

	Volume (ton)	Economic price (BDT/ton)	Value (BDT)
Rice producers	200	26,661	5,332,132
Vegetables producers	190	37,200	7,068,000
Total	390		12,400,132

Parameters	Unit	WOP	WP
Number of beneficiaries (1 km)	no.	200	200
Total volume of production	ton	390	390
Rice producers	ton	200	200
Vegetables producers	ton	190	190
Total value of production	BDT	12,400,132	12,400,132
Rice producers		5,332,132	5,332,132
Vegetables producers		7,068,000	7,068,000
Total volume of sales	ton	253	266
Rice producers		120	126
Vegetables producers		133	140
Average journey	km	4	4
Volume of sales transported	ton/km	1,012	1,063
Total value of sales transported	BDT	8,146,879	8,554,223
Rice producers		3,199,279	3,359,243
Vegetables producers		4,947,600	5,194,980
Net income from sales	BDT	4,358,131	5,510,446
Rice producers		1,026,347	1,409,366
Vegetables producers		3,331,784	4,101,080
Incremental net income from sales per km*	BDT		1,152,315

= WOP*1.05. Assuming a 5 per cent increase in the volumes of transported products

EIRR calculation – village road	PY 1	PY 2	PY 3	PY 4-20	PY 5	PY 6-20
Incremental net revenue (1 km)		230,463	460,926	691,389	921,852	1,152,315
Incremental net revenue (4 km)		921,852.10	1,843,704.19	2,765,556.29	3,687,408.38	4,609,260.48
Economic investment costs						
Village road	17,160,000					
Recurrent costs						
O&M (5% of investment cost)			858,000	858,000	858,000	858,000
Sub-total recurrent costs	-	-	858,000	858,000	858,000	858,000
Total incremental costs	17,160,000	858,000	1,716,000	1,716,000	1,716,000	1,716,000
Net benefit	-17,160,000	63,852	127,704	1,049,556	1,971,408	2,893,260

Internal rate of return	10.2%
NPV @ 10% (BDT)	281,427

Note: O&M = operation and maintenance.

* It was assumed that the total benefits increase gradually: 20% of optimum in year 2, 40% in year 3, 60% in year 4, 80% in year 5 and 100% in year 6.

TABLE 3

SMILE project, Bangladesh, economic analysis for union roads

Economic analysis – union road (5 km) (BDT '000,000)		
Technical and financial assumptions		
Road length	5.0	km
Opportunity cost of capital	10.0	%
Maintenance costs	5.0	% of total investment costs
Year-to-year traffic increase	5.0	%
(a) Annual cargo traffic	0.7	Source: M&E system of another IFAD project
(b) Transport cost	10.0	BDT per ton/km
(c) Total costs reduction	7.5	75% of total costs
(d) Savings	2.5	(b) - (c)
(e) Annual passenger traffic	5.3	Source: M&E system of another IFAD project
(f) Total cost per passenger	3.0	BDT per passenger
(g) Total costs passenger discount (PD)	2.2	75% of total costs
(h) Savings	0.7	(f) - (g)

Economic analysis – union road (BDT '000,000)

Year	Invest-ment cost per km	Total invest-ment cost	Mainte-nance cost per km	Total mainte-nance cost	Total cost	Current traffic benefits	Genera-ted traffic benefits*	Total benefits	Cash flow
1	7.8	39.0		-	39.0	5.7		5.7	-33.3
2			0.4	2.0	2.0	6.0	0.6	6.6	4.6
3			0.4	2.0	2.0	6.3	1.12	7.5	5.5
4			0.4	2.0	2.0	6.7	2.4	9.1	7.1
5			0.4	2.0	2.0	7.0	5.1	12.0	10.1
6			0.4	2.0	2.0	7.3	6.6	14.0	12.0
7			0.4	2.0	2.0	7.7	7.0	14.7	12.7
8			0.4	2.0	2.0	8.1	7.3	15.4	13.5
9			0.4	2.0	2.0	8.5	7.7	16.2	14.2
10			0.4	2.0	2.0	8.9	8.1	17.0	15.0
11			0.4	2.0	2.0	9.4	8.5	17.9	15.9
12			0.4	2.0	2.0	9.8	8.9	18.7	16.8
13			0.4	2.0	2.0	10.3	9.4	19.7	17.7
14			0.4	2.0	2.0	10.8	9.8	20.7	18.7
15			0.4	2.0	2.0	11.4	10.3	21.7	19.7
16			0.4	2.0	2.0	12.0	10.8	22.8	20.8
17			0.4	2.0	2.0	12.5	11.4	23.9	22.0
18			0.4	2.0	2.0	13.2	12.0	25.1	23.2
19			0.4	2.0	2.0	13.8	12.56	26.4	24.4
20			0.4	2.0	2.0	14.5	13.2	27.7	25.8

NPV @ 10%	**66.9**	**('000,000 BDT)**
ERR	**28%**	

* It was assumed that the total benefits increase gradually: 10% of optimum in year 1, 20% in year 2, 40% in year 3, 80% in year 4 and 100% in year 5.

BOX 2

Some tools for economic analysis of road projects

Road Costs Knowledge System (ROCKS) is a World Bank tool to estimate budget needs and assess the performance of road maintenance.

The Road Network Evaluations Tools (RONET) is designed to assess current characteristics of road networks and their future performance according to the diverse levels of intervention in the networks.

HDM-4 Road User Costs Model 2.00 (HDM-4 RUC) is an Excel-based model designed to compute Highway Development and Management Model (HDM-4) relationships.

Road User Costs Knowledge System (RUCKS) helps quantify the effects of vehicle fleet and road characteristics on road user costs.

Source: World Bank.

All tools described are available at: http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTTRANSPORT/EXTROADSHIGHWAYS/0,,contentMDK:20483189~menuPK:1097394~pagePK:148956~piPK:216618~theSitePK:338661,00.html

Of possible interest

IFRTD Poverty Watch: Making Transport Count in Poverty Reduction
www.ifrtd.org/index.php/projects/other-projects/109-poverty-watch-making-transport-count-in-poverty-reduction

FRTD Improving Mobility Workshops
www.ifrtd.org/index.php/projects/other-projects/112-improving-mobility-workshop-series

Rural Transport Services indicators
www.ruraltransport.info/RTSi/

Good Policies and Practices on Rural Transport – Monitoring & Evaluation (M&E considered part of planning and implementation)
See more at: www.ifrtd.org/index.php/resources/new-resources/item/9-good-policies-and-practices-on-rural-transport-monitoring-evaluation#sthash.DTfmfU9w.dpuf
And at: www.ssatp.org/sites/ssatp/files/publications/SSATPWP99-RT-ME.pdf

Source: Narrative extracted from the World Bank's Roads and Highways web page.

CASE STUDY 10

Small-scale irrigation

Conceptual section

Scope of the note

The present note, built on practical examples, aims to assist economists, irrigation engineers and project design teams in analysing returns on small-scale irrigation investments.[1] More particularly, it illustrates consideration in a CBA of aspects that go beyond the change in operating costs and increases in the value of production. In addition, it depicts how EFA of an irrigation intervention can support institutional strengthening, policy dialogue and improved decision-making in water resources management (WRM).[2]

Interventions

Investments in irrigation systems can take many different forms and will require diverse analytical approaches. First, they can differ greatly in scale, in technology and in the farming systems in which they will intervene. Additionally, although such investments usually aim to increase the value and volume of agricultural production, strategies to achieve such final outcomes can differ from one project to another. Such strategies or intermediate results depend on local specificities and are not all mutually exclusive, but can entail: increases in surface of arable land, water-use efficiency/productivity, resilience to climate shocks, or land-use intensity; a shift to higher-added-value crops; or a change in cropping patterns.

Depending on the irrigation scheme, investment in irrigation may require dealing with issues that constitute risks to its success and need to be incorporated into project analysis. For example, changes introduced by the project may: (i) increase the number and diversity of stakeholders and introduce risks of exacerbating inequality and of elite capture of benefits; (ii) increase a sometimes perishable surplus, which will need to find new marketing channels; and (iii) require improved technical, financial and water management skills and capacities – implying that investments in construction and equipment for irrigation will be matched with effective technical assistance services, institutional strengthening and policy analysis.

Given all this, the focus of the analysis of economic and financial results may vary considerably from one project to another. Box 1 illustrates some uses of EFA as an instrument for: (i) policy dialogue between competing economic sectors and local authorities; (ii) strengthening WRM institutions; and (iii) developing extension tools for water users' groups to assist in the improvement of regulations and the establishment of fairer water fees. Case studies 1 and 2 show examples of how these issues can be incorporated into EFAs, what costs and

1 In this context, small-scale irrigation schemes are those that, given their size, have only one sector and are administered by a single water users' organization. Larger schemes usually comprise more complex water distribution systems, greater heterogeneity in farming systems and more than one management institution. Those cases are not addressed here.

2 Integrated water resources management (IWRM) is defined by the Global Water Partnership (GWP) as "a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems." However, in this paper, we understand it as a broad concept – a process of coordinated decision-making on water and related resources (dams, wells, conveyance systems, etc.) by a group of stakeholders. As such, WRM institutions can be, for example, a municipal committee that decides on water sourcing and allocation and infrastructure maintenance for the whole municipality or simply a water users' group in an irrigation scheme.

benefits might need to be taken into account in each case, and their possible inter-year and inter-beneficiary-group variations. However, given the diversity of irrigation investment projects, these case studies do not constitute a complete account of all the costs and benefits that might need to be taken into consideration in other cases. In reality, for each new project, the analyst needs to assess what main variables will influence project results and to ensure that they are well accounted for.

Benefits

Small-scale irrigation projects can bring a number of direct and indirect benefits (table 1). These can be associated with: (i) increases in the value and volume of production, such as higher incomes, improved

TABLE 1

Main tangible and intangible benefits of investments in small-scale irrigation schemes

Tangible benefits	Due to …
Increased revenues	▶ increases in value of production from improved yields, greater surface of arable land, and improvements in product quality and marketing
Improved access to and availability of food	▶ greater production of food for subsistence or for purchasing power from the sale of larger surpluses; extension of cropping seasons and land-use intensification (Tesfaye, Bogale and Namara 2008; Lipton, Litchfield and Faurès 2003)
Increased resilience to climate shocks	▶ drip irrigation, water storage, drainage investments that mitigate the impact of droughts and floods; reduced water stress and improved crop management that increase plant resilience to plagues, diseases and extreme climate events. Dillon (2011) shows positive externalities of irrigation in Mali in which households engaging in irrigation save from 4.5 to 6.4 more tropical livestock units[3]
Job creation	▶ introduction of new cropping seasons, increased production, and shifts to labour-intensive crops that require hiring of additional labour
Improved income equity	▶ improved income for small-scale farmers. Attention must be paid to avoid elite capture or exacerbation of social differences among beneficiaries (case study 1)
Improved nutrition	▶ increased food diversity. Benefits will occur if the market/policy environment favours diversification and if complementary interventions, such as sensitization campaigns for diet improvement, are put in place (see the note on 'Nutrition')
Increase in market participation	▶ the Hagos et al. (2007) study in Ethiopia, which shows that, despite existing hindering factors (e.g. lack of mechanization and transport infrastructure), small- scale irrigation can contribute to increased market participation (marketed surplus production)
Intangible benefits	**Due to …**
Water and soil conservation	▶ properly managed, efficient irrigation schemes that reduce water losses (i.e. seepage, percolation and evaporation) and soil erosion with little impact on the local ecosystem
Developed capacities	▶ capacities for group decision-making, financial management, water management, produce marketing and agricultural technology use
Strengthened institutions	▶ strengthened water users' groups, more professional associations or enterprises formed by some water users' group members
Improved policy dialogue and policy framework	▶ improved land and water use rights for water users. Investments in irrigation also provide opportunities for dialogue and policy changes in water pricing or water assignation among users and economic sectors (case study 2)

3 The tropical livestock unit (TLU) is an 'exchange ratio' used to describe livestock numbers of various species as a single figure that expresses the total amount of livestock present – irrespective of the specific composition, i.e. different species of different average size can be compared and described in relation to a common unit.

food security and nutrition, increases in household assets and savings, and reduced vulnerability to shocks; (ii) improvement in environmental sustainability through adequate water and soil conservation practices (e.g. soil cover, gains in irrigation efficiency, improved drainage); (iii) capacity development, institutional strengthening and policy changes; and (iv) generation of positive economic externalities such as job creation, increased market participation and food availability, and improved social equity. However, some changes, such as environmental impacts, can constitute a benefit but also a risk to the water users' group or to the populations downstream of irrigation schemes (see row 3).

Methodologies and tools

CBAs for most irrigation investments will require a classic approach (crop models and whole/partial farm budgets, built around WP and WOP scenarios) as described in detail in volume 1 of these guidelines and in other reference works on the subject

BOX 1

EFA use in policy dialogue and risk assessment

Case study 1 presents an EFA undertaken during project implementation. It models the distribution of maintenance and operational costs, proceeds from harvest and irrigation fees among different types of users – landowners, land tenants and the scheme manager. The analysis assessed whether the project promoted a fair distribution of net benefits among project beneficiaries. The results can be used to identify needs for technical assistance to and mediation within the water users' groups in order to establish fairer regulations and fees. EFA results can also be used in the preparation of extension materials for discussion of irrigation costs and fees, thus contributing to the strengthening of water users' groups.

In case study 2, the focus is on rationalizing the allocation of limited water resources in dry years among economic sectors (agriculture, urban supply and industry) and improving the capacity of water management institutions to make informed decisions on cropping patterns. The case illustrates the use of EFA to define criteria for ceilings on water consumption for each competing economic sector, depending on water availability in each year, and to assist farmers in cropping decisions. Such models can be used by watershed management bodies, which require easy-to-use decision-support tools to facilitate dialogue among water users from different sectors, and by technicians assisting water users' groups. In the latter case, analysis can assist these groups in: (i) defining maximum irrigated areas under perennial crops (considering water availability and quality in dry years and different crops' varying resistance to drought); (ii) agreeing on a cropping pattern of perennial crops based on returns on investment and acceptable drought risk levels; and (iii) establishing the maximum irrigated surface of annual crops each year, depending on water availability at the start of the season.

This case also provides an example of an irrigation system that was improved to increase drinking and irrigation water availability in dry years as a strategy for improving farmers' resilience to extreme weather events and climate change. Some related major uncertainties are: (i) number and intensity of droughts that will occur in the future; (ii) how, in WOP and WP situations, permanent crops react to water stress or to a decrease in water quality; and (iii) how yields will recover, in WOP and WP situations, in the years subsequent to a drought when soil salinization might have occurred. In these cases, when elaborating an EFA, models must compute yearly cash-flow variations based on different weather scenarios and a range of possible drought impacts on production costs, productivity and crop losses. Given the number of variables, risk and sensitivity analyses might be strengthened by a Monte Carlo simulation (see the note on 'Probabilistic risk analysis').

Additionally, in cases where there is a high expected variability of yearly results, IRR and NPV estimations might not be sufficient to assess what incentive farmers might have to invest and to change their cropping patterns and technologies. The following can be good indicators of the risk of an investment in a particular technology and cropping pattern: (i) expected percentage of years with negative gross margins for each crop; (ii) expected consecutive years with negative gross margins; and (iii) average gross margins over a period of time.

(e.g. Gittinger 1982 or Savva and Frenken 2002).

However, depending on the main aims and characteristics of each project, it is important to ensure that significant benefits (and costs) that may constitute crucial drivers for investment (or unaccounted risks) are not overlooked. Some examples of what may have to be assessed are: (i) impacts of weather variability on water availability and quality; (ii) the impact of competition for and access to water, and of water rights, on various stakeholders; (iii) distribution of benefits among stakeholders; and (iv) impact on food diversification. In addition to crop models, beneficiaries' characteristics and project main targets, the analyst should equip him/herself with the relevant modelling methodologies and tools, as well as relevant datasets and sources of information. Depending on the project case, these may be: (i) weather time series or scenarios; (ii) hydrological models of water reservoirs; (iii) sociological studies on access to assets and decision-making in beneficiary communities; (iv) assistance from an agronomist with field experience and knowledge of crop responses to different levels of water stress; (v) water quality and soil fertility; and (vi) information on local institutional mandates, roles and existing capacities, as well as on land and water use rights (even if customary) and policies. Example 2 provides an example in which the use of such information was determinant in obtaining a meaningful analysis. An interdisciplinary team of experts would be required to conduct such assessments.

Small-scale irrigation

EXAMPLE 1

Integrated Agricultural Productivity Project

(Bangladesh, World Bank, 2013)

Project description

The development objective is to enhance productivity of agriculture in targeted pilot areas (Rangpur and Barisal). The US$63.6 million project comprises four components: (i) technology generation and adaptation; (ii) technology adoption; (iii) water management; and (iv) project management. It aims to rehabilitate 581 irrigation schemes in the two pilot regions. AnEFA was conducted for investment in installation of buried pipe networks to enhance water conveyance efficiency in existing irrigation schemes.

Costs and benefits

The schemes in Rangpur depend on deep tube wells. In Barisal, the buried pipes will be supplied with surface water through low-lift pumps. The pipes replace a previously existing network of earthen canals. Irrigation technology (flood irrigation) remains unchanged. Thus the main investment cost is acquisition and installation of the pipes. Other investment costs consist in training of farmers, pump operators and pump mechanics, and staff assigned to the project. Primary changes in the operating costs structure are lower energy requirements per hectare to pump water and elimination of the labour previously involved in maintenance of the earthen canals.

The main incremental quantifiable benefit is increased production due to expansion of irrigated area with a similar or slightly lower water consumption, owing to the increase in water conveyance efficiency. The sampled schemes showed a 20-30 per cent increase in irrigated areas. In the case of Barisal, rainfed land was uncultivated previously, while in Rangpur, it is thought that the land was previously planted with wheat. All newly irrigated areas are now sown with Boro rice during the dry season. There were also small increases in productivity in previously irrigated areas. The project is increasing water-use field application efficiency and achieving water savings per kilogram of rice produced (or per hectare of land). Some water saved is expressed in the net benefits obtained from the incremental sown area of Boro rice. However, the value of the saved water not used in the newly irrigated area is difficult to quantify and is only mentioned in the analysis as a positive externality.

