Center for Development Research University of Bonn




Ex-ante technology assessment for inclusive poverty reduction and sustainable productivity growth in agriculture (TIGA): A manual

by Malek Mohammad Abdul and Franz Gatzweiler

This publication *Ex-ante technology assessment for inclusive poverty reduction and sustainable productivity growth in agriculture (TIGA): A manual* has been produced with the financial support of from Bill and Melinda Gates Foundation.

Editing: Kristina Mensah/University of Bonn; Dr. MA Mazid/BRAC International
Layout: Katharina Zinn/ZEF
Photo credits: Daniel Mekonnen/ZEF, Saiful Islam/ZEF, Chirstine Husmann/ZEF and Md. Amzad Hossain/BRAC;

Bibliographic information published by the Deutsche Nationalbibliothek
The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at http://dnb.d-nb.de.

ISBN 978-3-00-054594-8

Publisher

Center for Development Research (ZEF)
University of Bonn
Walter-Flex-Strasse 3
53113 Bonn
Germany

Authors' addresses

Mohammad Abdul Malek
Center for Development Research (ZEF), University of Bonn, Walter-Flex-Str. 3, 53113 Bonn, Germany
& BRAC Research and Evaluation Division (RED), BRAC Center, 75 Mohakhali, Dhaka 1212, Bangladesh
Email: malekr25@gmail.com, malek.a@brac.net

Franz Gatzweiler
Center for Development Research (ZEF), University of Bonn, Walter-Flex-Str. 3, 53113 Bonn, Germany
Email: gatzweiler02@gmail.com

EX-ANTE TECHNOLOGY ASSESSMENT FOR INCLUSIVE POVERTY REDUCTION AND SUSTAINABLE PRODUCTIVITY GROWTH IN AGRICULTURE (TIGA): A MANUAL

Malek Mohammad Abdul and Franz Gatzweiler

with contributions by:

Valerie Graw, Devesh Roy, Praduman Kumar, Bekele Hundi, Samual Asuming-Brempong, Hilke Gieseke, Christine Husmann, Saiful Islam, Josefa Yesmin, Md. Latiful Haque, Ikhtiar Mohammad and Md. Amzad Hossain

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List of Acronyms

AEZ	Agro ecological Zone
AGRA	Alliance for a Green Revolution in Africa
AWD	Alternative Wetting and Drying
BEM	Bio-Economic Models
CGIAR	Consultative Group on International Agricultural Research
DAE	Department of Agricultural Extension
DSR	Direct Seeded Rice
EEA	Ethiopian Economic Association
FARA	Forum for Agricultural Research in Africa
FGD	Focus group discussion
GIAN	Grassroots Innovations Augmentation Network
GR 1	First Green Revolution
GR 2	Second Green Revolution
HR	Hybrid Resistant
IAD	Institutional Analysis and Development
IDI	In-depth Interview
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
LFAs	Less favored areas
LLP	Low Lift Pump
LSMS-ISA	Living Standards Measurement Study - Integrated Survey on Agriculture
MCRID	Multiple-Criteria Robust Interactive Decision Analysis
MOI	Market orientation index
MPI	Market participation index
NIF	National Innovation Foundation
PCA	Principal Component Analysis
PO	Producer organization
PWR	Participatory wealth ranking
RCTs	Resource Conserving Technologies
SHs	Smallholders
SRISTI	Society for Research and Initiatives for Sustainable Technologies and Institutions
SRI	System of Rice Intensification
SRV	Senegal River Valley
STW	Shallow Tube Well
SLF	Sustainable livelihoods framework
TIGA	Ex-ante technology assessment for inclusive poverty reduction and sustainable productivity growth in agriculture
TBP	Technology and Business Promotion
USG	Urea super Granule
ZEF	Center for Development Research

1 Introduction

1.1 Background

Based on the recent development of an interdisciplinary research framework on marginality the Center for Development Research (ZEF) at the University of Bonn embarked on a project entitled Ex-ante technology assessment and farm household segmentation for inclusive poverty reduction and sustainable productivity growth in agriculture (TIGA) which intends to identify potentials of marginal rural areas and people by means of technological and institutional innovations. The research activities take place within the broader framework and concept of marginality (von Braun &Gatzweiler2014). The project is implemented in South-Asia (India- Odisha and Bihar, Bangladesh) and Sub-Saharan Africa (Ethiopia and Ghana) in partnership with IFPRI, BRAC, Ethiopian Economic Association (EEA) and FARA, respectively.

The objective of the TIGA project is to enhance the inclusion of poor small farming communities in agricultural technology innovations. Specifically, the project seeks to create a thorough understanding of the interactions between technology needs, farming systems, ecological resources and poverty characteristics in the different strata of the poor, and to link these insights with technology assessments in order to guide action to overcome current barriers to technology access and adoption. In support of the objective to enable all segments of the poor to benefit from crop technology innovations (directly or by secondary growth linkages) the project also aims at identifying technology choices in combination with institutional innovation measures for reaching all strata of the rural poor. The TIGA project identified areas and people with unused potential in marginal locations. Whereas technology-driven approaches tend to favor those with better adoption capabilities, the TIGA approach aims at a cross section of segments of the rural poor which are characterized by varying degrees of overlapping human capabilities and agro-ecological potentials. Inclusive growth in the agricultural sectors of India (Odisha, Bihar) and Bangladeshrefers to addressing these potentials of poor smallholders (SHs) by means of technological and institutional innovations.

The study team based in ZEF in consultation primarily with BRAC and also with IFPRI, EEA and FARA develops the common approach and validates it with the partner researchers. Then the country partners implemented the research project and discussed their findings in three stages (Bonn: September 2012-reviewing the common approach and study area selection process; Addis Abeba: April 2013- reviewing of interim progress; and Bonn: Nov 2013- final findings). Through the process, the study team interacts among the relevant stakeholders both in country level and international level and prepared good report.

1.2 About the manual

The manual presented here is based on the experience and draw out the collected lessons learnt with regard to the design and implementation of TIGA project in the South Asia and Sub-Saharan Africa. As such, this builds on and expands existing guidelines and documentation for agricultural technology assessment. It adds the perspective of technology assessment of including the cross section of segments of the rural poor characterized by varying degrees of overlapping human capabilities and agro-ecological potentials rather than the technology-driven approaches that tend to favor those with better adoption capabilities. The manual also gives the reader a well-documented experience of bottom-up approach for technology assessment. The ultimate goal of the manual is to contribute to the inclusion of all poor small farming communities in agricultural technology innovations by presenting the improved way of understanding of the interactions between technology needs, farming systems, ecological resources and poverty characteristics in the different segments of the poor, and to link these insights with productivity enhancing technologies in order to guide action to overcome current barriers to technology access and adoption.

The main readership targeted by this publication consists of researchers involved in finding appropriate innovations for sustainable intensification in and around marginal areas of South Asia and Sub-Saharan Africa, donor-sponsored agricultural research and/or development projects, Centers of the Consultative Group on International Agricultural Research (CGIAR) working in those areas, international and local non-governmental organizations involved in promoting innovative agricultural technologies within the region, the national and international scientific research and extension community interested in "discovering", and development practitioners in and around those areas who are interested in diffusing agricultural technology innovations.

The following part describes the context of the experiences on which the manual is based, with a brief overview of historical perspectives of green revolution and the changing demands of agricultural technology assessment under which the TIGA project is deigned. Chapter 2 reviews the theory of change and the common approach and the four steps that have been followed for the assessment. Chapter 3 is the heart of the manual as it elaborates the three parts of the assessment and puts experiences from the partner countries.

1.3 From the first to the second green revolution

The first Green Revolution (GR 1) was mainly driven by rapid advances in sciences and substantial public investments and policy support for agriculture. However, the advances were much slower in reaching developing countries. In response, the Rockefeller and Ford Foundations took the lead in establishing an international agricultural research program facilitated mostly by the Consultative Group on International Agricultural Research (CGIAR) to help transfer and adapt scientific advances to developing countries(Tribe 1994). Pingali (2012) found that although GR1positively impacted productivity, fall in real food prices, poverty reduction and food security, it was not always the right answer for solving the numerous problems related to poverty, food security, and nutrition problems. Today, the average farmer in Sub-Saharan Africa harvests just over a ton of cereal per acre, while the average American farmer's crop yield is about seven tons per acre. (BMGF 2011) Despite the remarkable success achieved through GR 1 during the 1960s-90s, the GR 1 had its share of critics. Lessons needed to be learnt from the GR1 and the dominant approaches relating to sustainable intensification and technological innovation for making the second Green Revolution (GR 2) a success. Therefore themarginal and less favored areas[1] (LFAs) in Africa and Asia(hereinafter called "marginal areas") required special attention. The marginality perspective helped to refocus attention on the nexus of poverty, exclusion and ecology and thereby better recognize the systemic links between agro-ecological potentials and human capabilities which can be triggered for productivity growth by technological and institutional adjustments (von Braun & Gatzweiler 2014).