Methodology

Two generic crop models were developed based on data from the Bangladesh Bureau of Statistics – one for the four districts in Rangpur and another for the four in Barisal. The differences among the districts within each region were shown in the irrigation costs, irrigation fees and yields obtained from the project M&E system (tables 2-5). For each district, financial analysis was performed at two levels: the individual farm and the water users' group (WUG) – in this case, a group of farmers that benefit from one irrigation scheme. For individual farms, three main types of models were considered: (i) the average farm owner, who pays the irrigation fees agreed within the WUG; (ii) the average farm tenant, who pays 25 per cent of her/his production to the owner, but is exempt from paying irrigation fees (paid by owner); and (iii) the larger farmer/landowner, who is also the scheme manager, and thus actual costs are his/her share of the scheme irrigation costs, rather than an irrigation fee.

For analysis at the WUG level, a first set of gross and net margins for the average WUG in each district was obtained, using irrigation fees as the incurred irrigation cost. A second set of gross and net margins was obtained, ignoring the fees and incorporating actual irrigation costs into the crop models: canal repair and maintenance, pump rental when applicable, pump operator and energy (table 6). This allowed comparison of changes in both fee revenues and irrigation costs introduced by the project, thus assessing the financial sustainability of the WUG.

For economic analysis, financial prices were converted into economic prices (see volumes 1 and 2 of the guidelines for further methodological details). Energy costs were deducted from the taxes and subsidies extracted from a study on energy subsidies in Bangladesh (Mujeri, Chowdhury and Shahana 2013). Import parity prices were estimated for main inputs and outputs, and the current minimum wage for unskilled labour (manufacture) was taken as the opportunity cost of labour. Total irrigation costs were considered. The NPV was calculated with a discount rate of 12 per cent and project lifetimes of 15 and 20 years.

TABLE 2
Pump characteristics for deep tube wells (DTW) in Rangpur
(Bangladesh taka)

DTW electricity	Value	Unit
Discharge rate	56.0	litres (l)/sec
Consumption	15.0	Kwh
Price Kwh	3.9	Tk/Kwh
Unit cost	58.5	Tk/hour

DTW 25 hp diesel	Value	Unit
Discharge rate	56.0	l/sec
Diesel consumption	0.9	l/hour
Diesel price	66.6	Tk/l
Unit cost	59.9	Tk/hour

Note: The same was done for the low-lift pumps used in Barisal.

TABLE 3
Estimation of energy costs per district for the WOP situation in Rangpur

Districts in Rangpur	No. systems	Without project								
		Pumping hours (a) = (b)*(c)	Irrigated area (b)	Pumping hours/ha (c) = (d)/(e)/60/60	Discharge rate l/sec (d)	Pumped water requirements l/ha (e) = (f)*10,000	Pumped water requirements mm (f)	Conduction efficiency (g) - empirical data	Water need mm (h) = ETo* irrigation efficiency	Energy cost Tk/ha (i) = (a)*unit cost of used pump
Rangpur	21	15,351	343	45	48	7,733,706	773	0.6	464	2,683
Nilphamari	6	3,968	101	39	48	6,788,571	679	0.6	407	2,355
Lalmonrihart	4	3,120	60	52	48	8,985,600	899	0.6	539	3,117
Kurigram	11	8,255	154	54	48	9,262,782	926	0.6	556	3,213

Notes: The same estimate was performed for the WP situation and for Barisal. ETo = evapotranspiration.

TABLE 4
Construction costs
(Thousands of Bangladesh takas)

	Systems	Ha/system	Cost/system	Cost/ha
Rangpur (Boro)	21	20	849.5	41.6
Nilphamari	6	21	849.5	40.5
Lalmonrihart	4	19	849.5	45.3
Kurigram	11	18	849.5	47.4

TABLE 5
Characterization of the cropping pattern for Nilphamari District, Rangpur region

Crop (dry season)	Without project		Without project	
	ha	%	ha	%
Boro rice	101	80%	126	100%
Wheat	25	20%		
Land use by season	126	100%	126	100%

Note: Similar tables were built for each of the eight benefited districts.

Results

Financial results for the average scheme/WUG show that the investment is financially sustainable and the established irrigation fees are higher than irrigation costs. Financial results for each type of beneficiary show that, in the WOP situation, average tenants in the Barisal region obtain net margins comparable to those of average landowners, assuming the former pay a quarter of their production to the land owner, and the latter pay one fifth of their production in fees to the manager (table 7). In the Rangpur region, where irrigation fees were reported to be lower than in the south, there was already a considerable difference between the margins of landowners and tenants in the WOP situation. With installation of the buried pipes, there is little change in tenants' net margins, as, under current assumptions, their earnings per hectare have seen only small improvements from increases in productivity and from the area recovered from the previous earthen canal (unless they increase their area by renting newly available irrigated land). However, landowners that possessed land that was previously unproductive in the dry season, and that becomes productive with the project, benefit from project impact in these new areas. Another reason for larger increments in landowners' net margins is that the rent value per hectare remained unchanged, whereas landowners benefit from a decrease in irrigation fees/costs.

Given the assumption that managers do not bear the full fee cost, they do not benefit from the sharp decrease in irrigation fees brought about by the project, but from the smaller decrease in system costs (table 7). Thus their absolute change in margin is smaller than that of the average farm owner. Nevertheless, they continue to benefit from higher margins per hectare, as irrigation fees continue to be significantly higher than total irrigation costs (table 8). Economic results for the project as a whole were robust, for both the 15- and 20-year periods of analysis.

Such results can be used during the project to improve dialogue among WUG members on irrigation fees, and to lead, through informed planning, to a fairer distribution of investment benefits.

Estimation of irrigation costs for Rangpur (case study 1)

Total water requirements with and without project were estimated based on the plant water requirement, local irrigation efficiency and conveyance efficiency. Energy costs were estimated based on total water requirements and the unit cost (Bangladesh taka (Tk)/hour) for the type of pump predominant in each district. Construction costs were obtained from the project M&E system.

Maintenance and operational costs without project (canal repair, pump operation and repair) and with project (pump operation and repair) were added to these costs. Total irrigation costs are used for:

TABLE 6

Summary of an average scheme (21 ha) for Nilphamari District (Rangpur)*

		Nilphamari			
	Unit	Without project	With project	% change	Abs. change
Production	kg	98,211	126,000	28.3%	27,789
Revenues	US$	26,179	33,587	28.3%	7,408
Costs of production (excl. labour)	US$	11,513	12,929	12.3%	1,416
Costs of production (incl. hired labour)	US$	16,903	19,845	17.4%	2,941
Gross margin	US$	14,666	20,657	40.9%	5,992
Gross margin (incl. hired labour)	US$	9,276	13,742	48.1%	4,466
Labour	pers. day	1,536	1,970	28.3%	435
Family labour	pers. day	482	619	28.3%	136
Return to labour	US$/pers. day	9.5	10.5	9.8%	0.9
Return to family labour	US$/pers. day	19.2	22.2	15.5%	3.0
Net margin considering irrigation fees (i)	US$	7,042	10,876	54.4%	3,834
Irrigation fees (+)		5,024	4,604	-9.1%	-420
Irrigation system total cost (-)		1,426	1,349	-5.4%	-76
Net margin system (ii)		10,640	14,131	32.8%	3,491

* Considering: (i) 100% of the area sown with Boro rice in the WP situation; and (ii) 80% sown with Boro rice and 20% with wheat in the WOP situation.

(i) economic analysis after conversion for economic prices; (ii) estimation of total financial costs of the average scheme in each district with and without project; and (iii) estimation of actual irrigation costs of the scheme manager.

Financial results for one district in Rangpur (case study 1)

The analysis provides two net margins calculated using two approaches: (i) 'irrigation costs' correspond to total irrigation fees paid by the WUG; or (ii) 'irrigation costs' are the actual irrigation costs (energy, depreciation, maintenance and operation). The results highlight that the average scheme is sustainable, as the agreed irrigation fees are above the irrigation system total costs (provided that all farmers pay). However, it is not clear how the surplus is to be used by the WUG.

Financial results per beneficiary by type (average farm owner, farm tenant, scheme manager)

Summary results tables similar to the one above were prepared for each of the three types of beneficiary and for each of the eight districts, yielding tables for 24 farm models. The net margins include different land rent and irrigation costs for each type of beneficiary. The following tables present net margins for the 24 models for WP and WOP situations. WP situations are for a year after the project has reached maturity.

TABLE 7

Net margins for farm models

(United States dollars)

	Average farm owner				Average farm tenant				Large farm owner/scheme manager			
	Sown area (ha)	Without project	With project	% change	Sown area (ha)	Without project	With project	% change	Sown area (ha)	Without project	With project	% change
Rangpur	0.3	122	161	32.3%	0.3	75	78	4%	1.6	813	1,009	24.1%
Nilphamari	0.2	38	55	46.0%	0.2	7	10	54%	1.6	303	474	56.5%
Lalmonrihart	0.2	68	89	31.5%	0.2	39	40	4%	1.6	685	874	27.5%
Kurigram	0.2	57	76	33.7%	0.2	32	33	3%	1.6	661	842	27.4%
Barisal	0.2	74	114	54.4%	0.2	77	78	1%	1.6	947	1,125	18.7%
Jhalokati	0.2	62	96	55.8%	0.2	63	64	1%	1.6	886	1,056	19.2%
Patuakhali	0.3	51	99	93.9%	0.3	51	53	3%	1.6	573	711	24.1%
Barguna	0.3	40	76	87.2%	0.3	31	32	3%	1.6	445	570	28.1%

Note: Sown areas are for the WP situation after the project has reached maturity.

TABLE 8

Net margins per hectare for farm models

	Average farm owner			Average farm tenant			Large farm owner/scheme manager		
	Without project	With project	Abs. change	Without project	With project	Abs. change	Without project	With project	Abs. change
Rangpur	428	566	138	262	273	11	502	623	121
Nilphamari	184	269	85	33	50	18	187	292	106
Lalmonrihart	381	501	120	216	224	9	423	539	116
Kurigram	362	484	122	203	209	6	408	520	112
Barisal	335	518	183	350	353	4	585	694	109
Jhalokati	308	480	172	317	320	3	547	652	105
Patuakhali	152	294	142	152	156	4	354	439	85
Barguna	119	222	104	90	93	3	275	352	77

TABLE 9

Project targets

Km of pipe installed per year		Total project	1	2	3	4	5
Rangpur	Buried pipe line (250 mm dia) (L=650 m (yr2), 800 m (yr3), 950 m (yr4-yr5)	146		27.4	44.0	41.6	60.8
Barisal	Buried pipe line (200/250 mm dia) (L=550 m (yr2) to 700 m (yr3), 800 m (yr4-yr5)	163		19.8	45.5	48.0	69.6
Number of schemes rehabilitated per year							
Rangpur		225		42	55	64	64
Barisal		275		36	65	87	87

To table 10

TABLE 10
Project cash flow (economic prices)

From table 9

Project years		1	2	3	4	5	6
Incremental Net margin							
Investment year	Incremental net margins extrapolated for the whole project						
1 Rangpur pipes			16,667,771	16,667,771	16,667,771	16,667,771	16,667,771
2 Average incremental net margin for 650 m (excluding depreciation)	395,259			26,755,998	26,755,998	26,755,998	26,755,998
3					25,296,580	25,296,580	25,296,580
4						36,971,925	36,971,925
5							0
Subtotal			16,667,771	43,423,769	68,720,349	105,692,273	105,692,273
1 Barisal pipes			17,008,688	17,008,688	17,008,688	17,008,688	17,008,688
2 Average incremental net margin for 650 m (excluding depreciation)	472,464			39,085,621	39,085,621	39,085,621	39,085,621
3					41,104,329	41,104,329	41,104,329
4						59,788,115	59,788,115
5							0
Subtotal			17,008,688	56,094,309	97,198,638	156,986,753	156,986,753
Total Incremental net margin (a)			**33,676,458**	**99,518,078**	**165,918,987**	**262,679,026**	**262,679,026**
Investment cost (from project M&E)	Total for the project						
Ragpur	773,030	32,598,095	52,328,209	49,473,943	72,308,070	0	
Barisal	643,502	23,166,066	53,235,151	55,984,659	81,432,231	0	
Total investment costs (b)	**1,416,532**	**55,764,161**	**105,563,359**	**105,458,601**	**153,740,301**	**0**	
Project general costs (from COSTAB)							
Training of pump mechanics		0	5,195,000	5,195,000	5,195,000	0	
Training of pump mechanics		0	5,195,000	5,195,000	5,195,000	0	
Officers and technicians*		0	254,555	509,110	509,110	0	
Double-cabin pick-up vans		4,581,990	0	0	0	0	
Motorcycles		872,760	0	0	0	0	
Computers		349,104	0	0	0	0	
Fax machines		29,092	0	0	0	0	
Scanners		14,546	0	0	0	0	
Photocopiers		290,920	0	0	0	0	
Furniture		254,555	0	0	0	0	
E. BADC Regional Office Renovation		145,460	145,460	0	0	0	
F. Survey and Design consultancy		218,190	218,190	0	0	0	
Sub-inspector engineers (8 nos.)		1,815,341	1,815,341	1,815,341	1,815,341	1,815,341	
BADC field office allowances		181,825	181,825	181,825	181,825	181,825	
Travelling allowances		290,920	290,920	290,920	290,920	290,920	
Field vehicle operating costs		1,309	1,309	1,309	1,309	1,309	
Project coordination (12% of total project coordination costs)		24,530,020	10,794,230	9,930,220	9,724,036	9,655,308	
Total general costs (c)		**33,576,032**	**24,091,830**	**23,118,725**	**22,912,541**	**11,944,703**	
Project economic net revenue							
Total net revenue (a)-(b)-(c)		-89,340,193	-95,978,731	-29,059,249	-10,733,855	250,734,323	262,679,026

Project economic NPV (Tk)	997,966,888
Project economic NPV (US$)	12,763,357
Project economic IRR	47%

Average incremental net margins were calculated for the average scheme in each region (the average scheme comprising 650 m of buried pipe in Rangpur and 550 m of buried pipe in Barisal.

The sum of all schemes net margins was estimated by multiplying the average net margin per meter of buried pipe by the total length of buried pipe installed each year.

* Only considers 49% of general costs of component 3 as it is the proportion of investment in buried pipes (the rest being water harvesting).

EXAMPLE 2

Integrated Water Resources Management Project – rehabilitation and modernization of the irrigation scheme associated with the Cruzeta Dam

(Brazil, World Bank, 2015)[1]

Project description

The project invested in Rio Grande do Norte through four components: (i) institutional development and water resource management; (ii) natural resource conservation and protection; (iii) water infrastructure; and (iv) project management. The third component comprised a pilot intervention to rehabilitate and modernize the water supply system associated with the Cruzeta Dam and to establish a framework for water management and allocation in similar watersheds in the northeast of Brazil. This example describes only EFAs conducted for this particular pilot intervention.

Water stored in the Cruzeta Dam reservoir serves an irrigation system of 124 ha, over 6,500 inhabitants of the town of Cruzeta, approximately 52 ha of irrigated agriculture upstream of the dam and a local ceramics industry. In the period with available data (1936-1989), levels of precipitation in the watershed were not enough to fill the reservoir in 37 per cent of those years. This means that water users may be subject to water restrictions in dry years and that efficiency gains (i.e. water savings) by one sector in those years will benefit all water users. The project aimed to improve water efficiency in the Cruzeta irrigation scheme and proposed an integrated water-management framework for dry years.

Costs and benefits

The major investment costs were rehabilitation of the water conveyance infrastructure, installation of a new energy network and acquisition of drip irrigation systems, including equipment, pumps and individual reservoirs. The project also invested in technical assistance to farmers and government institutions over six years.

Analysis modelled the following main benefits derived from the project intervention: (i) increase in irrigated area for the same volume of available water due to water efficiency gains from changing from

1 Analysis performed during project implementation with project resources.

furrow to drip irrigation;[2] (ii) a more stable level of output, less damage to orchards and reduced losses of annual crops during dry years, owing to greater water availability for irrigation; and (iii) decrease in the number of months without piped water supply to the town of Cruzeta.

Methodology

The model developed aimed to assess a set of economic and financial indicators (figures 1 and 2) whose measurements reflect shifts in water availability in the reservoir over the 20 years of analysis, as well as availability of and access to underground water (figure 4). As such, the model considers area under production, crop production costs and benefits, and availability of water for domestic consumption in each year, all according to overall water availability and the soil and plant conditions caused by current and/or previous years of drought. Given the number of variables, it was important to work with an experienced engineer in developing the models.

EFA preparation employed the following steps:[3]

- *Step 1.* The volume of water entering and evaporating from the reservoir was modelled according to watershed hydrologic characteristics and historical climate data (precipitation, evaporation, inflows from the river) over the 1963-1979 period (figure 3).
- *Step 2.* Water available from river direct intakes and shallow wells in the Cruzeta irrigation scheme was modelled from data obtained from the field (figure 4). [Steps one and two defined all water available, in each year, to all economic sectors that depend on the reservoir.]
- *Step 3.* Criteria were defined for application of water restrictions to the different economic sectors depending on water availability in the reservoir at the end of each rainy season (figure 5).
- *Step 4.* Total water demand from each sector was estimated according to data on historical urban water consumption and population growth and to envisioned cropping patterns, cropping areas and crops' reference evapotranspiration (figure 6). In this regard, the project made the assumptions listed in table 11.
- *Step 5.* A hydrological model was constructed of the volume of water in the reservoir for each month in a 30-year period, considering all water entries to and exits from the reservoir characterized in the previous steps (figure 7). The model enables estimation of the level of water restriction to be applied to each sector each year, based on the available volume of water in the reservoir at the end of the rainy season.
- *Step 6.* Crop budgets were produced for each crop for WP and WOP situations. In the case of

TABLE 11

Assumptions (case study 2)

	Without project	With project
Demand from the Cruzeta irrigation scheme and urban water supply	Water supply is partially or completely interrupted without warning in dry years, when water in the reservoir reaches low levels. Demand is estimated based on cropped area (105 ha) and evapotranspiration (ETo) for each crop and on historical consumption	Depending on water availability at the end of each rainy season, water supply is capped at a certain level to ensure availability over 18 months (until the end of the next dry season). Demand is estimated as in the WOP situation, but for a cropped area of 124 ha
Demand from upstream irrigated agriculture and the ceramics industry	Estimated from surveys on water uptake from upstream of the dam. Water is withdrawn according to demand as long as it is available	No change in the WP situation, as there is no guarantee that water-use restrictions will be enforced for these users

2 It is important to mention that in years in which there is no water availability from the reservoir, some farmers have access to groundwater from shallow wells and direct intakes from the river (where the water table is shallow). This means that, with the introduction of drip irrigation, it was also possible to increase the area irrigated from these alternative sources in water-scarce years, increasing producers' resilience to drought.

3 This was a particularly complete and complex analysis, and should not be considered standard procedure.

perennial crops, there was a characterization of the time lag until each of them reached maturity, i.e. full costs and benefits as in the crop model (figure 8).

- *Step 7.* Effects of the water restrictions on cropped areas and plant productivity were characterized for years with different levels of water availability (see figure 9 for characterization of perennial crops). Considering the low water-use efficiency and cropped area of the WOP situation, it was estimated that only 70 per cent of the area of perennial crops could be irrigated in drought years, even with recurrence to alternative sources of water (as defined in step 2). This means that, in those years, 30 per cent of perennial crops would not produce any benefits in the WOP situation. In the WP situation, despite the increase in area cultivated with perennial crops (as characterized in step 4), this area is still only 80 per cent of what can be guaranteed by direct intakes from the river and shallow wells during drought years. Thus it is estimated that, in the WP situation, the whole area of perennial crops would be irrigated during dry years. It was also assumed that use of water from shallow wells and direct intakes from the river would cause a decrease in productivity due to a presumably lower water quality.
- *Step 8.* Plant development stages for perennial crops, perennial plant productivity changes due to water stress and cropped area of annual crops were estimated for each year, for WP and WOP situations, depending on water availability in the reservoir each year (figure 10). An algorithm attributes a code to each year depending on the area restricted (according to the criteria established in step 3) and the level of water stress to which perennial crops are subject.
- *Step 9.* Project cash flow was calculated (figure 11). An algorithm crossed data on costs and revenues from crop budgets with information estimated in the previous step on the development stage of perennial crops and a decrease in production due to water restrictions and stress. This enables computation of annual gross margins for annual and perennial crops. Irrigation energy costs were then deducted from these gross margins. Energy costs were modelled for each year using the water actually supplied to each plot. This means that, in each year, energy costs depend on that year's evapotranspiration, cropped area, precipitation, water allocation for irrigation, irrigation efficiency and period of irrigation under each energy tariff. All these data were inserted in the previous steps.
- *Step 10.* Incremental net benefits were estimated for the inhabitants of Cruzeta based on the volume increase in available piped water during the months subject to water shortages in the WOP situation. Water withdrawal per capita is higher in Cruzeta than in most European countries. Given high consumption and the fact that water in Cruzeta is priced at a flat rate, which provides no incentive for water savings, the marginal value of water of the last 80 per cent of consumption in a month with full supply was considered to be zero. On the other hand, when this saved water is supplied during what would be a month without water availability in the WOP situation, its value[4] was considered to be 5.53 Brazilian reais (R$)/m^3.
- *Step 11.* Finally, investment and maintenance costs were added to the cash flow.

Results

This component's results need to be interpreted in context: the investment was made in one of the poorest – and most vulnerable to weather variations – regions of Brazil. Alternatives to investment in income-generating activities are scarce, and peoples' livelihoods, including those of farmers of the irrigation scheme, are extremely vulnerable to weather conditions. Thus the expected economic IRR of 13.6 per cent (figure 1) can arguably be considered a good result. Figure 1 also shows a reduction in the number of months in which water volume available in the reservoir is not enough to satisfy demand – an important project achievement.

4 Median average water price charged in 27 European countries converted to Brazilian real in GDP purchasing power parity. European prices were considered a benchmark as they are prices of water where access to piped water and the capacity to pay for it are virtually universal, and should thus represent a minimum threshold for the economic value of water (this price is less than 33 per cent of the cost of water supplied by trucks in Brazil, rendering the estimated benefits rather conservative).

Financial results (figure 2) indicate that the average gross margin per hectare has also increased considerably for perennial crops, as the project, in addition to contributing to an increment in yields and a reduction in operational costs, has enabled their irrigation with water from alternative sources in dry years. This has resulted in lower decreases in yields in dry years, uninterrupted perennial plant development and reduced plant mortality. A risk analysis tool that performs Monte Carlo simulations was used (see the note on 'Probabilistic risk analysis'). Variation ranges were attributed to the most uncertain project variables using a triangular function in which the maximum cost was the cost of water supplied by truck during a drought and the minimum was the local water tariff/m³ (figure 12). The figure shows that with a confidence of 49% the project IRR will fall between 12 per cent and 6 per cent. It also shows how unlikely it is for this indicator to be lower than six per cent (one percent).

Presentation of results

TABLE 1

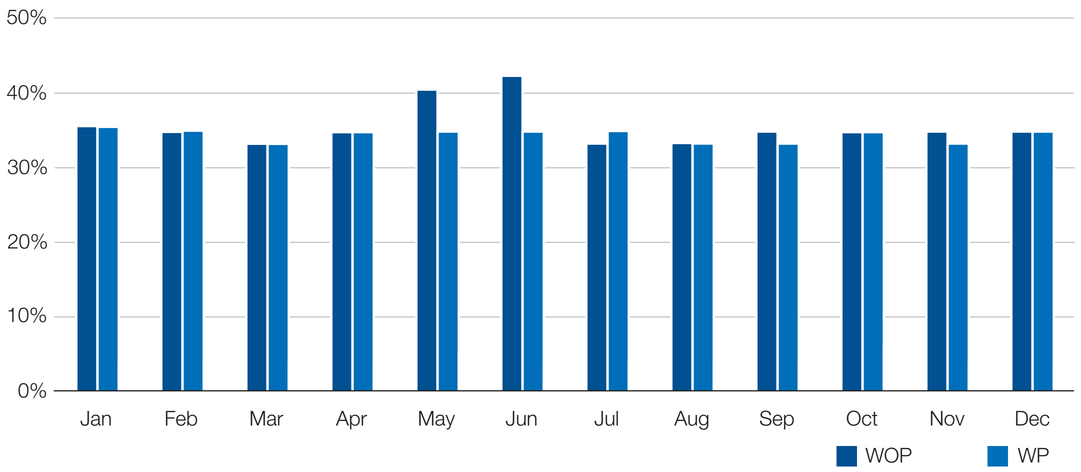
Example of presentation of project economic results, considering water supply for agriculture and urban consumption

Aggregated results in a 30-year period in Brazilian real Agriculture	WOP	WP
Total net benefits in 30 years		3,192,313
Number of years with negative net benefits	5	2
Years with irrigation water deficit in at least one of the months	67%	59%
Average number of months per year with water deficit	5.5	4.9
Months with water deficit	46%	41%
Months with water deficit above 50% of demand from irrigation	36%	35%
Total		
Total investment	**3,945,609**	
Net present value	**1,132,456**	
Internal rate of return	**13.6%**	
Discount rate	6%	

Urban supply	WOP	WP
Water shadow price (R$/m³)		5.3
Total net benefits in 30 years		3,831,157
Number of years with negative net benefits decrease		0
Years with water deficit in at least one of the months	44%	41%
Average number of months per year with water deficit	2.4	1.5
Months with water deficit	20%	13%
Months with water deficit above 50% of demand	20%	13%

Note: Economic results for urban supply assume that the marginal value of water of the last 20% of water demanded in a year of full availability is zero. Hence, there is no benefit loss brought about by the project in the years in which the water consumption cap is above 80% of demand. As such, the NPV translates the present value of the water supplied in the situation with the project in the months during which without the project there would be no water supply minus the present value of the water that is not supplied during years with a water supply cap lower than 80% of demand.

Share of months in a 30 years' period with water deficit above 50% of the demand from irrigation



Share of months in a 30 years' period with water deficit with regards to the demand for urban supply

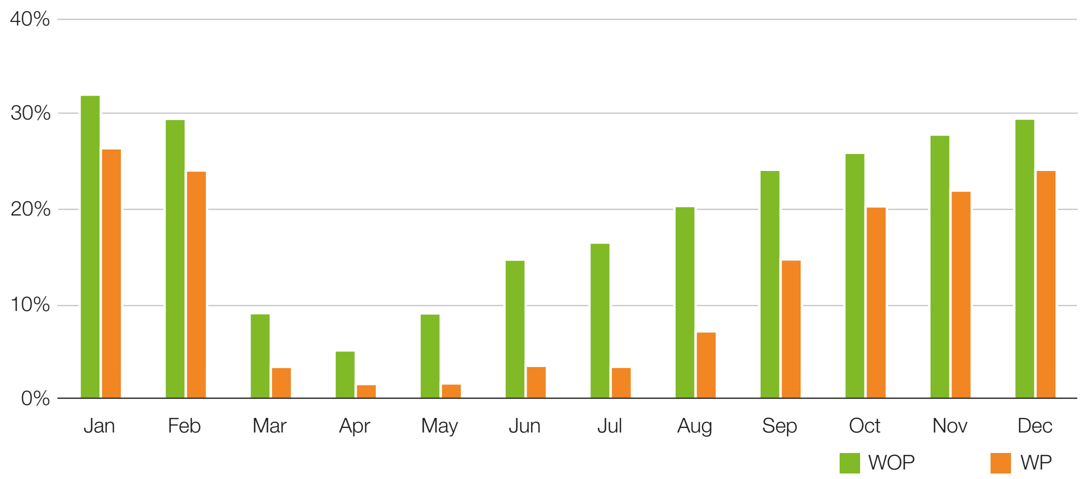


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TABLE 2

Example of individual crop performance assessment (financial)

Gross margins in years with full water availability	WOP	WP	Incremental
Annual crops			
Tomato	1,096	3,272	2,176
Beans	5,880	6,465	585
Cassava	15,340	16,720	1,380
Forage	6,980	7,610	630
Forage maize	4,410	4,830	420
Sorghum	7,114	7,688	574
Melon	9,680	10,425	745
Other	1,180	2,920	1,110
Perrennial crops			
Papaya	10,880	13,420	2,540
Guava	17,341	19,556	2,215
Banana	8,912	10,752	1,840
Acerola	13,704	15,864	2,160
Mango	6,007	6,647	640

Average gross margins for perennial crops should be calculated, as well as their standard deviations and number of years with negative results.

Average gross margins in a 30 years' period	w/out project	w/project	Incremental
Perrennial crops			
Papaya	5,514	7,602	2,088
Guava	12,562	15,435	2,873
Banana	6,010	7,992	1,982
Acerola	8,089	11,174	3,085
Mango	3,169	3,744	575

Data requirements

TABLE 3

Extract of 20-year historic water inflow to and outflow from the reservoir

Data to model behaviour of water reservoir.

1. Precipitation (mm)												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1936	12.9	39.2	50.7	74.1	58.3	109.9	19.2	0.2	0.0	0.0	0.0	1.0
1937	1.5	101.3	177	81.5	108.1	39.3	31.2	0.6	0.0	1.9	3.0	48.7
1938	28.2	0.4	154.6	219.0	66.9	7.1	1.7	4.1	0.3	0.0	0.0	0.0
1939	80.4	39.7	156.8	26.5	62.4	10.6	31.9	5.6	9.0	37.3	1.1	2.4
1940	151.8	79.0	314.2	176.5	140.7	36.6	4.4	5.7	0.0	0.0	0.0	3.7
1941	1.7	104.2	172.1	36.1	18.1	23.7	10.6	7.3	1.1	0.2	0.0	1.2

2. Evaporation (mm)												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1936	262.0	211.2	183.3	155.1	166.9	200.7	258.3	316.9	351.0	372.1	337.5	316.8
1937	262.0	211.2	183.3	155.1	166.9	200.7	258.3	316.9	351.0	372.1	337.5	316.8
1938	262.0	211.2	183.3	155.1	166.9	200.7	258.3	316.9	351.0	372.1	337.5	316.8
1939	262.0	211.2	183.3	155.1	166.9	200.7	258.3	316.9	351.0	372.1	337.5	316.8
1940	262.0	211.2	183.3	155.1	166.9	200.7	258.3	316.9	351.0	372.1	337.5	316.8
1941	262.0	211.2	183.3	155.1	166.9	200.7	258.3	316.9	351.0	372.1	337.5	316.8

3. Monthly average inflow from the river (m^3/s)												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1936	0.0	0.5	0.1	0.1	0.0	0.2	0.2	0.1	0.1	0.1	0.1	0.0
1937	0.0	0.1	0.9	2.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1938	0.0	0.0	0.9	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1939	0.0	0.1	1.0	0.3	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.0
1940	0.3	0.6	30.3	16.8	8.4	0.2	0.1	0.1	0.1	0.1	0.0	0.0
1941	0.0	0.1	10.43	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0

TABLE 4

Characterization of alternative water sources (direct intakes and shallow wells) to be used in dry years for perennial crop maintenance

Land plot number	Irrigated area (ha)	Water source type	Flow capacity (l/h)	Litres pumped per day	Monthly flow (m³)	Area that could be irrigated without project (ha)	Area that could be irrigated with project (ha)	Area currently being irrigated (from field data)
1	3.7	n/a		0	0	0.0	0.0	0.0
2	5.0	Shallow well	15,000	15,000	450	0.5	1.2	1.5
3	1.6	Shallow well	15,000	15,000	450	0.5	1.2	1.5
4	2.1	Shallow well	15,000	15,000	450	0.5	1.2	0.0
…					0	0.0	0.0	0.0
			Total irrigated surface			**5.6**	**29.4**	**22.4**

Data on alternative sources of water for when reservoir is empty.

This will establish the maximum area of perennial crops that can be irrigated in water deficit (D) years.

TABLE 5

Criteria for water allocation in dry years agreed to by management committee (according to a water distribution optimization model)

1. Water supply criteria						
Code	**Dam water availability level**	**% of dam's volume**	**Urban consumption**	**Agriculture**	**Volume of water in the dam**	**Water height**
N	Normal =	100%	100%	100%	23,545,745	123.5
R1	Reduced 1 >	95%	100%	80%	22,368,458	123.2
R2	Reduced 2 >	87%	90%	63%	17,812,945	123.0
R3	Reduced 3 >	76%	80%	55%	16,967,678	122.1
R4	Reduced 4 >	65%	70%	19%	15,215,355	122.0
D	Deficit <	59%	60%	0%	7,497,233	121.7

Do criteria apply upstream?	No

Identification of criteria for water allocation among users in the WP situation.

Share of total demand supplied to each sector during year depending on water level of reservoir at end of rainy season. Criteria established through hydrological models developed by engineers to guarantee 18 months of water supply. They are agreed with stakeholders organized in a management committee.

TABLE 6

Estimation of urban and agriculture upstream and downstream water demand

1. Urban water demand	
1.1 Estimated population growth	1.2%
1.2 Urban population in year 1	6,521

1.3 Total water consumption (m³) of urban population considering estimated population increase and average per capita consumption in during recent years

Project year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	61,106.2	53,962.3	58,248.6	55,591.0	57,690.8	57,127.6	62,248.4	60,437.9	59,738.6	58,981.8	62,733.0	61,265.0
2	61,839.5	54,609.8	58,947.6	56,258.1	58,383.1	57,813.1	62,995.4	61,163.2	60,455.4	59,689.6	63,485.8	62,000.2
3	62,581.6	55,265.1	59,655.0	56,933.2	59,083.7	58,506.8	63,751.3	61,897.1	61,180.9	60,405.8	64,247.7	62,744.2

2. Agriculture and industry upstream water demand

Estimation of monthly demands for water from the diverse users.

2.1 Irrigated areas upstream the dam (ha)

Crop	Total	% cult.
Perennial	17.3	
Papaya	7.5	43.5%
Fruit trees	9.8	56.5%
Annual	35.0	
Tomato	2.5	7.1%
Forage	32.5	92.9%
Total	**52.3**	

2.2 Demand from upstream (including industry)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ETo perennial crops (mm)	128.2	114.5	111.4	103.4	99.9	93.8	108.6	125.5	136.8	153.5	146.6	135.2
ETo annual crops (mm)	160.3	143.1	139.2	129.3	124.9	117.3	135.8	156.9	171.0	191.9	183.3	169.0
Monthly volume perennial crops + industry (m³)	19,002	15,925	17,320	15,999	16,183	15,072	17,049	18,730	19,217	21,523	20,166	19,694
Monthly volume annual crops (m³)	32,415	26,138	28,151	25,308	25,267	22,959	27,462	31,725	33,469	38,810	35,877	34,170
Conveyance losses	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Used volume perennial + industry (m³)	19,002	15,925	17,320	15,999	16,183	15,072	17,049	18,730	19,217	21,523	20,166	19,694
Used volume annual crops (m³)	32,415	26,138	28,151	25,308	25,267	22,959	27,462	31,725	33,469	38,810	35,877	34,170

TABLE 6 (CONT.)

2. Demand from the irrigated scheme				
3.1 Irrigated areas				
	Without project		With project	
	Area (ha)	%	Area (ha)	%
Papaya	1.5	1.8%	2.7	2.6%
Guava	3.8	4.4%	6.7	6.6%
Banana	0.7	0.8%	1.2	1.2%
Acerola	1.5	1.8%	2.7	2.6%
Mango	0.5	0.6%	0.9	0.9%
Sub-Total	8.0	9.3%	14.2	13.9%
Tomato	0.64	0.7%	0.7	0.7%
Beans	32.24	37.7%	36.5	35.8%
Forage	10.96	12.8%	12.4	12.2%
Cassava	3.52	4.1%	4.6	4.5%
Forage Maize	18	21.0%	18.0	17.6%
Sorghum	4.48	5.2%	5.3	5.2%
Melon	1.04	1.2%	2.8	2.7%
Other vegetables	6.72	7.9%	7.6	7.4%
Sub-Total	77.6	90.7%	87.8	86.1%
Total	85.6	100.0%	102.0	100.0%

Land use intensity in a year with full water availability

80%

You will require data on changes in cropping patterns and land-use intensity, as well as on reference evapotranspiration for each crop.