Jones (2005) argued that the past efforts of agricultural development so far were not sufficiently holistic for advancing complex social, environmental, and economic systems and had not been pursued with the necessary long-term vision and willingness to take the risks that were inherent in implementing innovations. Because of the passive role of the end-users, the pipeline approach for agricultural technology innovations has produced less than satisfactory returns on investments in Sub-Saharan Africa (Jones 2005).Thus the traditional 'pipeline' approach was abandoned in favor of a more inclusive and holistic approach. The International Fund for Agricultural Development (IFAD) and The World Bank are following an innovation systems approach that has no formal innovation pipeline or standard criteria for selecting or identifying innovations. Small-scale farmers' own creative responses continue to be important sources of improvement to agricultural productivity in many developing countries. The development and dissemination of innovations depend on the understanding of interactions between stakeholders (Oyeyinka 2004 cited in Jones 2005). The Society for Research and Initiatives for Sustainable Technologies and Institutions (SRISTI), the HoneyBee Network, the National Innovation Foundation (NIF) and Grassroots Innovations Augmentation Network (GIAN) are organizations which have been established to identify, assess, test, promote and develop innovations from smallholders (SHs) in 500 districts of India. Their approach perceives SHs not only as integral part of the innovation system but as valuable source of the innovation process (Gupta 2012).

Building on the lessons learnt from the GR1, the Alliance for a Green Revolution in Africa (AGRA) aims at a strategy to transform today's rural poverty into tomorrow's prosperity by sustainably and significantly increasing the productivity of smallholder farmers (AGRA 2012). AGRA is positioned in Africa's very diverse and largely rain-fed agriculture. The vision of a GR 2 is a single challenge in several layers(The Rockefeller Foundation 2006): improved seed varieties require not only a judicious application of science, but the development of new generations of trained African agricultural scientists, trained agro-dealers who enable the farmers to put the innovations to use, and the development of markets. This manual aims at providing guidance for the actors of the AGRA and many others committed to agricultural productivity growth in Sub-Saharan African and South Asia to achieve their goals.

1.4 Changing demands towards agricultural technology assessments

Recognizing the lessons learnt from the first Green Revolution also requires a different approach to agricultural technology adoption. Thornton,Kristjanson and Thorne(2003) as well as Maredia (n.d.) reviewed agricultural technology impact assessments conducted in the last decades. Following the pipeline approach, such impact assessments consisted of the evaluation of the effects for adopting any particular agricultural technology. The effects that are assessed include changes in production and productivity, income, food security, social welfare, and the environment (Peterson & Horton 1993; Thornton et al. 2003). These different effects are also assessed at different scales, such as the farm, watershed or region/nation. Most impact assessments study change that has already occurred (ex-post) and change that has yet to occur (ex-ante) and they entail mixtures of models and analytical tools to produce appropriate information concerning the effects of this change (Thornton & Herrero 2001).

In the context of poverty reduction and sustainability, the debate about marginal areas has gained much attention in the development literature (Conway 1999; Fan & Hazell 2000; Pinstrup-Andersen & Pandya-Lorch 1994; Pender 2008). Regardless of the past progress in productivity and poverty reduction, about 40% of the rural populations are estimated to live in these areas in developing countries, which face numerous biophysical and socio-economic constraints to sustaining livelihoods (Kuyvenhoven et al. 2004; Leonard 1989; Pender 2008). Hazell (2003) as cited in Pingali (2012) argued that in such areas technologies often bypassed the poorfor a number of reasons, for example, inequitable land distribution with insecure ownership or tenure rights, poorly developed input, credit, and output markets, policies that discriminated against smallholders, and slow growth in the non-farm economy that is unable to absorb the rising numbers of rural unemployed or underused people. National and international research and extension systems as well as the countries policy makers also bypassed these regions (Kuyvenhoven et al. 2004). Consequently, marginalareas are left behind the success from the GR1 (DFID 2000). Even where the GR1 successfully increased agricultural productivity, the GR1 was not always the panacea for solving the myriad of poverty, food security, and nutrition problems facing poor societies (Pingali 2012). Realizing the fact that "one size does not fit all", a more targeted approach is required to exploit the potentials of particular types of households and communities (Ruben & Pender 2004; Ruben et al. 2007).

For that reason Reardon and Chen (2012) advocated for government strategies to be tailored to different strata of farmers at hinterland zones[2]. Ruben et al. (2007) state, for effectivelydeveloping future targeted interventions it is necessary to investigate the types of the (untapped) profitable livelihood options for different strata of households. They investigate the reasons forthose potentials not being exploited and the extent to which policies, public investment and programs could facilitate the fulfillment of those untapped potentials. Pingali (2012) put more emphasis on the improved understanding of tropical and subtropical agro-ecologies to which innovations and new sustainable resource management practices need to be adjusted and advocated for innovative partnerships across the entire R&D value chain to channel the varied expertise for enhancing smallholder productivity growth.

The TIGA project is an attempt to fill the above research gaps by making use of an integrated framework under a wider range of geographical and institutional conditions in marginal areas. The objective of this project is to enhance the inclusion of all poor small farming communities in agricultural technology innovations. Specifically, the project seeks to create a thorough understanding of the interactions between technology needs, farming systems, ecological resources and poverty characteristics in the different segments of the poor, and to link these insights with technology assessments in order to guide action to overcome current barriers to technology access and adoption. The TIGA approach integrates the assessment of the needs and potentials of the different strata of the rural poor living in marginality hotspots – places which are marginal in some human or ecological dimensionsbutalso have hidden human and ecological potentials which can be triggered for productivity growth by technological and institutional innovations.

2 Conceptual framework and theory of change

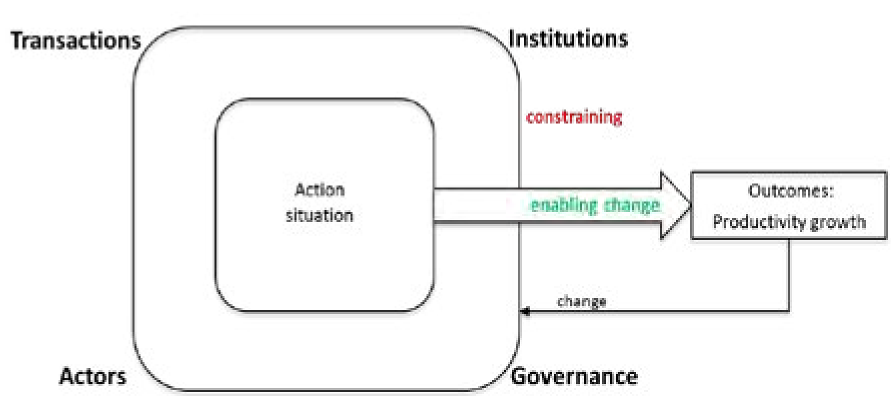
The trajectories of change for productivity growth for poor SHs can be found at different systemic scales. At a macro scale the trajectories of change can be broadly defined by the opportunity costs of land and labor. High opportunity costs of land and labor encourage high value agriculture and the adoption of relatively expensive technologies, whereas low opportunity costs of land and labor can be found in low productivity systems of the majority of the marginalized and poor. Whereas one strategy to improve the productivity of labor is to move people out of marginal lands, there are also areas where the shift is not possible or more costly and adaptation strategies need to be sought.

The conceptual framework and theory of change (Fig. 1) also borrows from the Institutions of Sustainability (IoS) framework of Hagedorn (2008) and the Institutional Analysis and Development (IAD) framework of Ostrom (1990 and Ostrom et al. 1994). It explains how actors with specific characteristics engage in different types of transactions in particular action situations, which are constrained or enabled by institutions and governance structures, thereby producing outputs which themselves can influence those farming conditions.

Adaptation strategies for the rural poor (Fig. 2) require a closer look at the marginality dimensions of poverty, the environment and the institutional framework in order to identify suitable innovations which can potentially lead to sustainable intensification (which can include income and farm system diversification). Innovations need to match the different combinations of higher or lower degrees of poverty mass and rate and agro-ecological potential of the land. Precisely because marginalized people and areas are often not part of the market system, when considering the costs and benefits of adaptation (including migration) as innovation strategy, not only the prices of land and labor need to be considered but also the values of ecosystem functions and socio-cultural values. In our framework the poor (actors) are trapped in action situations constrained by 1) particular types of transactions, 2) the actor characteristics and assets, 3) institutions which formally or informally rule behavior and define use and access to resources, especially property rights, and 4) governance structures. The configuration and effects of these four factors determine whether they work as barriers to innovation towards productivity growth, or as enablers. All four factors can be used as drivers of change so that they function less as inhibitors and more as enablers for technological or institutional innovations.