3.2 Monthly ETo per crop (mm) [Extract]

Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Papaya	128.2	114.5	111.4	103.4	99.9	93.8	108.6	125.5	136.8	153.5	146.6	135.2
Guava	128.2	114.5	111.4	103.4	99.9	93.8	108.6	125.5	136.8	153.5	146.6	135.2
Banana	160.3	143.1	139.2	129.3	124.9	117.3	135.8	156.9	171.0	191.9	183.3	169.0

3.3 Water demand without project (furrow irrigation) 85.6 ha Irrigation losses 64% Conveyance losses 32%

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average ETo (mm)	144.5	129.0	125.5	116.5	112.6	105.7	122.4	141.4	154.1	173.0	165.2	152.3
Required volume (m³)	253,268	204,222	219,956	197,736	197,421	179,384	214,567	247,879	261,507	303,235	280,317	266,984
Irrigation losses	64.0%	64.0%	64.0%	64.0%	64.0%	64.0%	64.0%	64.0%	64.0%	64.0%	64.0%	64.0%
Used volume (m³)	415,359	33,4924	360,727	324,287	323,771	294,191	351,890	406,521	428,871	497,306	459,720	437,854

3.3 Water demand with project (drip irrigation) 102 ha Irrigation losses 25%

Celula Culturas	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ET0 perennial crops (mm)	122.8	109.6	106.7	99.1	95.7	89.9	104.0	120.2	131.0	147.0	140.4	129.5
ET0 annual crops (mm)	147.3	131.5	128.0	118.9	114.8	107.8	124.8	144.2	157.2	176.4	168.5	155.3
Required volume – per. crops (m³)	22,944	18,501	19,926	17,913	17,885	16,251	19,438	22,456	23,690	27,471	25,394	24,187
Required volume – an. crops (m³)	170,278	137,303	147,882	132,943	132,731	120,605	144,259	166,655	175,817	203,872	188,464	179,500
Irrigation losses	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
Used volume per. crops (m³)	28,680	23,126	24,908	22,392	22,356	20,313	24,297	28,070	29,613	34,338	31,743	30,233
Used volume an. crops (m³)	212,847	171,629	184,852	166,178	165,914	150,756	180,323	208,319	219,772	254,840	235,580	224,375

TABLE 7

Extract of the model of water availability for each sector at the start of an agricultural season for the 30-year time series

Year	Month	Volume of water at the start of the year (m^3)	Inflow from the river (m^3)	Demand from upstream (-) (m^3)	Precipitation on the dam* (+) (m^3)	Evaporation (-) (m^3)
1936	Jan		-	51,416	-	-
1936	Feb	23,545,745	1,216,858	42,062	250,438	1,349,560
1936	Mar	23,440				

Year	Month	Volume after uptake from upstream the dam (m^3)	Water scarcity level Operation	Urban water demand that can be satisfied	Urban water demand (m^3)	Urban water demand actually met (m^3)
1936	Jan		n	100%	69,674	
1936	Feb	20,321,218	n	100%	61,528	61,528
1936	Mar	19,294,858				

Year	Month	Volume available for irrigation (m^3)	Demand for irrigation (m^3)	Restriction level on irrigation	Demand for irrigation actually met (m^3)
1936	Jan		241,527	100%	
1936	Feb	20,259,690	194,755	100%	194,755
1936	Mar	19,228,443	209,760	100%	209,760

With the described data set and the assistance of an engineer, it is possible to model the water availability in the dam for each month for the situations with and without project. The water level in the dam at the end of each rainy season will establish the water restriction level to apply during that year according to the criteria in table 5.

TABLE 8

Example of crop budget (summarized) and correspondent input and output flow from plantation to maturity for a perennial crop

1. Crop budgets (perennial crops)*			
Crop		Years to maturity	Economic life (years)
		4	15
Guava	Unit	WOP	WP
Yield	ton/ha	25.0	26.3
Sale price	R$/ton	1,400	1,400
Losses	% prod.	10%	10%
Total income	**R$**	**31,500**	**33,075**
Plantation costs (year 1)	R$	2,690	2,690
Soild preparation	R$	300	300
Plants	R$	1,750	1,750
Inputs	R$	640	640
Operating costs (maturity)	R$	13,980	13,340
Inputs	R$	760	760
Labour	R$	12,800	12,160
Other	R$	420	420
Gross margin/ha		**17,341**	**19,556**
Benefit/cost (without harvest costs)		**2.3**	**2.5**
Water productivity	**R$/m³**	**1.2**	**1.3**
Sown area	**ha**	**3.8**	**6.7**
% area of the total irrigation scheme	**%**	**4%**	**7%**

* As in any EFA, crop models must be produced for each crop. In the case of perennial crops, it was decided to input costs and benefits for a maturity year. Evolution in costs and benefits from plantation to maturity is defined through a share of costs and benefits defined for maturity.

TABLE 9

Changes in perennial crop yield and operating costs due to water stress

1. Impact of dry years in perennial crops[a] production

Estimated from the defined areas of perennial crops and from the water availability from direct river intake and shallow wells

Without project	Level of water restriction as previously defined					
	N	R1	R2	R3	R4	D
Share of total demand met by the dam	100%	80%	63%	55%	19%	0%
Share of the water demand from perennial crops met by all water sources	100%	100%	100%	100%	100%	70%
Assured production of perennial crops	100%	100%	100%	100%	100%	70%
Drop in operating costs (with regards to the crop budgets)	100%	100%	100%	100%	100%	80%

Note: demand is no longer completely satisfied when the area of perennial crops is larger than the area that can be irrigated with the available water from the dam, direct intakes and shallow wells.

With project	Level of water restriction as previously defined					
	N	R1	R2	R3	R4	D
Share of total demand met by the dam	100%	80%	63%	55%	19%	0%
Share of the water demand from perennial crops met by all water sources	100%	100%	100%	100%	100%	100%
Assured production of perennial crops	100%	100%	100%	100%	100%	100%
Drop in operating costs (with regards to the crop budgets)	100%	100%	100%	100%	100%	100%

2. Yield of perennial crops after drought periods[b] (plant and soil recovery) as compared to a year with optimal water supply and quality

Defines the yields with regards to a year of optimal water, soil and plant conditions as defined in the crop budgets

	Yield in drought years (alternative water sources)	Yield after one year of drought	Yield after more than one year of drought
Papaya	80%	100%	100%
Guava	100%	100%	100%
Banana	80%	100%	80%
Acerola	100%	100%	100%
Mango	80%	100%	80%
Coconut	80%	100%	80%
Cajá	80%	100%	80%
Graviola	100%	100%	100%

[a] Years of water deficit will impact yields of perennial crops and sown areas of annual crops (or cause losses in annual crops if production is not programmed). In the case of perennial crops, for each water availability level and correspondent water consumption cap, the surface area of perennial crops that can be irrigated with water from each water source must be calculated for both WOP and WP situations. Subsequently, changes in yields and operating costs compared with a year of full water availability must be estimated (by an agronomist) and attributed. The same exercise needs to be done for annual crops, considering that priority in water allocation will be given to maintenance of existing perennial crops.

[b] Water from direct intakes and shallow wells may not have same quality and can cause drops in yields in the year in which water is used – and sometimes in subsequent years due to soil salinization and tree damage. Drops in yields due to use of low-quality water and periods of soil and plant recovery can also be input for a more complete analysis.

TABLE 10

Characterization of each project year for attribution of yearly budgets in the cash flow

Drought and plant development scenarios[a] with project												
	2012	2013	2014									
Crop models[b] to be used	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Water height in the dam	122.6	121.7	119.8	118.3	123.1	122.6	119.1	119.4	123.0	123.0	121.5	123.0
Water availability level in July	D	D	D	R2	R1	N	R3	R1	R2	R2	D	R1
Water stress level	6	6	6	7	8	1	4	2	3	3	6	8
Development stage (year after planting) of existing perennial crops (assuming that at the start of the project all existing plants were half way through their economic life)												
Papaya	2	3	1	2	3	1	2	3	1	2	3	1
Guava	8	9	10	11	12	13	14	15	1	2	3	4
Banana	3	4	5	1	2	3	4	5	1	2	3	4
Acerola	5	6	7	8	9	10	1	2	3	4	5	6
Mango	7	8	9	10	11	12	13	14	1	2	3	4
Coconut	15	16	17	18	19	20	21	22	23	24	25	26
Cajá	8	9	10	11	12	13	14	15	1	2	3	4
Graviola	5	6	7	8	9	10	1	2	3	4	5	6
Development stage (year after planting) of newly planted perennial crops												
Papaya	0	1	2	3	1	2	3	1	2	3	1	2
Guava	0	1	2	3	4	5	6	7	8	9	10	11
Banana	0	1	2	3	4	5	1	2	3	4	5	1
Acerola	0	1	2	3	4	5	6	7	8	9	10	1
Mango	0	1	2	3	4	5	6	7	8	9	10	11
Coconut	0	1	2	3	4	5	6	7	8	9	10	11
Cajá	0	1	2	3	4	5	6	7	8	9	10	11
Graviola	0	1	2	3	4	5	6	7	8	9	10	1

[a] Depending on water restrictions for each year and on soil and plant damage caused by drought in previous years, different adjustments to each crop's financial results must be made. In this case study, codes 1 to 8 were attributed to each possible case so that project cash flow can compute inter-year variations in costs and benefits accordingly.

Financial models for each case of water stress

8 Perennial crops recovery after one year of drought (reduction in yields of perennial crops).
7 Perennial crops recovery after prolonged drought (reduction in yields of perennial crops).
6 Water supplied only to perennial crops from direct intake and shallow wells.
5 Reduction of 80% in irrigated area.
4 Reduction of 45% in irrigated area.
3 Reduction of 37% in irrigated area.
2 Reduction of 20% in irrigated area.
1 Full water availability for irrigation.

[b] Cash flow must also consider development stage of each perennial crop. In this case study, it was assumed that all existing plantations were halfway through their economic life and that all new plantations would be planted in year 2. This chronogram provided necessary information for an algorithm to attribute costs and benefits to each year of cash flow according to water availability for perennial and annual crops, to soil and perennial plant conditions and to perennial crop development stages.

TABLE 11

Extract of the WP cash flow, investment costs and incremental net benefits*

2. Cash flow with project	D 1	D 2	D 3	R2 4	R1 5
Income					
Income from perennial crops	**241,353**	**240,992**	**303,559**	**369,865**	**409,213**
Papaya	40,824	38,783	42,865	81,648	48,479
Guava	125,685	125,685	153,090	180,495	221,603
Banana	14,112	15,792	24,192	12,432	30,240
Acerola	56,700	56,700	79,380	90,720	102,060
Mango	4,032	4,032	4,032	4,570	6,832
Coconut	0	0	0	0	0
Cajá	0	0	0	0	0
Graviola	0	0	0	0	0
Note: Considers the crop development stage in each year as well as productivity losses due to water stress in the year in question and the two previous years.					
Income from annual crops	**83,912**	**83,912**	**83,912**	**741,754**	**898,882**
Operating costs					
Costs of perennial crops	**123,702**	**141,227**	**195,788**	**212,576**	**200,624**
Papaya	29,220	33,252	28,416	52,596	33,252
Guava	50,692	58,493	89,378	89,378	89,378
Banana	9,660	11,280	16,560	9,168	16,560
Acerola	32,460	36,012	58,428	58,428	58,428
Mango	1,670	2,190	3,006	3,006	3,006
Coconut	0	0	0	0	0
Cajá	0	0	0	0	0
Graviola	0	0	0	0	0
Costs of annual crops	**29,047**	**29,047**	**29,047**	**256,765**	**311,157**
Gross margin					
Permanent crops gross margin	**117,651**	**99,765**	**107,771**	**157,289**	**208,589**
Papaya	11,604	5,531	14,449	29,052	15,227
Guava	74,993	67,192	63,712	91,117	132,225
Banana	4,452	4,512	7,632	3,264	13,680
Acerola	24,240	20,688	20,952	32,292	43,632
Mango	2,362	1,842	1,026	1,564	3,826
Coconut	0	0	0	0	0
Cajá	0	0	0	0	0
Graviola	0	0	0	0	0
Annual crops cross margin	**54,865**	**54,865**	**54,865**	**484,988**	**587,725**
Value of urban water	**2,335,441**	**2,391,052**	**1,577,008**	**463,639**	**1,934,947**
Electricity costs	**5,005**	**5,005**	**5,005**	**20,415**	**31,466**
Engineering project					
Infrastructure works (World Bank)			201,453		
Infrastructure works (government)					
Irrigation material			81,008		
Pumps and pumps house (benef., contrib.)			692,077		
Energy network			175,721		
Technical assistance			37,800		
Other			20,565		
System maintainance			**29,781**	**29,781**	**29,781**

3. Incremental net benefits								
Agriculture net benefits	**-52,055**	**-186,421**	**-22,446**	**294,110**	**-1,038,543**	**-238,750**	**218,290**	**225,686**
Increase in the value of urban water	0	0	0	0	-164,612	528,600	463,639	-206,017
Total net benefits	**-52,055**	**-186,421**	**-22,446**	**294,110**	**-1,960,168**	**-284,703**	**660,670**	**-1,590**

Deficit year: annual crops are irrigated with water available from direct intakes and shallow wells after all perennial crops demand has been satisfied.

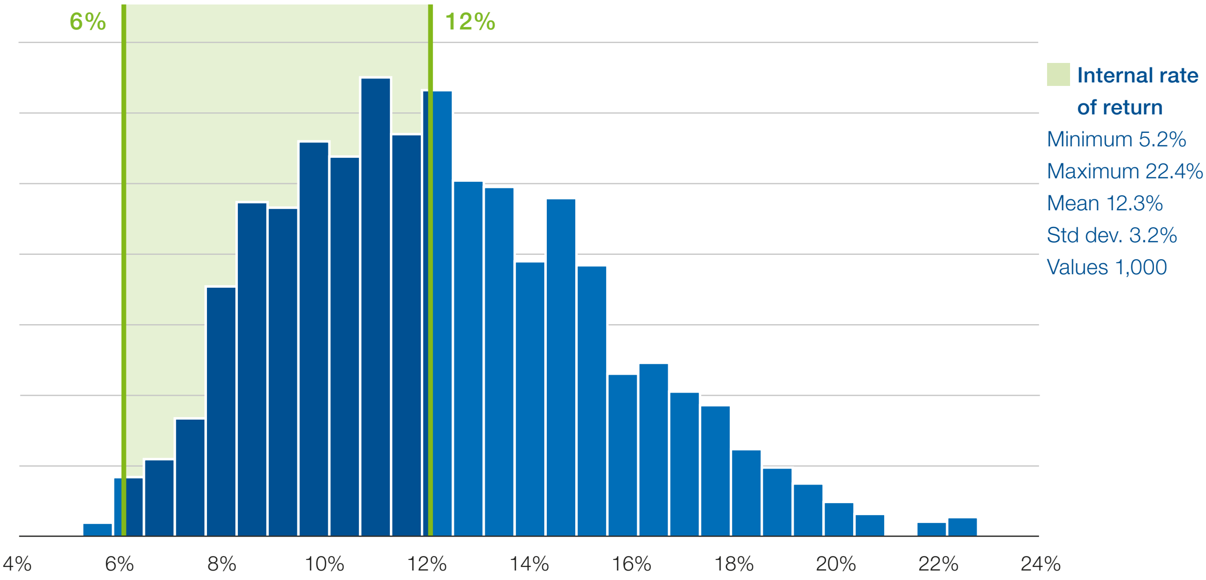
Years with larger water availability mean larger planted areas of annual crops.

Pumping electricity costs depend on water consumption in each year. When tariffs change within the day (e.g. day and night tariffs), it should be calculated how much water can be pumped at the lowest price and how much will have to be left for the higher tariff (depending on water needs and pump capacities).

* Economic IRR and NPV were shown in the summary table depicted in figure 1.

FIGURE 12

Results for the 1,000 iterations conducted with a Monte Carlo simulation*



* Main uncertain variables: domestic water shadow price; land-use intensity; average yield change from WOP to WP situation; expected yield change in water-scarce years; and operational costs.

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CASE STUDY 11

Value chains

Conceptual section

Scope of the note

This note provides methodological guidance for EFA of projects supporting the development of value chains (VCs). Improving a VC entails improving each or some steps along the way, from producer to consumer. In agriculture and agribusiness, VC development projects aim to support farmer productivity, preservation, processing, transportation, warehousing, distribution and/or retailing (IFAD 2014). In the context of a growing interest by IFIs in supporting sustainable and profitable agricultural projects through more efficient VCs, this note seeks to guide practitioners in the analysis of VCs from an economic and financial perspective. In the light of a wide array of available guidelines, a thorough description of EFA procedure for VC projects is not warranted here. Rather, the note summarizes a few methodological requirements for EFA in VCs and presents two practical case studies.

Interventions

The objective of projects supporting VCs is to make the linkages more efficient and profitable between 'upstream' and 'downstream' economic agents (i.e. input suppliers, organized farmers, small and medium enterprises [SMEs], processors, traders, transporters, wholesalers, retailers and financial institutions).[1] For IFAD, in particular, reaching poor rural people through a VC approach is a challenge, as smallholders are generally not integrated into formal VCs and their sustainable inclusion in them is challenging. Nevertheless, there is also evidence that for certain commodities and contexts, small-scale producers can be included in VCs under different business models, for example under public-private-producer partnerships (4Ps) (IFAD 2014) or outgrower and contract farming schemes (FAO 2013; IFAD 2014).

TABLE 1

Example of tangible and intangible benefits from VC activities

Tangible benefits	Due to …
Increased yields (farmers) and intermediate output (processors)	▶ better access to inputs owing to more efficient markets ▶ improved extension services
Increased herd productivity	▶ improved access to animal feed and animal health and extension services
Increased sales and net margins	▶ more efficient output markets (domestic and foreign) ▶ reduced market failures/distortions (investment in public goods such as rural infrastructure, reduction of transport/handling/storage costs, development of market information systems) ▶ better-quality products, resulting in higher prices
Institutional strengthening	▶ development of the commodity platforms 'governing' the VC
Increased trade (export), increased balance of payments and GDP	▶ increased value added at agent and VC levels ▶ improved institutional context and enabling environment (market regulation and functioning)
Intangible benefits	**Due to …**
Improved health	▶ nutrition-sensitive investments along the VC

1 A functional analysis allows identification of VC agents and economic activities.

Benefits

In VC interventions, a number of benefits are expected at private, local and national levels (tables 1 and 2). Benefits may arise: (i) at the 'agent' level, owing to increased yields (farmers, primary producers), herd efficiency (livestock herders, pastoralists, etc.), sales and net margins, quality and variety of outputs and incomes; and improved nutrition, owing to nutrition-sensitive investments along the VC;[2] and (ii) at the national level, owing to increased trade in agrifood products (export).

TABLE 2

Benefits of value chain interventions by value chain agent

Value chain agent	Main potential benefits
Input suppliers[a]	• Increased market/demand for goods • Reduced transaction costs • Increased value addition and income
Service providers[b]	• Increased market/demand for services[c] • Reduced transaction costs • Increased income
Producers (incl. individuals, groups, cooperatives, enterprises)	• Improved access to inputs, services, markets and information • Reduced climate risks due to climate-smart agricultural technologies and practices • Increased production and/or productivity, reduced cost per unit of output • Reduced losses • Improved product quality/increased producer prices • Enhanced market opportunities and increased proportion of farm output marketed • Economies of scale and strengthened position in market (e.g. cooperatives, contracts) • Enhanced access to longer-term credit and cofinancing • Reduced transaction costs • Increased productivity, value addition and income
Processors (incl. individuals, groups, cooperatives, enterprises)	• Improved access to inputs, services, markets and information • Increased output and/or productivity/reduced cost per unit of output • Reduced losses • Improved product quality/increased output prices • Enhanced market opportunities and increased volumes processed and marketed • Enhanced access to longer-term credit and cofinancing • Reduced transaction costs • Increased productivity, value addition and income
Traders (incl. collectors, transporters)[d]	• Increased supply of products • Enhanced market opportunities and increased volumes traded • Reduced transaction costs • Increased income
Marketers (wholesalers, retailers, exporters)	• Increased supply of products • Enhanced market opportunities and increased volumes marketed • Reduced transaction costs • Increased income
Consumers	• Reduced consumer prices • Increased availability of commodities of better quality • Improved food safety

[a] E.g. equipment, seed, fertilizer and agrochemicals (may not be directly targeted by VC intervention).
[b] E.g. technical/advisory, business development, financial and veterinary services. Not value chain agents, but part of enabling environment and may be affected by VC interventions.
[c] Including increased demand as a result of improved quality of services.
[d] May also act higher up in the VC.

2 See the note on 'Nutrition'.

Methodologies and tools

A VC represents a series of activities and mechanisms that create value for a defined commodity/product at every stage of the chain. Thus the two dimensions to consider when screening a specific VC are the physical dimension and the economic dimension.

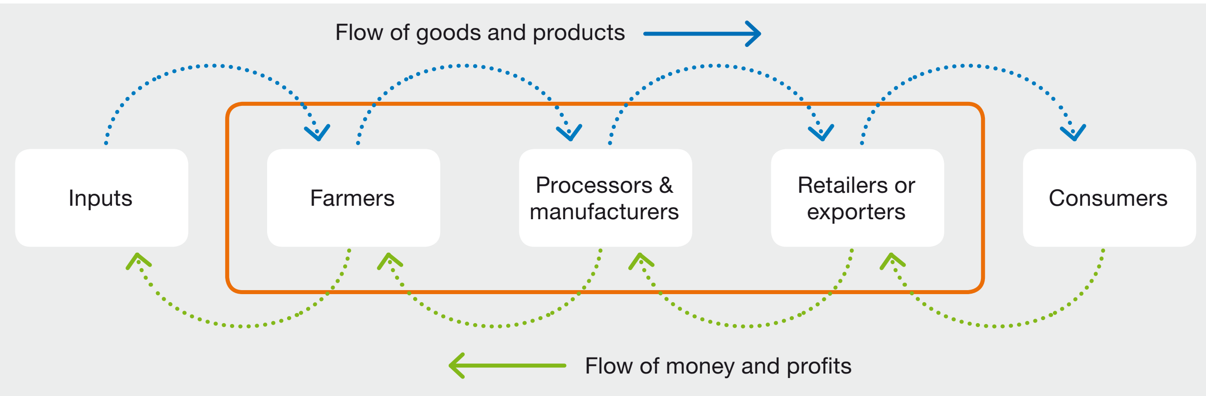
The *physical dimension* relates to the steps and phases concerning product build-up, starting from raw materials as inputs, adding value to the latter through various processes, and selling finished products to customers. Once key elements of the VC are identified (mainly actors and factors), analysis would focus on the physical flow of the main commodities among agents, and on the main bottlenecks affecting the VC. Differently, in the *economic dimension*, the analyst would value the inputs and outputs in monetary terms. Depending on the scope of the analysis, this can be carried out considering market prices or economic prices.[3] The value added (VA), as well as total margins generated at each stage of the chain and their distribution among actors (figure 1), are the key elements of this analysis. However, defining VA in VC analysis is slightly different than in EFA of a VC. In VC analysis it follows accounting standards,[4] while in EFA it follows income statements for cost-benefit investment analysis (Gittinger 1982).

Thus a thorough VC analysis is difficult to perform, especially with limited time and data availability. Depending on the scope of the study, the analyst might opt to narrow down the boundaries and the number of actors under scrutiny, identifying only the main agents in the context of the project to be included (orange square in figure 1).

The suggested technical approach for IFAD-funded projects consists in analysing the financial viability of each agent participating in the VC through a standard CBA. Conceptually, there are no major differences in the analysis of any project when EFA is used as a decision-making tool for investment in VCs.

In financial analysis, models for each player (or only key ones) at each stage of the VC should be described in terms of WOP, WP and incremental situations, so as to determine the financial profitability of each intervention. Economic analysis – based on the financial analysis – includes correction of market distortions through the use of economic prices instead of market prices, identification and valuation

FIGURE 1
Simplified value chain scheme

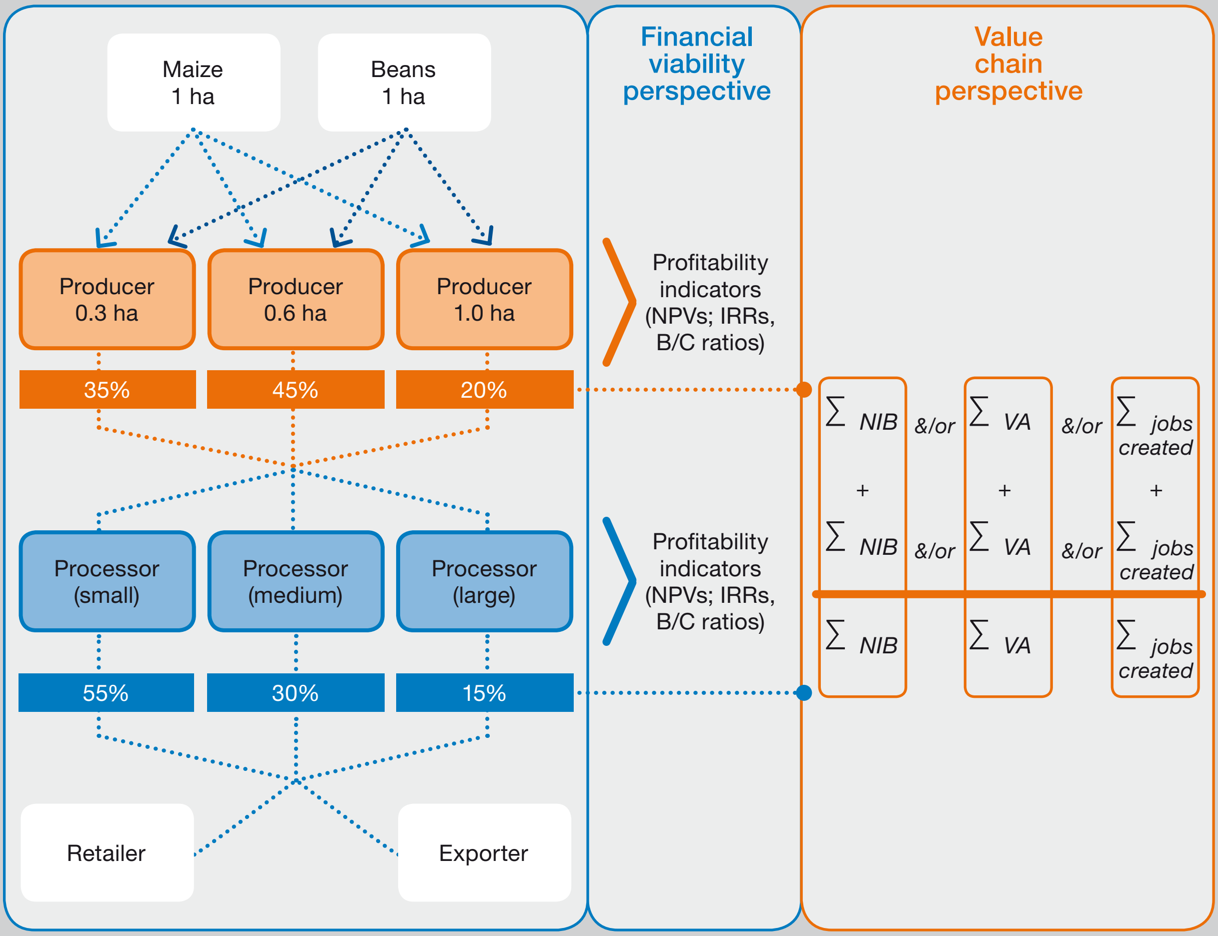


3 Market prices are used to assess the financial profitability for farmers/individuals, while economic prices are considered in evaluating the project for the society as a whole (refer to volumes 1 and 2 for further guidance).

4 The VA is a measure of wealth created in an economic system by a production system (gross revenue), net of the resources consumed by the process itself (e.g. labour, material and services consumed to produce a specific good). 'Gross value added' is the value of output less the value of intermediate inputs, while 'net value added' is the value of output less the values of both intermediate inputs and consumption of fixed capital. From the net value added we can finally obtain the profit (or loss), deducting labour costs (whether employed or from family), taxes, interest (on credit received for purchasing working capital) and rents (payments received by the owner of natural resources).

BOX 1

Value chain analysis



The above figure summarizes the basic logic of VC analysis. The left-hand side shows the usual logical scheme of CBA for an agricultural intervention. Maize and bean crop models are merged into farm models, so as to describe how the proposed intervention would affect producers with different land endowments (0.3, 0.6 and 1 ha). Each farm model is then assumed to represent a share of the overall target population (35 per cent of farmers own a plot of 0.3 ha, etc.). The part of production that is marketed will be conveyed towards processors, whose processing capacity has been specified (e.g. small, medium and large). Equally, each processor model is representative of a part of the overall target population (e.g. the majority are small processors). Final goods will then be in the 'hands' of agents at the end of the chain, responsible for product placement on national and international markets.
Before analysing the whole VC, the analyst needs to check that project activities will result in technically viable and financially sound proposals for project beneficiaries. This implies that profitability indicators, at all levels and for all agents involved, calculated on the differences between WP and WOP scenarios, ought to be positive. Thus single producer and processor models represent the unit of measure for this assessment. Analysis of the VC can then begin by looking at some aggregated indicators as shown in the right-hand side of the figure. These indicators can be expressed in financial or economic terms, each responding to some specific question. For instance, to what extent would the project increase total wealth (i.e. VA) in the chain? Would there be any redistribution effect along the VC and among the agents? Would the project contribute to job creation? All these basic questions can be answered when pooling results from the basic models. For example, if the increase in VA (or alternatively in net incremental benefits [NIB]) is more pronounced for large producers, one could conclude that the project would result in wealth redistribution and increased income inequalities among agents. Can we then define it as a pro-poor VC? To do so, we should check whether the variation of wealth between the clusters of producers, vis-à-vis the respective baseline scenario differences, has been more pronounced for smallholders than for large landholders.

of externalities, and use of a social discount rate (SDR). In this case, the net aggregated incremental benefits of all involved productive units should be compared with total project costs to assess project viability. The main methodological issue is the aggregation of benefits arising from stakeholders involved in the VC but not targeted by the project (i.e. private-sector processors, traders, transporters, wholesalers, retailers and financial institutions, etc.). In these cases, It is advisable to narrow analysis to project target groups.

Other aspects of VCs to consider in economic analysis are: (i) the VA of each agent; (ii) creation and distribution of total VA of the VC among agents (more particularly, poor and disadvantaged groups); and (iii) location of the bottlenecks that impede a fair and competitive distribution of benefits. At this point, the analyst can assess which players are realizing the biggest margins and whether the VC is pro-poor (i.e. inclusive of the poorest smallholders of the chain). The impact on local economies (through job creation and poverty reduction) could complement this analysis.

A conceptually equivalent approach is proposed by Belli and Anderson (2013), which, in effect, considers VC projects several projects in one. Theoretically, they are equivalent to a single project with several components, which might be strictly intertwined or separable. If improving a link in the chain has no impact on any another link, then evaluation of that link should be done independently and accepted only if its expected NPV is

BOX 2

Possible software for VC analysis

FAO VCA-Tool. This tool was developed to analyse and compare the effects of different policy options for agriculture (see case study 2). While the software is mainly designed to support policymaking, it can be used to inform EFA of investment projects – with some methodological caution.[5] The software allows building of: (i) a baseline scenario corresponding to a counterfactual; and (ii) a 'with policy'/'with project' scenario in which policy/project impacts are modelled. It enables CBA and value chain analysis (VCA). More specifically, the software enables calculation of: (i) flows and availability of physical quantities of inputs and outputs; (ii) flows of aggregated costs, benefits, net benefits and VA, at agent and VC levels; (iii) flows of incremental costs, benefits, net benefits and VA for different policies/projects; and (iv) a set of economic indicators, such as profitability indexes, protection indicators (nominal rates of trade protection) and indicators for competitiveness (domestic resource cost ratio, domestic factor ratio, etc.) – enabling construction of a policy accounting matrix (PAM). A detailed manual provides guidance on how to input and manage data, compare scenarios and carry out calculations of indicators for the different components and levels of VC analysis. The manual and case studies are available on FAO's website.[6]

Livestock Sector Investment Policy Toolkit (LSIPT). The LSIPT is a comprehensive analytical tool for analysing livestock projects and policies.[7] It contains five modules and provides various functionalities, such as analysis of livestock VCs, production systems, economy and vulnerability of livestock-dependant households, contribution of livestock to poverty alleviation and to national GDP assessment. Possible investment scenarios or technical changes can be simulated using the models, which can help decision-makers choose the most appropriate investment options. The note on 'Livestock' provides some insights/guidance on how to use the tool's EcoRum module. LSIPT modules can be downloaded from the ALive website.[8]

5 EFA provided by the software does not meet all IFAD requirements (e.g. profitability indicators are not provided and the VCA-tool approach is an accounting analysis rather than a discount cash-flow analysis). Neither does it provide the cash-flow perspective over a number of years. Moreover, it can be difficult to execute in three weeks' time (the usual time spent performing EFAs of IFAD-funded investments, including data collection in the field), considering the data requirements and input labour that the software requires. On the other hand, it is particularly useful for policy analysis in the context of a VC and it certainly helps account for VC development constraints.

6 www.fao.org/easypol/output/browse_by_training_path.asp?pub_id=439&id=439&id_elem=439&id_cat=336

7 LSIPT was designed in the context of the ALive programme, under the leadership of the World Bank, FAO and CIRAD.

8 www.alive-lsiptoolkit.org/tools/download (login: alive, password: toolkit).

non-negative. If, on the other hand, improvement of one link is dependent on the improvement of another, then those links should be evaluated as one unit, as is done with non-separable components.

Lastly, many IFAD-funded VC projects support public-private partnerships (PPP). In these, collective assets are provided or cofinanced by the project on approval of business plans prepared jointly by the association of farmers' groups and its business partners. The collective benefits generated by these types of projects, following Belli and Anderson's approach of linked units, could be assessed by ensuring that each of the PPP business proposals is financially viable and that project support is addressing the key bottlenecks in the VC.

Analytical tools. Literature and guidelines on VC analysis are abundant.[9] Among many references, FAO offers a technical blueprint (Bellù 2012) and software (Bellù and Cappi 2013) for EFA of VC.

Example 1, developed in the context of an investment project in the Niger, and example 2, a policy analysis in El Salvador, are presented as examples of EFA of VC projects.

9 See: Fabre 1994; Bockel, Fabre and Manssouri 1994; Bockel and Tallec 2005; CARE 2012; UNIDO, IFAD and DIIS 2011; and GTZ 2007.

Value chains

EXAMPLE 1

Family Farming Development Programme (ProDAF)

(Niger, IFAD, 2015)

Programme description

The ProDAF, a US$207 million programme to be implemented over eight years in the Niger, targets the Maradi, Tahoua and Zinder regions. It is financed through several sources (IFAD, OFID, the Italian Cooperation, beneficiaries and the Government of the Niger) and includes grants from IFAD's ASAP (US$13 million) and the GEF (US$8 million). Programme objectives are to support the emergence of resilient family agriculture enterprises and promote economic development of agro-sylvo-pastoral production. The programme is structured in two technical components: (i) strengthening sustainable family farming systems; and (ii) facilitating market access and trade.

ProDAF invests in the development of clusters (*pôles de développement economique* [PDE]). In this context, a PDE is defined as a territory in which stakeholders aim to develop and implement coordinated investments to increase commercialization of diversified, high-value, processed commodities for domestic and export markets. Under the VC approach, these PDE integrate various economic activities and agents into production basins, primary (*centres de collecte*) and wholesale markets (*marchés de demi-gros*). These agents include producers, traders, handlers, wholesalers, communities (*mairies*) and market management groups (*groupes d'intérêt economique* [GIE]).

Costs and benefits

Investments include: (i) component 1 (US$78 million) – construction of watershed-management infrastructures, promotion of small-scale irrigation technologies and support to sustainable intensification of crop production; and (ii) component 2 (US$45 million) – rural road rehabilitation, primary/wholesale market construction, institutional strengthening (capacity development within Chambers of Commerce and Agriculture for programme identification and implementation) and social engineering (establishing GIEs from the traditional market management groups [*hadin gwiwa*[10]]). Detailed costs for each component were compiled in Costab. Finally, additional costs relate to programme coordination and management.

The programme will generate financial benefits for all agents operating in the PDEs. Private agents are expected to benefit from improved net margins through increased volumes of products sold and traded on PDE markets. GEF and ASAP investments will strengthen producers' resilience to climate change and induce social benefits such as reduced GHG emissions (positive externalities).

Methodology and assumptions

In each targeted cluster, the net margin of the various VC agents was calculated – for 'with' and 'without investment' situations – through a simple financial assessment of benefits/revenues (arising from the sale of goods and/or the provision of services, etc.) and costs (variable and fixed costs, transport and handling costs, etc.). Price seasonality for the different commodities traded in the PDE was considered in the calculations.[11] All data were recovered from interviews with VC agents and operators of the market information system (MIS). In the 'with investment' scenario, net margins for each VC agent were calculated considering:
(i) a 30-per-cent increase in commodities traded in the PDE after four years (base scenario); and
(ii) a stepped increase in the volume traded in years 1-3 (25 per cent of the optimum in year 1, 50 per cent in year 2, 75 per cent in year 3 and 100 per cent in year 4). The aggregated financial net incremental benefits arising from a PDE (proxy used: the sum of the incremental net margins of all VC agents) were compared with the costs of establishing it (social[12] and civil engineering costs). For each cluster, a financial IRR was calculated over a period of 20 years. A 10 per cent discount rate was assumed, based on the long-term interest rates prevailing in the Niger. A sensitivity analysis was performed to see the impact of more modest assumptions regarding the percentage increase in traded volumes due to the programme (table 4B).