For explaining barriers to change which prevent the unleashing of the potentials of the poor North (2007) refers to limited access (in contrast to open access) orders, Acemoglu and Robinson (2012, 2008) refer to extractive (in contrast to inclusive) institutions and Hagedorn (2008) refers to segregative (in contrast to integrative) institutions. Despite the different use of terms all theories contribute to explaining that the poor are locked in action situations defined by institutions[3] and governance structures which define the types of

Figure1: Conceptual framework and theory of change



Source: Adjusted from Hagedorn (2008) and Ostrom (1994)

Figure 2: Adaptation strategies and investments for different scenarios defined by poverty and agro-ecological potential

CAPABILITY POTENTIAL	AGRO-ECOLOGICAL POTENTIAL: Low	AGRO-ECOLOGICAL POTENTIAL: High
High	Areas with low agro-ecological potential and poverty just below the line require investments in people and technology to tap the unused potential of people. More sophisticated, adaptive but affordable technologies making efficient use of the scarce resources. Investments into people to use the technology, diversify income and achieve food security.	Areas with poverty just below the line and high agro-ecological potential require investments to tap benefits from closing yield gaps. Short term returns on investment likely. Fluctuations in and out of poverty if innovations are not sustainable. More sophisticated technology solutions for intensification. Risk of env. externalities and social conflict (land grabbing).
Low	Areas with low agro-ecological potential and extreme poverty require basic investments in people *and* technology. Long term returns on investment likely Basic education, health, nutrition. Access to land, water and other resources. Basic infrastructure (roads, communication). Access to basic public services and markets.	Areas with high agro-ecological potential and extreme poverty require investments in people and technology to tap high yield gaps. Non-sophisticated and affordable local technologies which enable to bridge yield gaps and produce surplus for food security and the market. Investments into people to enable them to make use of the high agro-ecological potential.

transactions the poor are engaged in and the conditions under which they live. From that perspective it becomes obvious that poverty and marginality is to a large extend man-made. The institutions of marginality keep people marginalized.

For understanding how institutions of marginality work it is helpful to explore Hagedorn (2008) who differentiates social from physical dimensions of transactions as well as the process of transactions which is costly[4]. Transactions have physical effects when physical ex/changes of resources and impacts on the environment are created, e.g. exchange of goods/resources between actors or impact on the environment. They have social impacts as social relations are affected. Institutions define who benefits from the positive and bares the negative effects of a transaction. Under segregative institutions the decision maker has the freedom to segregate positive or negative effects of his actions to others or to the environment, from his “area of accountability” (Hagedorn 2008: 4).

Both, physical and social dimensions of transactions are particularly relevant for the action situations the poor find themselves in: institutions and governance structures manifest existing types of transactions which do not set incentives for creative change, innovation, or competition. They keep the poor trapped in vicious circles of dependence and make it too costly to change these established types of behaviors and dependencies. Although efforts to change towards productivity growth (e.g. by investing and saving) also requires capital inputs, De Soto (2000) and Riketts (2005) argue that the poor have assets, but because of the prevailing institutions and governance structures, these, particularly land, are prevented from being used as capital, e.g. as collateral. Thereby the poor cannot make use of their “dead capital”. North (2007) emphasizes the constraints institutions and governance structures have on access to e.g. decision making in political markets, education and income opportunities, opportunities for progressing along the value chain, or access to transport, communication and information infrastructure. When institutions and governance structures are inclusive (Acemoglu and Robinsion 2008, 2012) or integrative (Hagedorn 2008), they change the ruling framing conditions in a manner that enable the poor to change manifested types of transactions. They create incentives to innovate, opportunities for alternative income sources, and do not prevent access to political and economic markets.

3 The ex-ante assessment

The ex-ante assessment is divided into three main parts and several steps (Fig. 3).

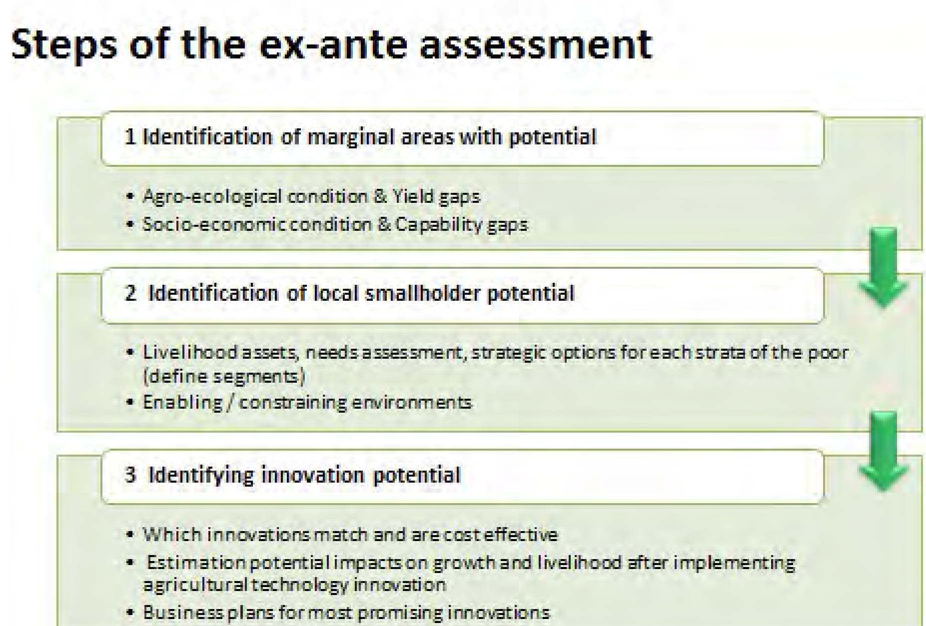
3.1 Brief review of data sources

The explanatory power of an analysis is highly dependent on the used data. There are several important conditions, namely the quality, timeliness, relevance and the adequate presentation of the data. (von Braun & Puetz 1993) The efficient use of data is often hindered by several limitations such as institutional or financial ones. Methods to collect data are e.g. methods that collect data on an entire population or area, methods that use a statistically representative sample of a population or methods that use purposive sampling. Data for household surveys are often gathered through national statistic services. IFPRI successfully uses data collected through household surveys for its research agenda. (von Braun & Puetz 1993) The Living Standards Measurement Study - Integrated Survey on Agriculture (LSMS-ISA) project tries to implement systems of multi-topic, nationally representative panel household surveys with a focus on agriculture in collaboration with national statistic services in Sub-Saharan Africa. The primary goal is to improve the availability and quality of agricultural data. This project is set to help create better analysis for policy decision makers by also establishing the use of new technologies for data collection. In addition, the open source character and standardization of data presentation guarantees a better availability for stakeholders. (LSMS-ISA 2015)

3.2 Identifying marginality hotspots[5]

This part of the manual represents an approach to mapping marginality and identifying marginality hotspots with agro-ecological potentials ideally followed by the partner countries in South Asia and Sub-Saharan Africa. The approach supports the identification of people who live in more or less socio-economically marginalized conditions and are located in agro-ecologically marginalized areas to varying degrees of overlap. Being able to map the overlap of marginalized people and areas in turn enables the identification of unused peoples' capabilities and agro-ecological potentials. Areas in which both overlap are marginality hotspots and could become priority areas for development investments. Though the common methodology for study area selection is suggested to partner country study teams, all partner countries did not adopt the approach equally-some countries followed exactly what the ZEF team

Figure 3: Steps of the TIGA ex-ante assessment



suggested (for example, Ethiopia and Bangladesh) but others adopted it with some modification (for example, India and Ghana). As an example, this section discusses more detail of the study area selection following mapping approach adopted in Ethiopia – summary findings of four countries is given at the end of this part of the manual (Table 1).

Poverty and marginality are two terms often used concurrently. Poverty measurements often inform about peoples' economic characteristics. Well-known is the assessment of poverty by indicating a person living below "one dollar a day" as poor which was introduced in the World Development Report (WDR) on Poverty in 1990. Ravallion et al. (2009) revisited that measure about 20 years later stating that an international comparison still needs to include country-specific information. Therefore national poverty lines were used to come up with an adjusted measurement of poverty. Later the average poverty line was set at $1.25 (Ravallion et al. 2009). Among the poor adjustments were also made. For example, people living on $0.75 to $1 a day were defines as subjacent poor, those living on $0.50 to $0.75 a day as medial poor and people living below 50cents a day as ultra-poor (Ahmed et al. 2007). While early research on poverty was of descriptive character focusing on monetary values, poverty research started to shift to a more analytical approach during the last decades, realizing that the causes of poverty are important but complex, multifaceted and difficult to isolate (Haveman&Schwabish, 2000).

Besides efforts of finding the right poverty-lines, several approaches on poverty mapping developed, most of them using small area estimation[6] for the analysis (Simler and Nhate 2005, Bedi et al. 2007, Davis 2003). They also draw on economic indicators and rarely include a wider range of indicators. Given the fact that especially the poor depend on goods and services provided by ecosystems (Kumar 2014), more attention is now being paid to ecological and geographical indicators for the measurement of marginality. This part of the manual is based on the concept of marginality as developed by von Braun and Gatzweiler (2014) which represents an inclusive and interdisciplinary framework to analyze the various patterns of poverty.

"Marginality is the position of people on the edges, preventing their access to resources and opportunities, freedom of choices, and the development of personal capabilities. Being excluded, not only from growth but also from other dimensions of developmental and societal progress, is an indication of the extremely poor being at the margins of society and in many cases marginality is a root cause of poverty" (von Braun &Gatzweiler 2014: 3). The concept of marginality thereby responds to the need to draw a broader and more inclusive picture of poverty by addressing ecological in addition to socio-economic variables (von Braun &Gatzweiler 2014).

A first approach to mapping global marginality hotspots had been taken by Graw and Husmann (2014) by making use of proxies representing spheres of life. Five so-called *marginality dimensions* were used to visualize global marginality hotspots. By defining cut-off points for all marginality indicators the degree of marginality of countries in Sub-Saharan Africa and South Asia could be compared. Overlaying the different dimensions of marginality then helped to identify areas in which several dimensions of marginality overlap. By this also regions could be identified in which in-depth research would be necessary to validate the results and get more detailed information on country-level. Maps are a powerful tool and bear chances to get a spatial perspective of an emerging issue, such as poverty and marginality. Maps also provide the opportunity to get insights into ecological vulnerabilities and environmental change processes. Geospatial analysis can help to visualize and observe the assets of the poor in their localized environment by combining social and economic data with biophysical data. Making the marginalized visible and underpinning their ecological environment is therefore one of the core issues of this study. Mapping marginality hotspots therefore serves as an opportunity to get a spatial distribution of inequalities but also opportunities to identify areas where further research is needed.

3.2.1 Dimensions of marginality

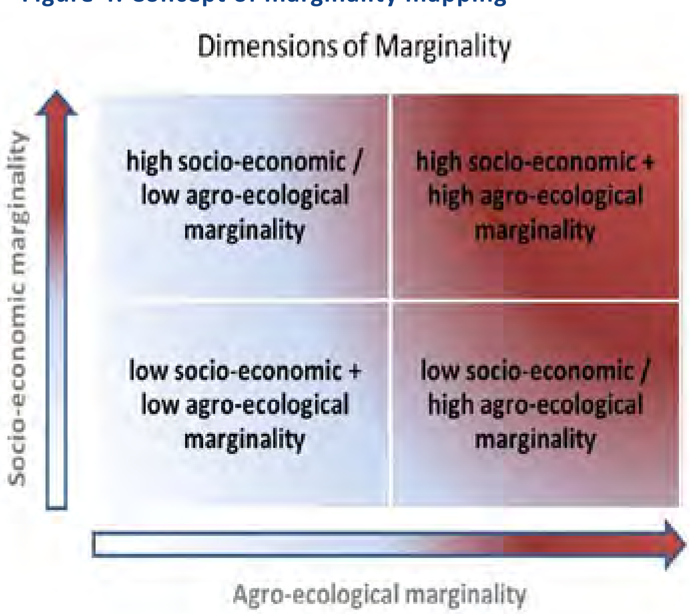
Figure 4 depicts our concept for mapping marginality. It looks at the socio-economic and agro-ecological dimensions of marginality which people in different areas are facing. While the socio-economic dimension is in our approach subdivided into three spheres – economy, health and education – the agro-ecological dimension refers to biophysical preconditions and possible suitability for the cultivation of certain crops.

Both dimensions are mapped by using so-called conditional and positional indicators. Our concept of marginality does define marginality not only by the assets a household owns but also by its access to infrastructure, public services and resources (Gatzweiler&Baumüller

2014). Accordingly, a poor household located adjacent to a river, a forest or a road, will be in a better position than one with the same endowments but which is located more remote. *Conditional indicators* therefore present the current state of an individual or household and its endowments, e.g. educational or income level, land ownership and other assets. *Positional indicators* refer to positions in physical and social space and indicate the potential to enhance the current condition of an individual or group in an identified area. Conditional indicators are e.g., access to education, access to markets, communication and transport infrastructure, or positions in social organizations or ethnically defines strata, which define rights to make decisions. Positional indicators within the agro-ecological dimension do focus on the economic and technological situation of farmers, like access to finance, knowledge and technology.

Both types of indicators can be strongly interdependent. Having better access to education and health services do for example not necessarily correspond with a better education and health condition. There are trade-offs between social and spatial positional indicators. Better spatial positional indicators might indicate improved access to public services, e.g. by moving from the rural area to the urban areas. So e.g. belonging to a low caste in India and moving to the city will, however not necessarily improve educational and health conditions. Lack of knowledge of the specific interdependencies between both types of indicators may justify a neglect of differentiating between both and strengthen the need for including both types of indicators for the mapping of marginality.

Figure 4: Concept of marginality mapping



3.2.2 Capability and potential gaps

Mapping marginality hotspots aims at identifying areas and people at the margin of social and ecological systems with unused human capabilities and agro-ecological potentials and are therefore facing capability and potential gaps (Fig. 5).

Capability gaps refer to the lack of socio-economic capability to use the agro-ecological potential. Here they are defined as unused socio-economic possibilities due to limited access to knowledge, finance, and technology. To identify capability gaps in Ethiopia we overlaid information on agro-ecological suitability with data on positional agro-ecological marginality (farmers' access to credits, fertilizer, and advisory service) and compared the degree of marginality of both maps.

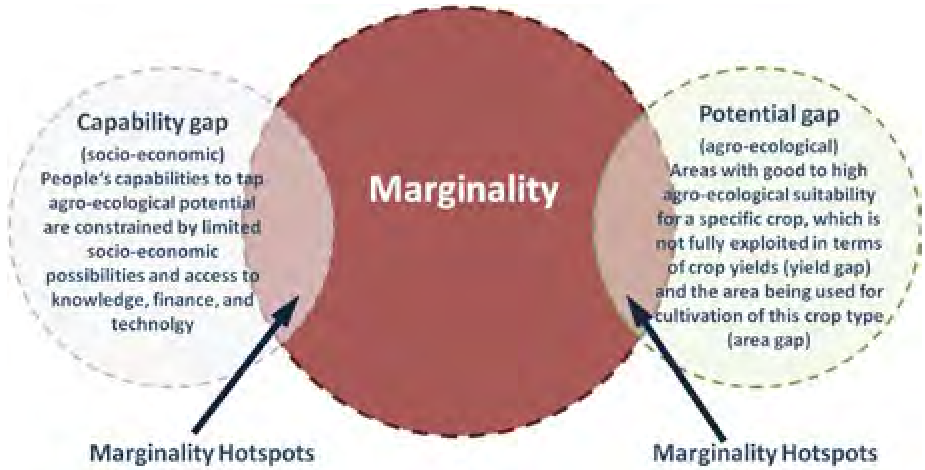
Potential gaps are defined as areas with good to high agro-ecological suitability for a specific crop, which are not fully exploited in terms of crop yields (yield gap) and the area being used for crop cultivation of this crop type (area gap). In order to identify potential gaps we overlapped areas with good to high agro-ecological suitability for Sorghum, Wheat and Maize – crops that are important to agriculture in Ethiopia – with yield gaps and area gaps.

Hence, a capability gap is related to people and their capabilities, while the potential gap is related to land and its environmental characteristics such as climate, soil and topography. The overlap between marginalized areas (or people) and capability/potential gaps are defined as marginality hotspots, which are prospective for productivity growth and poverty reduction.

3.2.3 Marginality Map of Ethiopia (socio-economic dimension)

The mean degree of marginality of conditional (a) and positional (c) indicators of the three spheres economy, health and education is shown in figure 6. The lowest degree of conditional indicators in Ethiopia is 3, which is only the case in weredas[7] of Addis Ababa. The highest degree is 8, which is prevailing in the eastern region Somali and Afar in the northeast. In Afar, the degree of marginality in the economic and health sphere is higher than in the rest of Ethiopia, closely followed by

Figure 5: Mapping concept to define marginality hotspots (marginalized areas, being also characterized by a lack of socio-economic capabilities and/or un-/underused agro-ecological potential) which are prospective for productivity growth and poverty reduction



the region of Somali. The educational marginalization is highest in both regions, showing very high illiterate rates and low enrolment rates of primary school. The conditional indicators have a mean degree of marginality of 5.7 within the whole country, while positional indicators have a mean degree of marginality of 7.1 with the lowest degree being 3 and the highest being 9. The pattern of positional indicators of socio-economic marginality is more even distributed over the whole country, but in weredas of the region Somali and Afar again remarkable high degrees of marginality can be identified.