Results

Table 4A shows that the proposed investments are financially desirable for each cluster, with IRR above the opportunity cost of capital and fairly robust results against changes in the main parameter of the model (percentage increase in volumes traded, see sensitivity analysis in tables 4B-C). However, sensitivity analysis shows that some clusters

TABLE 3

Tangible and intangible benefits of PDE (clusters)

Tangible benefits	Due to ...
Increased net margins of PDE economic agents (F)	▶ increased production and volumes sold and better marketing in the PDEs (30% increase in traded volumes)
Intangible benefits	**Due to ...**
Carbon sequestration reduced GHG emissions (E)	▶ increased carbon in biomass and soils, owing to improved watershed management, drought management, sustainability of cropping systems, conservation agriculture, erosion and nutrient depletion control, and flood risk management
Institutional strengthening	▶ establishment/strengthening of market management groups (GIE)

Note: F = financial benefits, E = economic benefits.

10 In the Houssa language, 'consultative group', which includes all market users.

11 Three periods were considered: September-November, December-February and March-August.

12 In the ProDAF, social engineering consisted in institutionalizing forums involving the various market agents.

TABLE 4A

Financial IRR per cluster (base scenario)

Cluster	Products traded	Investment (US$)	IRR	Model assumption
Tessaoua	Millet, cowpea, sorghum, sesame, groundnuts	2.2 million	14.2%	+30% increase in traded volumes due to the programme
Dogueraoua	Tomato	0.3 million	26.7%	+30% increase in traded volumes due to the programme
Guidimouni	Onion, squash, cabbage	0.6 million	48.0%	+30% increase in traded volumes due to the programme
Bandé	Sugar cane	1.1 million	28.0%	+30% increase in traded volumes due to the programme

TABLE 4B

Financial IRR per cluster (sensitivity analysis 1)

Cluster	Products traded	Investment (US$)	IRR	Model assumption
Tessaoua	Millet, cowpea, sorghum, sesame, groundnuts	2.2 million	10.5%	+20% increase in traded volumes due to the programme
Dogueraoua	Tomato	0.3 million	19.6%	+20% increase in traded volumes due to the programme
Guidimouni	Onion, squash, cabbage	0.6 million	36.0%	+20% increase in traded volumes due to the programme
Bandé	Sugar cane	1.1 million	21.0%	+20% increase in traded volumes due to the programme

TABLE 4C

Financial IRR per cluster (sensitivity analysis 2)

Cluster	Products traded	Investment (US$)	IRR	Model assumption
Tessaoua	Millet, cowpea, sorghum, sesame, groundnuts	2.2 million	6.1%	+10% increase in traded volumes due to the programme
Dogueraoua	Tomato	0.3 million	11.1%	+10% increase in traded volumes due to the programme
Guidimouni	Onion, squash, cabbage	0.6 million	22.0%	+10% increase in traded volumes due to the programme
Bandé	Sugar cane	1.1 million	13.0%	+10% increase in traded volumes due to the programme

(i.e. those trading millet, cowpea, sorghum, sesame, groundnuts) will not be financially viable if increases in traded volumes are less than expected (about a 20 per cent increase is needed to make the cluster viable). Although these clusters may not be financially viable under certain parameters, their results may be compensated by the good performance of other clusters, thus making the overall public investments economically viable. Aggregated economic net incremental benefits from all clusters were compared with economic programme costs. Over 20 years, and under the assumptions used in the analysis, economic IRR is 15.7 per cent and NPV averages US$43.8 million.

EXAMPLE 2

Vegetables value chain analysis and policy option assessment

(El Salvador, IFAD, 2015)

Purpose

This analysis aims to throw some light on two recurrent issues under debate in agricultural VCs: (i) how can the public sector facilitate and promote a more efficient set of investments in VCs? and (ii) what sort of incentives will ensure a more equal distribution of wealth among the operators involved? A thorough analysis of these two dimensions can provide very useful elements for decision- and policymakers at diverse levels of governance.

Description

The study analysed some of these elements in the context of vegetable VCs, focusing, in particular, on two important commodities for El Salvador (tomato and cucumber). The VCA tool developed by EASYPol in FAO was used to perform the analysis. The following subsections show results of three possible policy scenarios aimed at increasing the efficiency and profitability of vegetable production and trade for diverse actors.

Investment scenarios and assumptions

Table 5 summarizes the three scenarios considered to assess how public policies or direct interventions, typically included in IFAD projects, could impact small and medium-sized producers in this VC.

The first scenario (i.e. technical assistance) assumes that in order to increase productivity and reduce post-harvest losses, the Government would promote adoption of higher-quality seed and enhance farmers' capacity through training and technical assistance. It is assumed that the cost of training courses and technical assistance is not paid by producers, but rather fully covered by the Government or a project. The cost of improved seed, however, is fully borne by producers.

The second scenario (i.e. tax incentives) is devoted to increasing access to formal markets by reducing taxes for farmers willing to invest in new production technologies (greenhouses, inputs, etc.). A reduction in income tax rates (of 1-3 per cent) for each actor is assumed.

Finally, the third scenario (i.e. mix) combines scenarios 1 and 2.

Benefits

A project is expected to generate financial and economic benefits to all agents operating in the VC. Producers would mainly realize an increase in net margins and, reciprocally, an increase in volumes sold and traded on the market due to a reduction in post-harvest losses. The Government would instead benefit from an increase in taxes and from exchange rate savings due to reduction of imports.

Methodology

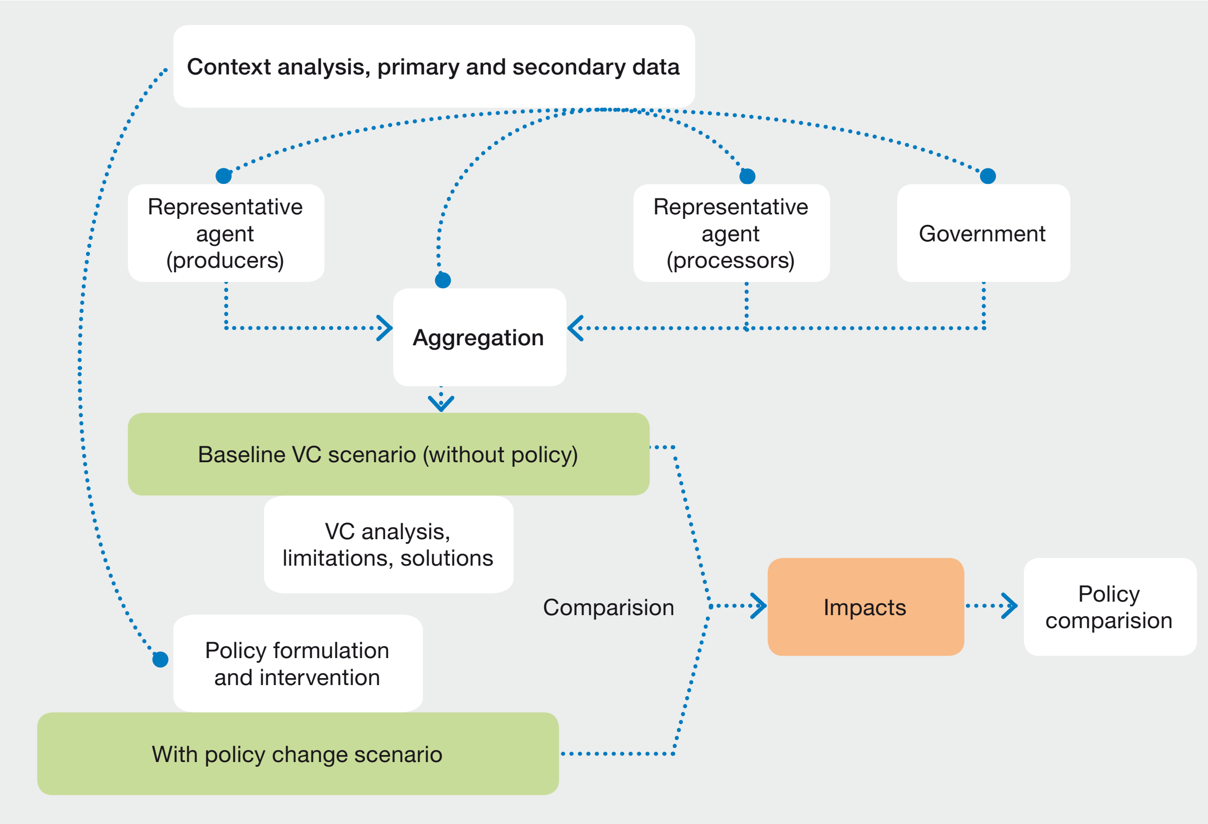
Figure 2 summarizes the approach adopted in the analysis. Basic crop models for tomato and cucumber were elaborated so as to determine representative models for the main actors of the VC (small and medium-sized producers cultivating in greenhouses or in open fields, and cooperatives of small- and medium-scale producers). The Government has also been included as an agent, so as to account for policy contributions to tax leverage. 'With' and 'without intervention/policy' scenarios are then elaborated and compared to identify main outcomes and redistribution effects. Finally, the various scenarios are ranked on the basis of six indicators.

TABLE 5

Impact on small and medium-sized producers

Scenario 1 Technical assistance	Scenario 2 Tax incentives	Scenario 3 Mix
• New seed promotion able to increase production by 10% • Provision of training and technical assistance to reduce post-harvest losses by 50%, while increasing productivity by about 5%	• Reduction in taxes when increasing productive investments (greenhouses, inputs and production factors) • Reduction in income tax: – Small producers from 10% to 9% – Medium producers from 20% to 18% – Cooperatives from 30% to 27%	• Combination of scenarios 1 and 2, assuming simultaneous implementation

FIGURE 2
Schematic approach of the analysis



Results

- *Scenario 1 – technical assistance (TA).* Figure 3 illustrates the different effects of TA activities that aim to reduce post-harvest losses and improve productivity. The most interesting result in the analysis of net profit (profit/losses) is that, among those producers under traditional cultivation, small farmers benefit substantially more than medium-sized ones (an increase over the baseline scenario of 31 per cent for the former and 17 per cent for the latter), indicating a significant policy impact on smallholders. Nevertheless, those benefiting the most under this scenario are cooperatives and medium-sized producers using greenhouses, with 49 and 43 per cent increases in margins respectively, confirming the great profitability of greenhouse vegetable production.

Other very relevant results concern:

(i) A 20 per cent increase in total production equivalent to 13,000 tons and a 13 per cent decrease in imports of about 16.7 tons;
(ii) An increase in total production of 1,300 tons owing to the introduction of improved seed;
(iii) A reduction in post-harvest losses of 1,800 tons, and an increase in productivity of about 300 lb/*mz*[13] due to training;
(iv) Additional government revenues in the form of taxes equivalent to US$2.3 million (+43 per cent).

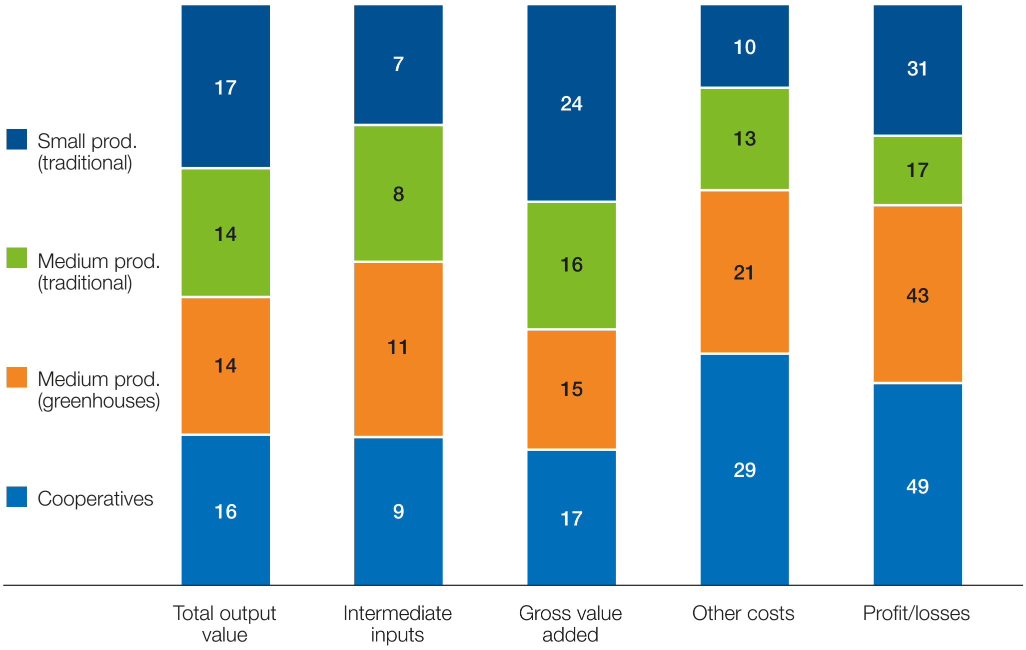
The B/C ratio[14] for the Government is 1.29, indicating that every dollar invested in the TA policy would generate an additional net positive fiscal impact of 29 cents. The social B/C,[15] which considers benefits

13 A *manzana* (*mz*) is a unit of area in Latin American countries; one *manzana* is equivalent to almost 0.7 ha.

14 The ratio has been calculated as a variation of the taxes collected owing to increased production, divided by the cost of the policy.

15 The numerator of the social B/C ratio is the difference, in monetary terms, between the variation in domestic production channelled into formal markets (hence subject to taxes) and the variation in imports of the same product. The denominator includes the cost of the policy.

FIGURE 3
Percentage variations with respect to the baseline



from an increase in production and productivity at the country level vis-à-vis the reduction of imports, is equal to 2.04. This result indicates that every dollar invested under this policy framework would leverage benefits of up to US$2.04 for the society.

- *Scenario 2 – tax incentives.* This scenario simulates a tax relief mechanism for those farmers willing to invest in new production technologies. Savings derived from this policy must be reinvested in newer technology to facilitate modernization of the agriculture sector.

FIGURE 4
Percentage variations with respect to the baseline

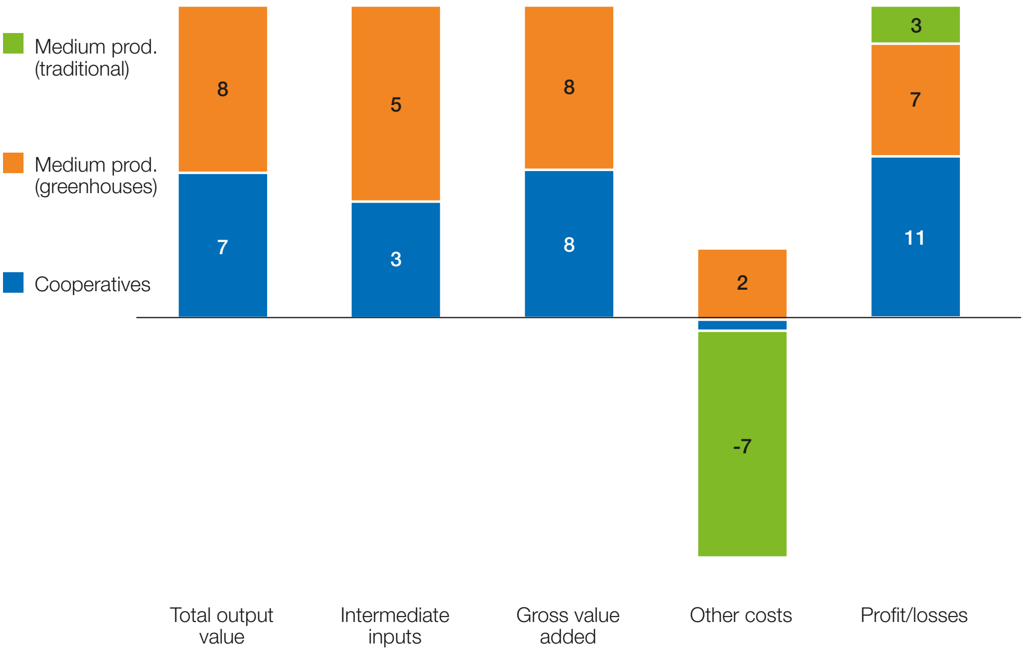
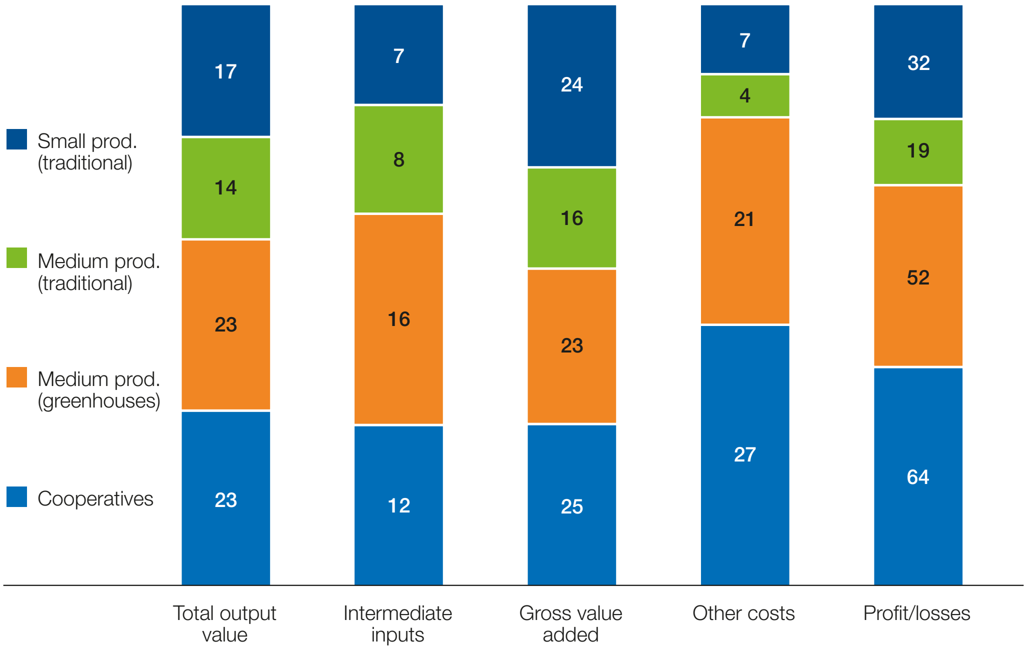


FIGURE 5

Percentage variations with respect to the baseline



This policy will mainly affect those producers with a stake in reaching formal markets and that are currently paying greater shares of taxes (medium-sized landholders and cooperatives). Given the modest impact on smallholders under this scenario, they are not included in figure 4. In contrast, medium-sized landholders and cooperatives will benefit from increases in gross and net value added, as well as from reduced expenditures owing to the lighter tax regime. Overall production will increase by about 6,022 tons (+8 per cent), with average growth of 36 tons for medium-sized landholders and 134 tons for cooperatives. In addition, imports of tomatoes are reduced by 6,539 tons (-5 per cent) vis-à-vis the baseline scenario.