Upper figures show mean degree of marginality from conditional indicators of the economic, health and education sphere displayed in class values (a) and z-scores (b); lower figures show mean degree of marginality from positional indicators of economic, health and education sphere in class values (c) and z-scores (d)

Z-scores of all conditional indicators of the socio-economic marginality dimension and all positional indicators are shown in figure 6 (b) and (d), respectively. Yellow to orange classes represent positive z-score values, indicating a higher degree of marginality than the average of the country, while green classes represent negative z-score values, indicating a lower degree of marginality than average. Z-score values of positional indicators show higher variation (ranging from -3.2 to 1.3) than z-score values of conditional indicators (-1.7 to 1.2), indicating higher inequalities of peoples´ capabilities within the country.

Marginality Hotspots: Areas which are characterized by a lack of socio-economic capability (capability gaps) and/or un-/underused agro-ecological potential (potential gaps), and therefore bear chances for productivity growth and poverty reduction.

Capability gap (socio-economic): People´s capabilities to tap agro-ecological potential are constrained by limited socio-economic possibilities and access to knowledge, finance and technology.

Potential gap (agro-ecological): Areas of good to high agro-ecological suitability for a specific crop, which is not fully exploited with regard to yield potential and area potential as they show yield and area gaps.

Yield Gap: Areas with good to high agro-ecological suitability for a specific crop which is not fully exploited in terms of crops yields.

Area Gap: Areas with good to high agro-ecological suitability for a specific crop but not being used for the cultivation of this crop type.

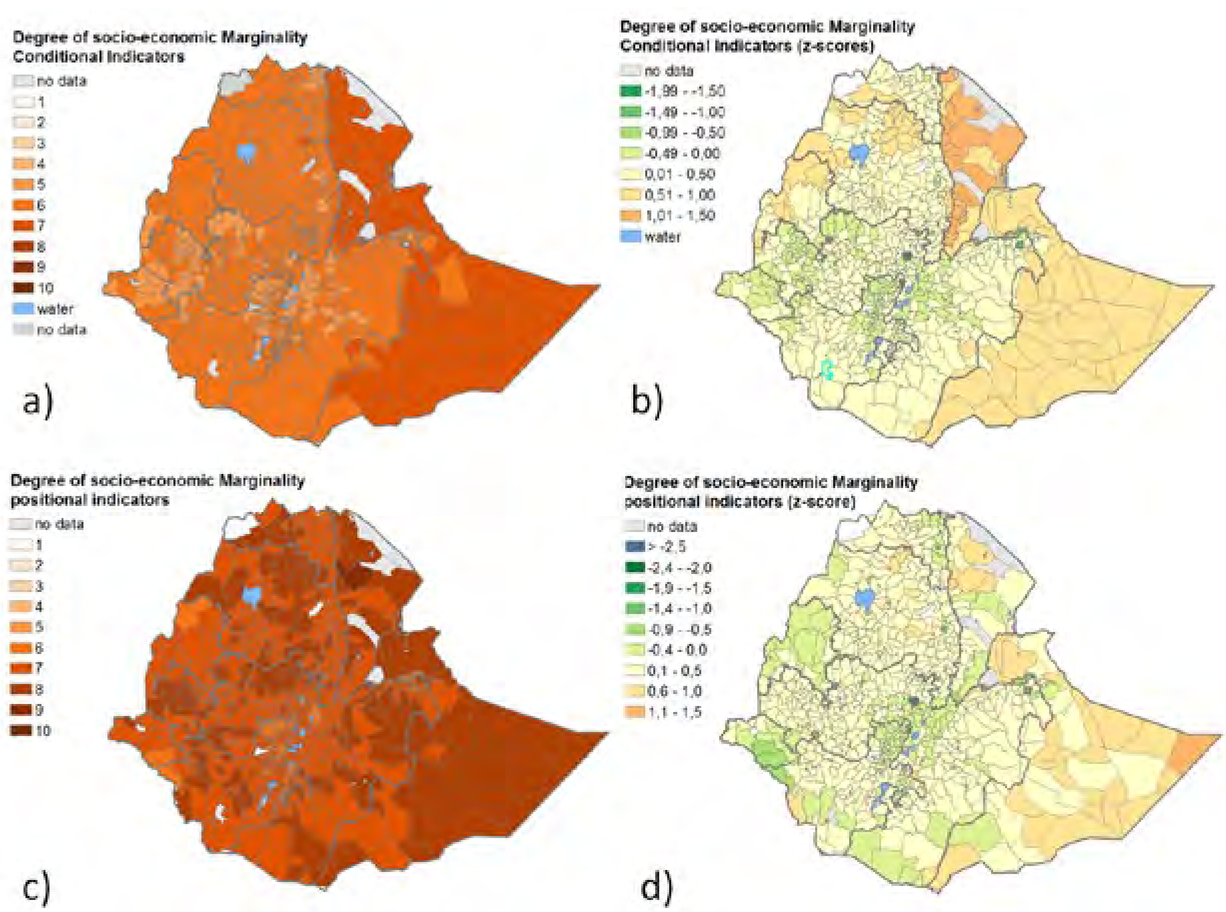
3.2.4 Marginality mapping in Ethiopia: the agro-ecological dimension

The raster data set “agronomic suitability for rain-fed crop” provided by Fischer et al. (2002) was applied as conditional indicator of the agro-ecological dimension. Fischer et al. 2002 produced a worldwide classification raster data set with a spatial resolution of 5 arc-minute of agro-ecological suitability based on crop modeling, including climate, soil and slope data[8]. Zonal statistics were used to calculate the average agro-ecological suitability of each wereda. As irrigation agriculture plays a minor role in Ethiopia, we did not include the dataset of “agronomic suitability for irrigated crop” of Fischer et al.2002.

Data of the socio-economic position of farmers, giving information about their access to technology, finance, and knowledge, were used as positional indicators to map agro-ecological marginality. Data on wereda level was obtained from (CSA 2002). In consistency with the 8 classes of agro-ecological suitability, all positional indicators were divided into 8 equal interval classes in the range of 0-100%, representing the share of farmers being marginalized. Access to technology is depicted as the percentage of farmers using inorganic fertilizer during the main cropping season. Access to finance is represented by the percentage of farmers utilizing credit service. Access to knowledge is defined as the percentage of farmers using advisory services.

All positional indicators of the agro-ecological dimension were also transferred into z-scores as described before. The degree of conditional agro-ecological marginality in Ethiopia is shown in figure 7. Classes in green are not marginalized, as they have good to very high agro-ecological suitability for rainfed crops. Classes in

Figure 6: Socio-economic dimension of marginality

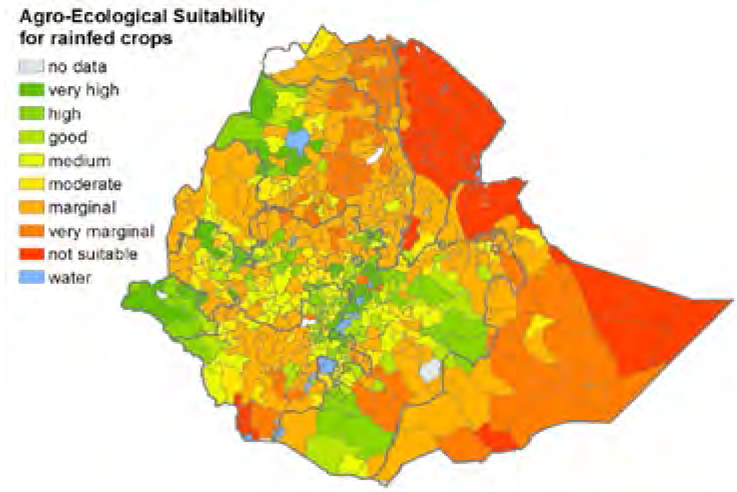


orange show agro-ecological marginality, as they are characterized by moderate to very marginal suitability for rainfed crops. Classes in red are not suitable for rainfed crops and therefore highly agro-ecological marginalized. According to the data set of Fischer et al. (2002), very high to medium agro-ecological suitability for rainfed crops is defined in north-western, western, southern and central parts of Ethiopia, while agro-ecological suitability is low in the semi-arid Somali and Afar regions, located in the east and north-east of the country. Agro-ecological marginality defined from this data set is likely being overrated in the highlands of Ethiopia due to slope.

The mean degree of positional indicators of the agro-ecological dimension of marginality is shown in figure 8 expressed in classes (left) and z-scores (right). Darker areas on the left map signify a higher degree of marginality, meaning limited possibilities for farmers to get access to fertilizer, credits and advisory services. Z-scores in the right map reflect the unequal distribution of socio-economic possibilities for farmers throughout the country. Areas in green signify better access to technology, finance and knowledge in relation to the national mean, while areas in yellow signify limited access to those resources. No data was available for great parts of the Somali and Afar region. This is mostly related to the fact, that inhabitants of these regions are mainly pastoral populations characterized by seasonal migration as agricultural production in these arid and semi-arid areas is limited by available moisture (Central Statistical Association, 2006). Moreover, population density in these regions is very low.

The map on the left shows the degree of agro-ecological marginality in 8 classes with 1 being the lowest and 8 the highest degree of marginality. Classes 1 and 2 do not occur. The map on the right shows the same results expressed in z-scores. Positive z-scores (yellow classes) signify a higher class of marginality than the national average, while negative z-scores (green classes) signify that marginality is below the national average.

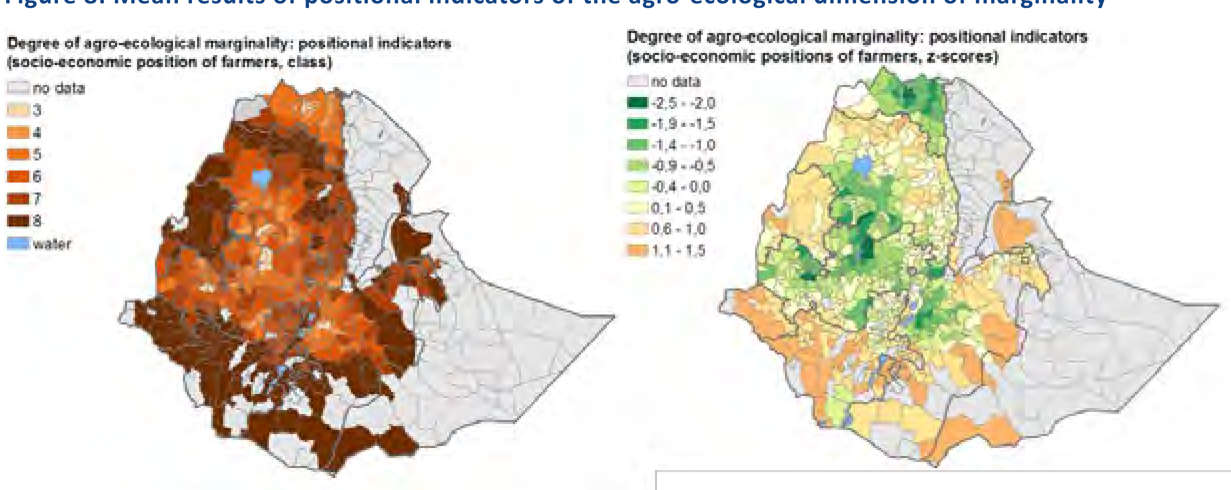
Figure 7: Agro-ecological suitability for rainfed crops at wereda level



3.2.5 Capability gap: people (farmers) with limited socio-economic capabilities

Capability gaps are related to people in certain areas, not being able to exploit the untapped agro-ecological potential due to a lack in their socio-economic capa-

Figure 8: Mean results of positional indicators of the agro-ecological dimension of marginality



bilities. Capability gaps in Ethiopia were mapped by overlaying the information on agro-ecological suitability with the data on positional agro-ecological marginality (farmers' access to credits, fertilizer, and advisory service) and comparing the degree of marginality of both maps. Capability gaps occur in areas characterized by good to high agro-ecological suitability with farmers having limited socio-economic capabilities.

Blue classes show capability gaps as agro-ecological suitability is good in these areas, while socio-economic capabilities of farmers are limited.

Capability gaps, showing the gap between agro-ecological suitability and socio-economic capabilities of farmers in getting access to finance, technology and knowledge, is shown in figure 9. Classes in blue define capability gaps, where agro-ecological suitability is good while socio-economic conditions of farmers are poor in these areas. Classes in orange/red show areas in which socio-economic possibilities of farmers are good, while agro-ecological suitability is poor. High capability gaps are prevailing in the north-west in the region of Amhara, in the western region Gambella, in the south (Borena zone) and east (Bale, Arsi and West Harerghe zone) of Oromia, and along the north-eastern border between the regions Oromia and SNNP.

Trading fish in Bangladesh

Figure 9: Capability gap in Ethiopia

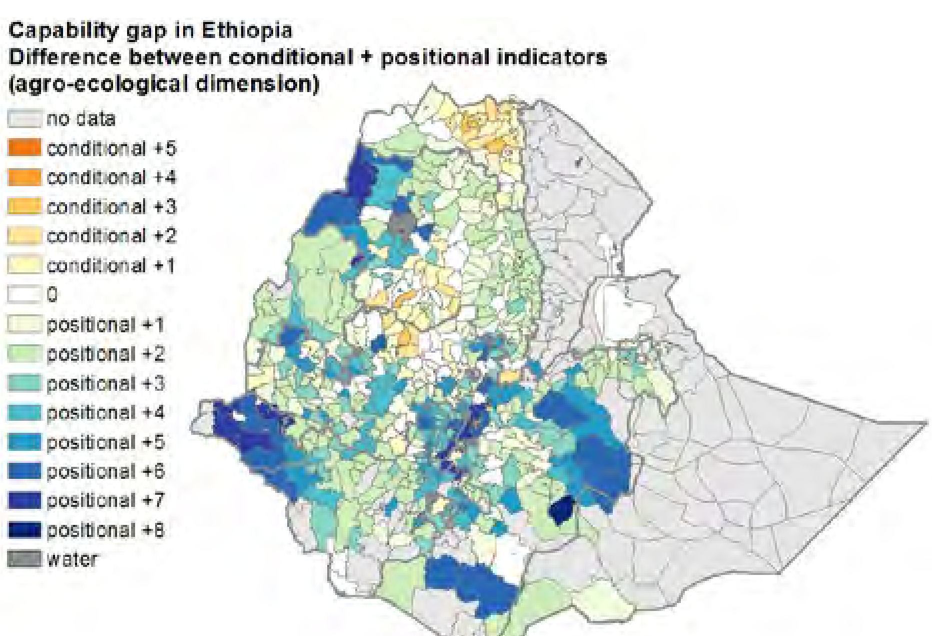


Figure 10: Potential gap in Ethiopia

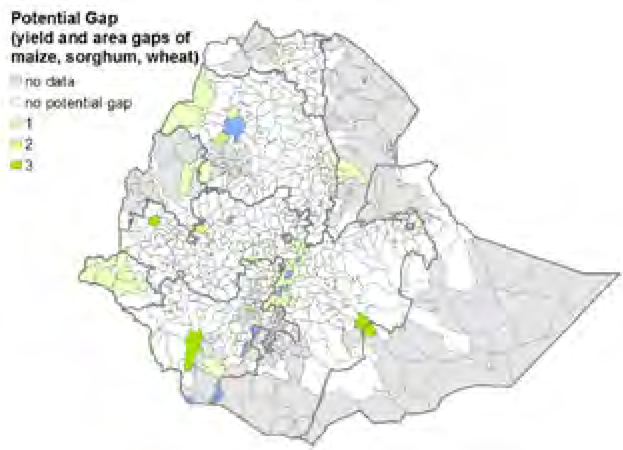
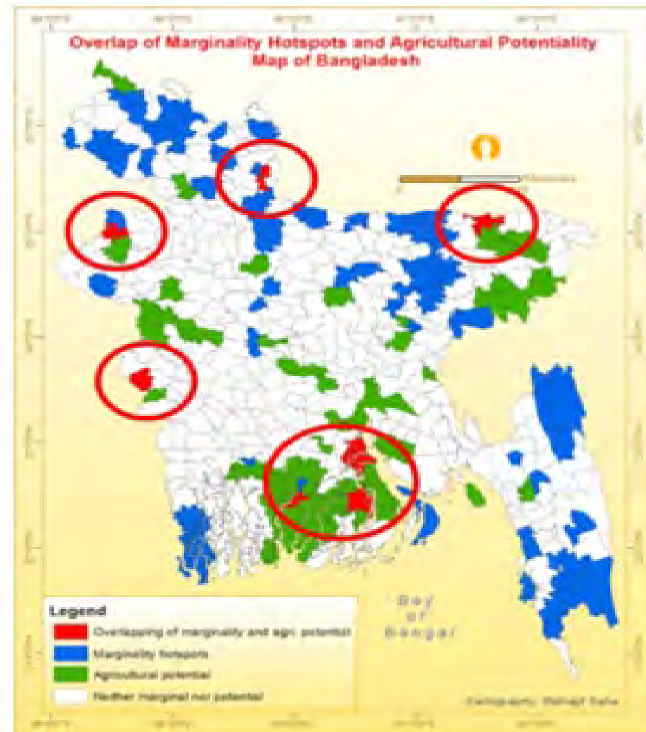


Figure 11: Study areas-overlap of marginality hotspot and agricultural potential in Bangladesh



Source: Malek et al (2013)

3.2.6 Potential gap: areas of un-/underused agro-ecological potential

Potential gaps take place in areas of good agro-ecological suitability due to their environmental setting, which are also in the same time characterized by un-/underused agricultural potential in terms of crop yields (yield gap) and the choice of crop (area gap).