Under this scenario, the B/C ratio for the Government could not be calculated, as the policy does not generate direct gains at the fiscal level (quite the opposite, the Government bears a loss for reducing taxes). However, for the society as a whole, the social B/C ratio reaches 1.68, indicating that every dollar invested under this scenario will ultimately leverage a gross positive impact for the society of US$1.68.

- *Scenario 3 – a mixed strategy.* This scenario simultaneously combines the two already tested public interventions. Total gross value added and profits show positive changes. Profit margins are more pronounced for cooperatives and technologically advanced medium-sized producers. Yet we should note that a cooperative is ultimately an aggregate of small-scale and medium-sized producers and that the impact on independent small producers is quite substantial (+32 per cent).

Other relevant results concern a reduction in imports of 23,455 tons (-18 per cent) and an increase in production of 20,000 tons (+30 per cent). Similarly, government revenues will still increase for a total of US$1.82 million (+34 per cent). But despite these positive figures, results are slightly lower than those obtained under the first policy scenario. Indeed, the government B/C ratio lowers to 1.02 due to the combined effect of tax reduction and capacity-building costs, but the mixed policy scenario remains a viable option for the Government. The social B/C ratio, on the other hand, is equal to 2.48, indicating that tax alleviation and technical support, when jointly pursued, constitute the most viable and socially desirable policy option among the three scenarios.

Table 6 provides an outcome comparison under the three policy scenarios. It can be noticed immediately that combining the two policies (third scenario) obtains the best results on three of the six indicators considered (i.e. social B/C, reduction of imports and increased production). Scenario 1 (TA) is instead a 'second best' option, as it still generates good results for most of the indicators and precludes changes in fiscal policy, which can always be controversial. Additionally, this scenario is a pro-poor option, as the policy has a relatively greater impact on smallholders than on medium-sized producers. Finally, scenario 2 cannot be considered as desirable as the other two policy options, as it generates low results and induces a net fiscal loss for the Government, while contributing very little to smallholder welfare.

TABLE 6

Results

Indicator	Policy 1 TA	Policy 2 Tax	Policy 3 Mixed
B/C (Government)	++	n/a	+
Social B/C	++	+	+++
Increase in tax revenues	+++	- /+	++
Policy cost per beneficiary	+	++	+
Reduction of imports	++	+	+++
Increase in production	++	+	+++

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CASE STUDY 12

Water and sanitation

Conceptual section

Scope of the note

IFAD's interventions in the water, sanitation and hygiene (WASH) sector are usually limited to activities that are not the core of the project, but are embedded in a component focusing on irrigation or community-driven development.[1] Thus the present EFA note aims to support analysts in quantifying return on WASH investments in terms of IRR and NPV, as is the case with EFAs of other IFAD-funded interventions.[2]

Interventions

WASH investments tackle the three dimensions of water, sanitation and hygiene. They include the construction and/or rehabilitation of drinking water supply schemes and sanitation facilities, and campaigns and training in hygiene.

Benefits

The benefits of water and sanitation interventions are multidimensional (economic, social, human) and can be found at various levels (household, community, society/economy). Their relevance varies substantially according to the local cultural and economic context and the targeted population. These projects generate direct monetary benefits, but also important benefits in terms of health and time freed, which are less easy to value. The main tangible and intangible benefits resulting from water and sanitation investments are presented in table 1. The benefits of avoided days of school absenteeism, avoided loss of life and improved nutrition are usually difficult to translate into monetary terms.[3]

Methodologies and tools

The quantification of financial and economic benefits mentioned above can be undertaken through various methodologies that estimate incremental benefits compared with WOP situations. To estimate the direct financial and economic benefits related to time, cash and natural resource savings, the following methodology can be adopted for savings occurring at both the household/private level and the macro/public level: (i) estimation of cash and time savings per unit; (ii) valuation using financial prices and labour opportunity costs when relevant to financial analysis; (iii) valuation using economic prices; and (iv) aggregation based on number and phasing for economic analysis.

To estimate the losses avoided from illness or death occurring at the private or public level, the first steps consist in: (i) examining statistics for each benefit if available; and (ii) estimating the likely frequency and severity of potential future incidence in the targeted population. A two-pronged approach can then be adopted: (i) valuation of non-productive days avoided through the opportunity cost of labour, both financial and economic; and (ii) valuation of avoided losses of human capital, including the long-term impact of illnesses and death, using the DALY methodology. The DALY approach is described and used in an example in the note on 'Nutrition'.

1 Other IFIs, such as the World Bank or AsDB, have substantial investments in the water and sanitation sector.

2 There is an ethical debate on the relevance of conducting an economic analysis of WASH projects, as their public good nature, social impact and importance to life are no longer questioned. Instead, there is a shift towards performing a sustainability analysis of WASH investments, focusing on the financial resources needed (water tariffs, government subsidies) to ensure sustainability, such as cash flows to cover O&M costs or debt service when applicable. This aspect is not presented in this note, as it is depicted well in the literature on financial analysis. See FAO's RuralInvest guidelines (FAO 2007) for sustainability analysis of non-income-generating projects.

3 See the note on 'Nutrition' for methodological hints on quantifying these benefits.

TABLE 1

Main tangible and intangible benefits of water and sanitation interventions

Tangible benefits	Due to ...
Reduction of access time	▶ not having to collect water from the original water source, to spend time travelling for sanitation or waiting in a queue[a] (convenience time) – *case studies 1 and 2*
Reduction of private water expenditures	▶ not having to buy drinking water or water treatment products (if higher than O&M costs paid by households)
Reduction of private health expenditures	▶ reducing WASH-related diseases – *case study 2*
Reduction of public health expenditures	▶ reducing public campaigns to treat WASH-related diseases such as diarrhoea or cholera
Avoided income loss	▶ days lost from work avoided due to fewer sick days for: (i) working adults; and (ii) ill-child caretakers – *case study 2*
Avoided days of school absenteeism	▶ sick days avoided through consumption of better-quality water and access to sanitation facilities – *case study 2*
Avoided loss-of-life	▶ decreasing ill-health, disability or early death, in particular regarding under-five children[b] and maternal mortality[c] – *case study 2*
Reduction of water losses	▶ eliminating leakages of previous systems – *case study 1*
Improved nutrition	▶ (i) better absorption of food nutrients through reduced water-borne and sanitation-linked diseases;[d] and (ii) time freed for women is dedicated to child nutrition or breast feeding[e]
Reduction of production costs	▶ increased supply of water for the economic activity, small local business or industry requiring it
MSME and job creation	▶ additional economic activities resulting from service and suppliers related to sanitation and water facilities
Increased revenues	▶ tourism and other investments fostered by improved facilities. In IFAD projects, WASH interventions are usually embedded in agricultural and livestock production components with potential increases in revenues as well (check for potential double-counting)

Intangible benefits	Due to ...
Avoided human capital losses	▶ reducing physical and cognitive stunting from water-related nutrient-consuming parasites and other sanitation-linked diseases that aggravate malnutrition, retard children's physical development and result in poor school attendance/ performance – *case study 1* (school absenteeism)
Improved gender equality	▶ (i) relieving the time and energy spent by women collecting water and looking after sick family members; (ii) contributing to reduction of maternal mortality; and in some countries (iii) improving security and safety when distance travelled is reduced
Environmental sustainability	▶ more sustainable ecosystems through improved water management and quality

[a] 2.5 days per person per year in African countries (Economics of Sanitation Initiative).
[b] According to WHO, good sanitation reduces diarrhoea morbidity by 32%.
[c] Contaminated water and poor hygiene lead to infections and slow postnatal recovery; poor general health conditions and water collection can generate miscarriages.
[d] Due to worms, which rob their hosts of calories.
[e] Women usually being responsible for water collection, some studies argue that this would liberate time that would be spent caring for children and preparing meals with positive externalities for malnutrition.

The positive incremental benefits of job creation and increased revenues can be valued using the methodology usually applied for small and medium enterprise (SME) creation: (i) establishment of a crop, livestock or enterprise model and financial and economic budgets using WOP and WP scenarios; (ii) estimation of the number of SMEs and phasing, using assumptions in terms of survival rate; and (iii) aggregation to estimate the overall incremental economic benefits. Improved gender equality is an intangible economic benefit that is usually not quantified, but could be integrated through assumptions related to adoption rates of promoted technologies (e.g. the higher a woman's empowerment, the higher the likelihood of adoption).

As mentioned earlier, financial/sustainability analysis of stand-alone drinking water supply interventions can also be done to analyse the potential revenue stream (arising from tariff, local government or community contributions, etc.) and to assess to what extent it would cover O&M costs. As these investments often face the challenge of sustainability once external funding stops, this type of analysis would help determine a pro-poor water tariff that takes into account the willingness and ability to pay and the use of 'smart subsidies'. This approach was not subject to a specific example in these guidelines,[6] although it is relevant to projects with strong social objectives.

BOX 1

Calculating the value of time – opportunity cost of time

The opportunity cost of time should be based on clear assumptions (unemployment rates, evolution of minimum wage over the period, etc.) and should be differentiated according to the population considered (adult/child, work force, rural/urban, etc. – see case study 3). Given IFAD's mandate and targeting policy, projects are usually set up in places where employment is almost non-existent, except for a few public jobs. In these cases, the recommended approach for the opportunity cost of time is the average return to labour per day from the main household subsistence activities, adjusted by the effective number of productive hours per day (3-4 hours/day).

There are different approaches to valuing non-productive time freed from activities such as water collection, reaching sanitation facilities or fetching wood: (i) in some IFAD projects, the average rural wage is used to monetize time freed from non-productive activities; (ii) the Inter-American Development Bank (IDB) assumes that time savings should be valued at 50 per cent of the market wage for unskilled labour; (iii) Whittington et al. (1990) value it at near or above the market wage rate for unskilled labour; (iv) in Nepal, the World Bank made the assumption that 30 per cent of the time saved is devoted to productive activities and was thus valued at full rural market wage; 15 per cent was devoted to household activities and valued at 50 per cent of the rural market wage; and 55 per cent was valued at 25 per cent of the rural market wage.[4] In Ghana, the World Bank valued the opportunity time of working adults at the median income in the targeted area, while 50 per cent of the median income was used for avoided days of school absenteeism and for care of ill children.[5]

BOX 2

Aggregation and phasing

Project outreach. The valuation of the benefits of water supply and sanitation interventions usually requires global statistics (e.g. for diseases/incidence of illness). However, caution is required when applying these statistics to the target population with an eye to adoption rates (see case study 3 – only 30 per cent of WASH-related incidence in the targeted population could be avoided by the project).

Phasing of benefits. Some water- and sanitation-related benefits are medium and long term, and should be integrated into the benefit timeline accordingly, especially for DALYs. Moreover, variables such as population growth (to be assumed over the period of analysis) – which will affect the overall target population throughout the period considered – must be taken into account in analysis (dynamic dimension).

4 World Bank, Water Supply and Sanitation Project.

5 World Bank, Greater Accra Metropolitan Area Sanitation and Water Project (GAMASW).

6 As already noted, the methodology is described well in the literature, but no example on these aspects – either by IFAD or the World Bank – was found in IFI literature.

Water and sanitation

EXAMPLE 1

Rural Assets Creation Programme – rehabilitation of the drinking water supply scheme

(Armenia, IFAD, 2010-2016)

Programme description

The programme aims to support the fruit and nut sector and to improve public infrastructure critical to economic development and improved livelihoods. Specifically, investments in construction and rehabilitation of the water supply, natural gas supply and rural roads are envisaged. This case provides an example of quantifying the benefits of a clean water supply in the programme area, as well as of assessing the viability of rural infrastructure investments.

Investments in water supply involve extending existing distribution networks, increasing the capacity of storage tanks, combining additional water sources to meet present and projected demand and providing adequate purification facilities (IFAD 2010). Design of the water supply schemes is based on a 20-year population projection, assumption of demand of 150 litres/person/day and assessment of demand related to livestock.

Benefits	Costs (financial prices)
• Reduced water losses (leakages in old system) • Time savings of one hour/day/household • Improved health status (clean drinking water)	• Investment costs: 77 million Armenian drams (US$200,000 equivalent) • O&M costs: 1.5 per cent of investment costs (1.16 million drams)

Costs and benefits

The main benefit would be reduced water losses (caused by leakages in the old system) and time savings from not having to collect water from the original source (one hour per day per household). Reduced O&M costs were not considered in this case. Benefits in terms of avoided illness (from consumption of unclean water) are also expected, but are not quantified. Programme costs relate to rehabilitation of a drinking water pipeline (3.2 km), its internal network (3.4 km) and a small pump station benefiting 200 households. Investment costs, including the beneficiaries' contribution, total some US$200,000, and the estimated annual O&M cost is about 1.5 per cent of investment costs.

TABLE 2

Rural Assets Creation Programme – drinking water supply model (financial prices)

Financial benefits			
Time saved			
Average time saved per day	hours	1	
Time saved per year	days	30	(1)
Opportunity cost of labour per day	AMD	2,500	(2)
Benefits per household per year	AMD	76,042	(3) = (1)*(2)
Number of households	HH	200	(4)
Total benefits	**AMD**	**15,208,333**	(5) = (3)*(4)
Avoided water losses			
Annual water losses	m^3	47,000	(6)
Water price per m^3	AMD	25	(7)
Total benefits	**AMD**	**1,175,000**	(8) = (6)*(7)

			Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10-20
Project incremental benefits												
Time saving benefits	AMD	(5)	0	15,208,333	15,208,333	15,208,333	15,208,333	15,208,333	15,208,333	15,208,333	15,208,333	15,208,333
Water saving benefits	AMD	(8)	0	1,175,000	1,175,000	1,175,000	1,175,000	1,175,000	1,175,000	1,175,000	1,175,000	1,175,000
Total incremental benefits	**AMD**		**0**	**16,383,333**	**16,383,333**	**16,383,333**	**16,383,333**	**16,383,333**	**16,383,333**	**16,383,333**	**16,383,333**	**16,383,333**
		NPV @ 10%	124,578,000									
Project costs												
Investment costs	AMD		77,000,000									
		NPV @ 10%	70,000,000									
O&M costs (1.5% of investment costs)	AMD		0	1,155,000	1,155,000	1,155,000	1,155,000	1,155,000	1,155,000	1,155,000	1,155,000	1,155,000
		NPV @ 10%	8,783,166									
Total costs	**AMD**		**77,000,000**	**1,155,000**	**1,155,000**	**1,155,000**	**1,155,000**	**1,155,000**	**1,155,000**	**1,155,000**	**1,155,000**	**1,155,000**
Net incremental benefits	AMD		-77,000,000	15,228,333	15,228,333	15,228,333	15,228,333	15,228,333	15,228,333	15,228,333	15,228,333	15,228,333

IRR	**19%**
NPV @ 10% (AMD million)	**45.8**

Switching values	Appraisal value	Switching value	% change
Incremental benefits (AMD '000)	124,578	78,783	-37%
Incremental costs (AMD '000)	86,661	132,456	53%
Investment costs	77,000	122,794	59%
Operating costs	9,661	55,456	474%

Methodology

First, a financial model of a drinking water supply scheme was established (see table 2) through: (i) calculation of the financial benefits of water savings by multiplying the volumes of water saved by the cost of water per household; and (ii) calculation of the financial benefits per household by multiplying the daily time savings by the opportunity cost of rural labour. Second, an economic analysis of the overall rural infrastructure component was conducted (see table 3). The benefits and costs of the drinking water supply have been converted into economic prices and added to the benefits generated by other rural infrastructure (e.g. gasification and road rehabilitation). The following elements were considered: (i) an average incremental annual net benefit per dollar of investment, estimated using the ratio calculated for each of the three rural infrastructure interventions; (ii) total incremental net benefits, calculated by multiplying this indicator by the amount of estimated investments (considering the gradual increase of such benefits over the six-year period); (iii) an 80 per cent success rate of the three models of intervention; (iv) deduction of financing flows representing transfer payments (grants, contributions and taxes); and (v) a total number of 200,000 beneficiary households.

Results

The drinking water supply model delivers an estimated economic IRR of 19 per cent and an NPV of 45.7 million drams (US$98,918 equivalent), using a 10 per cent discount rate.