For this crop-specific approach we defined favorable crops based on their agro-ecological suitability, food energy and safety, and economical output for different agro-ecological zones.

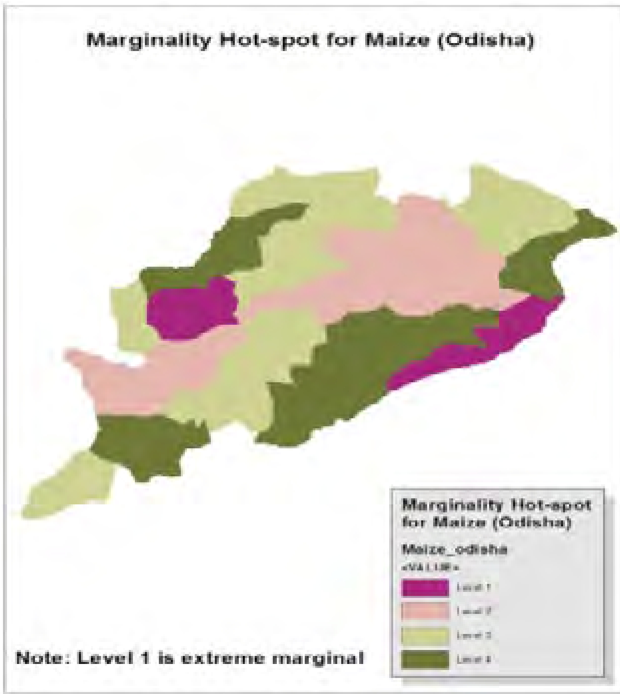
We defined areas of un-/underused agricultural potential from yield and area gaps of these three crops. Yield gaps were classified in areas being characterized by good to very high agro-ecological suitability for the respective crop, while yields of this crop type stay below the national mean (z-scores < 0). Area gaps were classified in areas of good to very high agro-ecological suitability for the respective crop, while the percentage area used for this crop type related to total cereal area is below the national mean (z-scores < 0). Crop specific agro-ecological suitability was defined from the data sets provided by Fischer et al. (2002). Yield and area information for the specific crops was obtained from the "Crop Production Forecast Sample Survey, 2011/12" (Central Statistical Association 2011).

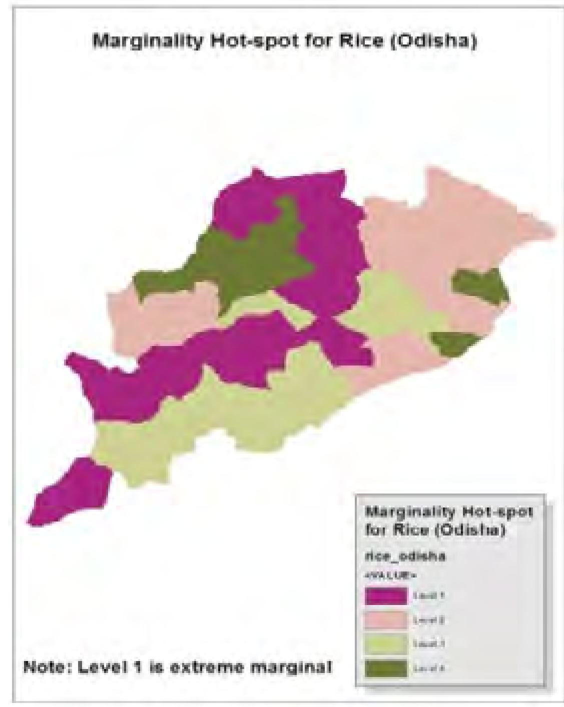
Yield and area gaps of wheat, maize and sorghum are shown as green classes in figure 10. Classes 2 and 3 define areas, where two or three gaps occur. Large areas with un-/underused agricultural potential do occur in the western part of the region Amhara, the region Gambella, in the East Shewa and Arsi zone of Oromia and in one part between the border of Afar and Amhara. Highest potential gaps of class 3 were defined in the weredasSelamago (SNNP), DaweQachen and BaboGembel (Oromia). Green areas show yield and area gaps of maize, sorghum and wheat. A value >1 signifies the overlap of several gaps.

Table 1: Study areas selection by TIGA partner study teams in South Asia and Sub-Saharan Africa

Country	Study areas (marginality hotspots) selection
Bangladesh (Fig. 11)	Bangladesh identifies hotspots (sub-districts) with high prevalence of societal and spatial marginality which are overlaid with areas of high (un/der utilized) agricultural crop potentials. National level datasets are used. For mapping marginality hotspots, eight societal and spatial marginality dimensions representing different spheres of life are used and also cross validated by poverty data. In each case, a reasonable cut-off point is used. For mapping un/der usedagricultural potentials, the areas (sub-districts) where the agricultural (crop) potentialscould not be unleashed with micro-investments or could be exploited only under costly interventions are excluded. For this, the land suitability assessment and crop zoning data are used. Finally, five marginal hotspots with agricultural potentials (sub-districts) are selected for the assessment: Rajibpur (Kurigram), Dowarabazar(Sunamgonj), Porsha(Naogaon), Damurhuda(Chuadanga) and Bhandaria(Pirojpur). Then, the research team visited the localities, understood the bio-physical condition, arranged consultation meeting with the local level stakeholders and prepared the list of all marginal villages with agricultural potentials. Finally, 16 villages are randomly selected for the detail investigation.
India (Bihar and Odisha) (Fig. 12)	Marginal areas are defined as the ones where yields (for principal crops- rice, maize and pulse) have been declining over time and are currently at levels that lie in the bottom quartiles of the yield distribution (across districts). Then, two workshops were organized in Bihar and Odisha respectively including experts from frontline agriculture research institutions and agricultural universities, government officials, private sector representatives, members of NGOs, farmers and other relevant organizations. The workshop followed a clearing house model where the identification of marginal districts was put to participants and a commonly agreed list of marginal areas was prepared for each crop. Thus, the districts are selected to cover marginal areas in both rice and maize in Odisha are Angul, Deogarh and Boudhandin Bihar are Araria, Muzaffarpur and East Champaran. These lists overlap significantly with the set of backward districts selected by the planning commission in India. The prominent marginal districts for pulses in Bihar are Madhubani, Darbhanga, Sheohar and Vaishali and in Odisha are Khordha, Gajapati, Nuapada, Kendujhar and Angul.
Ethiopia (Fig. 13)	First visual assessment and selection based on marginality hotspot map by Graw and Ladenburger (2012) Focus on cereal based farming systems: teff, maize, sorghum, and wheat Precipitation was used as a proxy variable to measure agricultural potential. Thus, all drought-prone woredas were excluded and Basoliben, East Gojam zone and Halaba, SNNPR were selected for the study. Marginality and agricultural potential were considered to select kebeles. Marginality was proxied by the distances of kebeles from woreda town, whereas agricultural potential was proxied by a composite of parameters such as amount and reliability of rainfall, irrigation potential, soil fertility, and topographic characteristic.
Ghana	• Study sites selected from three agro-ecological zones of Ghana: forest, forest-savannah transition, and savannah zones. • Two districts were selected purposively from each zone using the crop types produced.

Figure 12: Marginality map for Rice, maize and pulses in Odisha





Source: IFFPRI TIGA Project Report (2013)

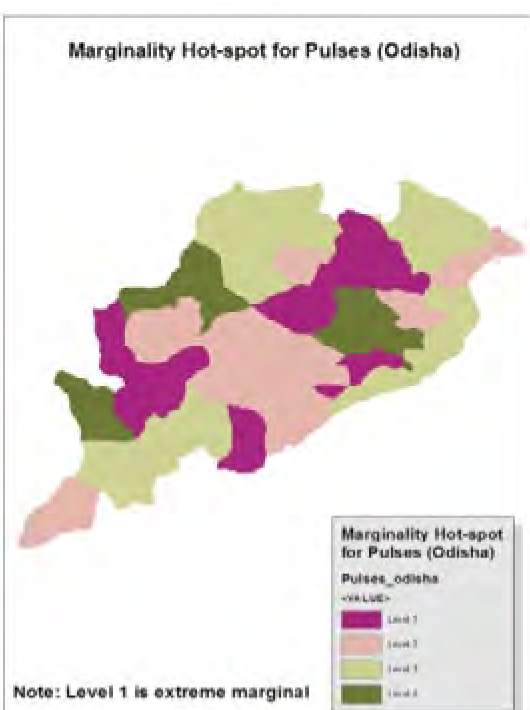
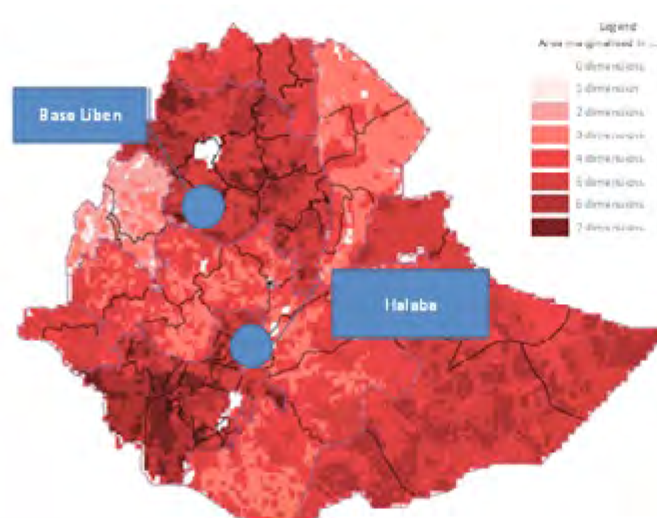