TABLE 3

Rural Assets Creation Programme – benefits of rural infrastructure interventions (economic prices)

		Drinking water supply	Gasification	Roads	Average rural infrastructure	
Project costs						
Grant	US$	149,994	187,493	569,977	569,977	
Beneficiary's contribution	US$	16,666	20,833	63,331	33,610	
Total costs	**US$**	166,660	**208,325**	**633,308**	**336,098**	
Project net benefits						
Without project	US$	0	0	0	0	
With project full development	US$	55,850	41,923	208,692	102,155	
Total incremental benefits		55,850	41,923	208,692	102,155	
Incremental annual net benefit of US$1 invested	US$	0.3	0.2	0.3	0.3	(1)
IRR		33.4%	18.9%	30.3%	27.5%	
NPV @ 10% (US$)		273,197	123,527	938,990	198,362	
Average incremental annual net income per US$1 invested (full development)			0.29 (1)			
Success rate			80% (2)			
		PY1	PY2	PY3		
Investment costs (US$ '000)	(3)	9,331	12,365	9,105		

		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10-20
Incremental benefits (US$ '000)											
Phasing of benefits	(4)	0%	20%	40%	60%	80%	100%	100%	100%	100%	100%
Incremental benefits pf year 1	(5) = (1)*(2)*(3)*(4)	0	433	866	1,299	1,732	2,165	2,165	2,165	2,165	2,165
Incremental benefits pf year 2			0	574	1,147	1,721	2,295	2,869	2,869	2,869	2,869
Incremental benefits pf year 3				0	422	845	1,267	1,690	2,112	2,112	2,112
Total incremental benefits	(6)	0	433	1,440	2,869	4,298	5,727	6,723	7,146	7,146	7,146

EXAMPLE 2

Community-based Food Security and Economic Opportunities Programme – village drinking water supply scheme

(Lao People's Democratic Republic, IFAD, 2011)

Programme description

The objective of the programme is to ensure sustainable food security and income generation for poor rural people in target villages. Activities to promote integrated farming systems include the establishment of 40 drinking water supply schemes as a social entry point. The schemes are gravity-fed, taking water from an upland spring or stream, and are designed with 30 per cent more capacity than necessary to allow for population growth over the next five years of implementation. User committees are responsible for maintenance. Of the 40 schemes, 30 will include provision for limited irrigation for home gardening. This case illustrates the benefits experienced at the household level from the provision of drinking water schemes.

Benefits	Costs
• Time savings of about 40 min./day/household • Reduced absenteeism caused by drinking unclean water (225 person-days/year/village)	• Investment costs: US$92,736 • O&M costs: 5% of investment costs (years 2-10)

TABLE 4

Community-based Food Security and Economic Opportunities Programme – economic analysis of a village drinking water supply scheme

Economic benefits				Conversion factor (CF)				
Time saving (water collection)						CF assumed	Weighted CF	
No of families/village	#	75	(1)		(A)	(B)	(C) = (A)*(B)	
No of economically active persons collecting water per family	#	2	(2)	Skilled labour	10%	1	0.1	
No of economically active persons collecting water total	#	150	(3) = (1)*(2)	Unskilled labour	10%	0.5	0.1	
Time saved per day for water collection (20 min.)	hours	0.3	(4)	Fuel	20%	0.6	0.1	
Financial daily wage rate	LAK '000	30		Other costs	60%	1.0	0.6	
Economic unskilled shadow wage rate	LAK '000	15	(5)				0.8	(D) = sum (C)
Total benefits	**LAK '000**	**34,185**	(6) = (3)*(4)*(5)/8*365					
Avoided sick days				Economic costs				
No. of families/village	#	75	(1)	Financial investment cost		110,400	(1)	
Economically active persons per family	#	3	(2)	Economic conversion factor		0.8	(D)	
Economically active persons total	#	225	(3) = (1)*(2)	Economic investment cost		92,736	(2) = (1)*(D)	
No. of sick days per person (linked to drinking water)	days	5	(4)	Maintenance costs		5%	of investment costs	
Financial daily wage rate	LAK '000	30		Economic maintenance costs		4,637	(3)	
Economic unskilled shadow wage rate	LAK '000	15	(5)					
Total benefits	**LAK '000**	**16,875**	(6) = (3)*(4)*(5)					

			Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10-20
Project incremental benefits												
Time saving benefits	LAK '000	(6)	0	34,185	34,185	34,185	34,185	34,185	34,185	34,185	34,185	34,185
Avoided sick days benefits	LAK '000	(6)	0	16,875	16,875	16,875	16,875	16,875	16,875	16,875	16,875	16,875
Total incremental benefits	**LAK '000**		**0**	**51,060**	**51,060**	**51,060**	**51,060**	**51,060**	**51,060**	**51,060**	**51,060**	**51,060**
Investment costs	LAK '000	(2)	92,736									
O&M costs	LAK '000	(3)	0	4,637	4,637	4,637	4,637	4,637	4,637	4,637	4,637	4,637
Total costs	**LAK '000**		**92,736**	**4,637**	**4,637**	**4,637**	**4,637**	**4,637**	**4,637**	**4,637**	**4,637**	**4,637**
Net incremental benefits	LAK '000		-92,736	46,423	46,423	46,423	46,423	46,423	46,423	46,423	46,423	46,423

EIRR	**49%**
NPV @ 10% (LAK '000)	**158,740**

Sensitivity analysis	
ERR – with time savings halved	17%
ERR – with cost of scheme doubled	17%
ERR – with shadow wage rate equal to actual wage rate	99%

Costs and benefits

The expected benefits of the schemes are: (i) avoiding time lost in water collection; and (ii) reducing absenteeism caused by the consumption of unclean water. Costs accounted for in the analysis include: (i) construction of 30 schemes; (ii) training for user committees and government staff; (iii) programme operational costs; and (iv) O&M.

Methodology

The analysis includes a drinking water supply economic model based on the following assumptions: (i) an average number of 75 families per village, with 3 economically active people per household; and (ii) 2 people per household save about 20 minutes per day by avoiding carrying water from the original source (500 metres distant). The number of days saved for 150 people is multiplied by the economic wage rate. Economic benefits of the reduction of sick days are determined by multiplying the average number of person-days saved per village (5 days for 225 workers per year) by the same economic wage rate. Both incremental benefits are fully phased in from year 2. Details are presented in table 4.

Results

The economic IRR of the model, calculated over 10 years, is estimated at 49 per cent for the base scenario. Sensitivity analysis was conducted for various scenarios: (i) time saved halved (IRR of 17 per cent); (ii) shadow wage rate equal to actual wage rate (IRR of 99 per cent); and (iii) construction costs doubled (IRR of 17 per cent). The ERR of the overall programme is estimated at 9 per cent.

Limitations include: (i) full phasing in of incremental benefits from year 2 onwards, while it is unlikely that all drinking schemes will be constructed in year 1; (ii) the choice of a discount rate of 40 per cent is not justified for the drinking water scheme economic model. However, the approach described under this case can be easily replicated for EFA of other projects.

EXAMPLE 3

Greater Accra Metropolitan Area Sanitation and Water Project

(Nicaragua, World Bank, 2013)

Project description

The project aims to increase access by low-income communities to improved sanitation services. It includes four components: (i) provision of water and environmental sanitation services; (ii) improvement and expansion of the water distribution network; (iii) improvement and expansion of environmental waste collection, transportation and treatment; and (iv) institutional strengthening. The sanitation interventions include provision or rehabilitation of household latrines and public toilets. This case demonstrates assessment of the impact of a pure WASH project. Although this is not very common for IFAD, it could serve as an important WASH infrastructure component.

Costs and benefits

Benefits in the analysis comprise: (i) direct private health expenditures avoided due to decreased illness; (ii) income gained as a result of decreased illness-related absenteeism in the working-age population; (iii) income gained as a result of decreased child-illness-related absenteeism among caretakers; (iv) the opportunity cost of school absenteeism among the targeted school-age population; (v) estimated value of loss-of-life avoided as a result of improvements in water and sanitation; and (vi) estimated value of time savings resulting from improved convenience of access to sanitation facilities. Costs include: (i) investment costs of the sanitation infrastructure, comprising public toilet facilities, condominial sewerage network and external wastewater treatment plants, for a total of US$66.7 million (financial); and (ii) operating costs of the sanitation infrastructure for the assumed lifespan of each type of investment, which will be covered by users' fees.

Benefits	Costs
• Reduction in annual private health expenditures • Income gained due to avoided absenteeism caused by illness and by time for accessing sanitation facilities • Income gained due to avoided absenteeism for caretakers as a result of child illness • Future income gained due to avoided days of school absenteeism for school-age population • Avoided loss-of-life	• Construction costs of latrines, water closets and biofilm toilets • Construction of sewerage network • Construction of external wastewater treatment plants • Annual de-sludging costs per household (O&M)

Methodology

Calculation of benefits is detailed in table 5. For avoided direct cash expenditures, avoided health expenditures were calculated based on: (i) the burden of diseases attributable to diarrhoea caused by lack of WASH services, combined with estimated monthly health expenditures per household; and (ii) the share of these diseases prevented as a result of the project.

For the reduction of workdays lost among the working-age population, the methodology includes the following elements: (i) estimated total incidence of illness per person multiplied by the working age population of the project; (iii) WASH-related share of these incidents; (iii) share of the WASH-related incidents avoided through project interventions; (iv) number of workdays lost per incident; and (v) opportunity cost of time saved equal to median income in the target area. The same approach was adopted to estimate convenience time savings owing to closer access to latrines and shorter wait times at public latrines. Only the share of time saved that would be otherwise dedicated to productive activities was kept. The same methodology was used to calculate the incidence of WASH-related child illness, translating into number of workdays lost for caretakers. As not all caretakers are paid for their work, the opportunity cost of time was taken at 50 per cent of the adult population's opportunity cost of time, in accordance with WHO methodology.

For avoided days of absenteeism among the school-age population, the same methodology was applied to estimate the total number of WASH-related absent days avoided through the project intervention. The analysis argues that the opportunity cost of time for this segment of the population must be taken into account, because, although most of the school age population is probably not productively employed, school absenteeism affects the future earning potential of the target population. An economic value to this benefit was thus assigned based on the population's estimated future earnings potential, estimated at 50 per cent of the adult working population's figure.

For valuation of loss-of-life avoided, the DALY methodology is used (see the note on 'Nutrition'), based on the following parameters: (i) DALYs lost per 1,000 people per year among the target population as a result of lack of water and sanitation; (ii) the share avoided through project interventions; and (iii) the minimum wage per year in the target area.

Results

Economic analysis of the latrines intervention was conducted over a period of 20 years, with phasing in from year 2 and a total number of 250,000 low-income householders. The NPV was estimated at US$1.7 million for an IRR of 33 per cent. Results were compared across the various investments of the project, including the sewage and treatment (component 3) and water supply (component 2) interventions.

Based on the benefit streams of each component (table 6), overall economic NPV of the project was estimated at US$26 million for an ERR of 14 per cent. The number of beneficiaries for each type of intervention was adjusted after five years of project implementation to account for demographic growth (3 per cent per year). A similar growth rate was applied to project costs. Sensitivity analysis was conducted with scenarios in which some benefits would be excluded or O&M costs would increase. In the case of exclusion of costs and benefits tied to sanitation activities, NPV would increase to US$50 million and IRR to 18 per cent.

TABLE 5

Greater Accra Metropolitan Area Sanitation and Water Project – latrine infrastructure benefits

Avoided health expenditures			
Average health expenditures per household for WASH-related diseases	US$	113	(1)
Share of diarrheal incidents avoided through project's intervention	%	30%	(2)
Avoided annual health expenditures per household	US$	34	(3) = (1)*(2)
Number of tarteted households	no.	62,500	(4)
Total benefits	**US$**	**2,125,000**	(5) = (3)*(4)

Avoided income losses (adult sickness)			
Sickness incidents in targeted population per year (WHO)	no.	108,125	(1)
Share of WASH-related incidents (WHO)	%	3.6%	(2)
WASH-related sickness incidents	no.	3,920	(3) = (1)*(2)
Share of incidents avoided through project's intervention	no.	30%	(4)
WASH-related sickness incidents avoided through project's intervention	no.	1,176	(5) = (3)*(4)
Number of sick days per incident	no.	2	(6)
WASH-related sick days avoided through project's intervention	no.	2,352	(7) = (5)*(6)
Median income for working adults in the project area	US$	14	(8)
Total benefits	**US$**	**33,160**	(9) = (7)*(8)

Avoided income losses for children caretakers (children sickness)			
Diarrheal sickness incidents in targeted population per year	no.	3,920	(3)
Share of incidents concerning children between 0 and 5 years old	%	19.2%	(10)
Duration of illness (WHO)	days	5	(11)
Number of days lost from work for sick children caretakers	no.	3,765	(12) = (3)*(10)*(11)
Opportunity cost of time of caretakers as % of working adults' opportunity cost	%	50%	(13)
Opportunity cost of time of caretakers	US$	7	(14) = (13)*(8)
Total benefits	**US$**	**26,540**	(15) = (12)*(14)

Value of loss-of-life avoided			
WASH related DALYs lost per 1,000 members per year	DALYs	18	(22)
Targeted population	no.	250,000	(23)
Share of DALYs saved with intervention	%	30%	(24)
DALYs saved with intervention	DALYs	1,350	(25) = (22)*(23)*(24)
Minimum income per year in project area	US$	448	(26)
Total benefits	**US$**	**604,260**	(27) = (25)*(26)

Convenience time savings			
Time saved per day per person (WHO)	min.	30	
Conservative estimate	min.	15	(28)
Time saved per year per person	days	2.5	(29)
Targeted working age population	persons	62,400	(30)
Productive days saved per year	days	156,000	(31) = (29)*(30)
Daily minimum wage	US$	2	(32)
Total benefits	**US$**	**291,000**	(33) = (31)*(32)

Avoided future income losses for school age population due to absenteeism			
WASH-related sickness in targeted school age population per year	no.	1,176	(16)
Number of sick days per incident (WHO)	days	3	(17)
Total absent days in the target population	days	3,528	(18) = (16)*(17)
Opportunity cost of time as % of working adults' opportunity cost	%	50%	(19)
Opportunity cost of time of school age population	US$	7	(20) = (19)*(8)
Total benefits	**US$**	**24,695**	(21) = (18)*(20)

TABLE 6

Greater Accra Metropolitan Area Sanitation and Water Project – synthesis of latrine benefits and total project benefits

Synthesis of latrine benefits Benefits	Annual benefits from latrines		Present value of future benefits from latrines	Present value of future benefits from latrines and condominial sewers
Avoided health expenditures	2,125,000	(5)	13,975,246	17,046,338
Avoided income loss (working adults)	33,160	(9)	218,080	237,503
Avoided future income losses due to school absenteeism	24,695	(21)	162,409	176,874
Avoided income loss (caretakers for sick children)	26,540	(15)	174,543	190,088
Avoided loss of life	604,260	(27)	3,973,968	4,327,908
Convenience time saving	291,000	(33)	1,913,787	2,084,237
Total benefits	**3,104,655**		**20,418,032**	**24,062,947**

Synthesis of total project benefits Activities	Economic life (years)	Primary beneficiaries	Average annual benefits (US$)	First benefits occurrence
House latrines	20	250,000	3,104,655	2nd year of project implementation
Public toilets	20	1,500/day	399,088	2nd year of project implementation
Condominial sewerage	30	12,500	920,000	2nd year of project implementation
Standpipes	20	175,000	3,103,210	2nd year of project implementation
House connections (low income)	30	75,000	3,828,636	2nd year of project implementation
House connections (high income)	30	500,000	25,021,855	2nd year of project implementation

Value of loss-of-life avoided			
WASH related DALYs lost per 1,000 members per year	DALYs	18	(22)
Targeted population	no.	250,000	(23)
Share of DALYs saved with intervention	%	30%	(24)
DALYs saved with intervention	DALYs	1,350	(25) = (22)*(23)*(24)
Minimum income per year in project area	US$	448	(26)
Total benefits	**US$**	**604,260**	(27) = (25)*(26)

Convenience time savings			
Time saved per day per person (WHO)	min.	30	
Conservative estimate	min.	15	(28)
Time saved per year per person	days	2.5	(29)
Targeted working age population	persons	62,400	(30)
Productive days saved per year	days	156,000	(31) = (29)*(30)
Daily minimum wage	US$	2	(32)
Total benefits	**US$**	**291,000**	(33) = (31)*(32)

Avoided future income losses for school age population due to absenteeism			
WASH-related sickness in targeted school age population per year	no.	1,176	(16)
Number of sick days per incident (WHO)	days	3	(17)
Total absent days in the target population	days	3,528	(18) = (16)*(17)
Opportunity cost of time as % of working adults' opportunity cost	%	50%	(19)
Opportunity cost of time of school age population	US$	7	(20) = (19)*(8)
Total benefits	**US$**	**24,695**	(21) = (18)*(20)

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Summary steps in financial and economic analysis

Steps in financial analysis

The typical sequence of tasks to be undertaken in financial analysis is the following:

1. Develop farm/enterprise models and identify benefits and costs (investment and recurrent) for WOP and WP scenarios (based on crop budgets).
2. Compare the discounted flows of benefits and costs and calculate the differences between the obtained results and the WOP scenario in order to determine the net incremental benefits (NIB) of the proposed interventions.
3. Calculate the project financial profitability indicators of each model (i.e. financial NPV, financial IRR and B/C ratio), applying these investment criteria to make an investment decision (positive or negative).
4. Assess family incomes and establish financing/credit needs by performing a 'sustainability analysis'.

Steps in economic analysis

Economic analysis requires assessment of a project's net impact on economic welfare by considering:

5. Convert all market prices into economic/shadow prices (SP) that better reflect the social opportunity cost of the good.
6. Remove transfer payments (taxes and subsidies) and quantify externalities (positive and negative).
7. Aggregate all models' NIB cash flows respecting incorporation phasing patterns of targeted beneficiaries into project's activities.
8. Compare aggregated benefits with other project costs to obtain incremental discounted cash flows. Calculate economic performance indicators adopting a social discount rate: ENPV, ERR, B/C ratio.
9. Perform sensitivity analysis (SA) in order to deal with the main risks and uncertainties that could affect the proposed project.

EFA step by step

Financial analysis

1 WP-WOP develop and identify

Develop farm/enterprise models and identify benefits and costs (investment and recurrent) for WOP and WP scenarios (based on crop budgets).

2 Discount flows – costs and benefit

Compare the discounted flows of benefits and costs and calculate the differences between the obtained results and the WOP scenario in order to determine the net incremental benefits (NIB) of the proposed interventions.

3 Calculate indicators

Calculate the project financial profitability indicators of each model (i.e. financial NPV, financial IRR and B/C ratio), applying these criteria to make an investment decision.

4 Financial sustainability

Assess family incomes and establish credit needs by performing a 'sustainability analysis'.

Economic analysis

5 Shadow prices

Convert all market prices into economic/shadow prices (SP) that better reflect the social opportunity cost of the good.

6 Transfers and externalities

Deduct taxes and subsidies – Consider positive and negative externalities.

7 Aggregation

Aggregate all model's NIB cash flows respecting incorporation phasing patterns of targeted beneficiaries.

8 Cash flows

Compare aggregated benefits with other project costs to obtain incremental discounted cash flows. Calculate economic performance indicators adopting a social discount rate: ENPV, ERR, B/C ratio.

9 Perform sensitivity analysis

in order to deal with the main risks and uncertainties that could affect the proposed project

ISBN-978-92-9072-689-0