Figure 13: Marginality map for Ethiopia



Source: Ethiopian Economic Association TIGA Project Report (2013)

4 Identification of smallholders' potentials

Step 1: Selection of villages and sample selection for the assessment

Once the marginality hotspots (say, sub-districts/district/state) are identified study villages within the marginality hotspots are selected. For this purpose, sub- district level statistics, if available, help to identify the villages. An initial visit by the research team at the locality and consultation at sub-district level with agricultural officers/field workers working in the selected sub-districts may be useful. The consultation answers the questions of which villages are more marginal than others, which agricultural technologies have been adopted, which innovations (e.g. high yielding varieties, hybrid varieties, farming systems or management practices) have been adopted, etc. Finally, a list of all marginal villages is prepared and few villages are randomly selected for the assessment.

First, a household census containing few basic information mainly related with assets may be conducted for the entire households in the selected villages and poor small farm households (involved with household own farming activities either part time or full time) are identified. For the categorization of poor (with different strata) and non-poor small farm households (small holders), principal component analysis (PCA) may be used. The categorization may be validated by participatory wealth ranking (PWR) exercise. By means of stratified random sampling, a selection from the different strata of poor SHs are made for the assessment. This may be the first level of stratification but this is done only for the sampling purpose- final stratification is made based on the income criteria (when income/ expenditure data are be available) after the quantitative sample survey is conducted. The household self-perception about stratification is also collected during quantitative sample survey. However, the procedure for selecting the study villages and drawing sample varies country to country. Table 2 gives us a snapshot about how different countries selected the study villages and sample for the detail investigations from the marginality hotspots described in the previous part of the manual.

Step 2: Livelihood assets and need assessment

Development strategies for sustainable resource intensification in marginal areas need a careful adjustment of resource use at field farm- household and village level looking for a portfolio of activities and technologies that guarantee input efficiency and labor productivity (Ruben et al. 2007). The sustainable livelihoods framework (SLF) developed by DFID (2008) is used to improve our understanding of livelihoods of the selected poor SHs. The livelihoods approach places households and their members at the center of analysis and decision making, with the implication that the household-centered methods of analysis must play a central role in developing an understanding of livelihood strategies. Applying SLF highlights the multilayered interactions between technologies and the vulnerability context of households – their asset base, access to social capital, and livelihood strategies. However, additional aspects of culture, power, and history are integrated to understand the role of agricultural research in the lives of the poor (DFID 1999; OECD 2001; Carney 1998).

As different literatures suggest, the SLF:

- Provides a checklist of important livelihood issues with particular focus on current farming practices and agricultural technology use and sketches out the way these link to each other;
- Draws attention to core influences and processes; and
- Emphasizes the multiple interactions between the various factors which affect the livelihoods.

The framework is centered on people. It does not work in a linear manner and does not try to present a model of reality. Its aim is to help stakeholders with different perspectives to engage in structured and coherent debate about the many factors that affect livelihoods, their relative importance and the way in which they interact. This, in turn, should help in the identification of appropriate entry points for support of livelihoods (DIFD, 1998).People and their access to assets are at the heart of livelihoods approaches. In the original DFID

Table 2: Selection of villages and sample selection for the assessment by TIGA partner study teams in South Asia and Sub-Saharan Africa

Country	Selection of villages and sample selection
Bangladesh	After identifying the hotspots (sub-districts), the research team visited the localities, understood the bio-physical condition, arranged consultation meeting with the local level stakeholders and prepared the list of all marginal villages with agricultural potentials. Finally, 16 villages are randomly selected for the detail investigation. To identify poor SHs' households'[9] population a household census was conducted for selected 16 villages and wealth index was developed using Principal Component Analysis (PCA). The PCA results were validated both internally and externally. From the study population (858), following proportionate random sampling a sample of the poor SHs (357) was drawn for quantitative sample household survey. Prior to conducting the quantitative sample survey, qualitative survey in 5 villages (1 village/sub-district) was also conducted that helped the study team to identify the issues for detail quantitative investigation. Existing cropping pattern, yield rate, cropping intensity and livelihood options available in the locality shows the unused potentials for the cereal crops and other innovative livelihoods.
India (Bihar and Odisha)	After selecting the marginal districts and shortlisting the technologies and summarizing factors behind their adoption through literature review and field visits, the study team draw representative sample of farmers in 3 marginal districts each in both Bihar and Odisha mainly to assess the state of awareness about those technologies and the level of adoption.
Ethiopia	Marginality and agricultural potential were considered to select kebeles. Marginality was proxied by the distances of kebeles from woreda town, whereas agricultural potential was proxied by a composite of parameters such as amount and reliability of rainfall, irrigation potential, soil fertility, and topographic characteristic. The study team found about 3,865 households in the selected *kebeles*. Then, they used two main parameters to ensure the inclusion of the poor into our analysis namely land holdings and gender of household heads. The selection process involved three steps. First, households were grouped into three categories based on landholding: bottom category (<34%), medium category (34-66%), and upper category (>66%) which represents three poor categories i.e. subjacent poor, medial poor, and ultra-poor, from top to bottom, respectively. Second, each stratum was stratified again into two sub-strata based on the gender of household heads. Third, sample households were drawn from each sub-stratum using a proportionate to size sampling technique such that the total number of sample households in each stratum would be 20. The entire process of sampling resulted in a total of 360 sample households.
Ghana	After selecting two districts each from three zones, three communities within each district (18 communities = 3 zones* 2 districts* 3 communities) were randomly selected using the lottery approach. A simple random sampling technique was employed to select farmers within the communities and finally, 139 respondents from the forest zone, 156 respondents from the transition zone and 107 SHs from the savannah zone were selected for the detail investigation.

framework, 5 categories of assets or capitals are identified, the original five categories are: Human capital, natural capital, financial capital, physical capital, social capital- these livelihood assets are the locked potentials of the poor SHs.

Within the framework assets are both destroyed and created as a result of the trends, shocks and seasonality of the vulnerability context. Farmer's livelihood assets are affected by the vulnerability context: critical trends, shocks and seasonality – over which they have limited or no control and which are parts of the barriers identified in the Next step:

- Critical trends may (or may not) be more benign, though they are more predictable. They have a particularly important influence on rates of return (economic or otherwise) to chosen livelihood strategies.
- Shocks can destroy assets directly (in the case of floods, storms, civil conflict, etc.). They can also force people to abandon their home areas and dispose of assets (such as land) prematurely as part of coping strategies. Recent events have highlighted the impact that international economic shocks, including rapid changes in exchange rates and terms of trade, can have on the very poor.
- Seasonal shifts in prices, employment opportunities and food availability are one of the greatest and most enduring sources of hardship for poor people in developing countries

The livelihoods analysis does not have to be exhaustive in order to be useful for determining the potentials of the poor SHs that can be developed by appropriate technology innovations. Rather than trying to develop a full understanding of all dimensions of the vulnerability context, the aim is to identify those capital assets, trends, shocks and aspects of seasonality that are of particular importance to livelihoods of the poor smallholders. Effort can then be concentrated on understanding the impact of these factors and how negative aspects can be minimized.

A need assessment can in addition identify demands, wants and requirements for improving the quality of current livelihoods. Such needs can be discrepancies between current and needed or desired conditions of SHs and they are assessed to ensure that technological innovations which are economically possible also match the wants and aspirations of the poor – an important aspect which is also captured by allocating the surveyed SHs to the strategic options.

Under participatory methods the following tools may be used –social and resource mapping, participatory wealth ranking (PWR), in-depth Interview (IDI), focus group discussion (FGD), key informants' interview (Table 3). Sample quantitative surveys and community level survey in the selected villages (to be done in the previous step) are complementary to, and often informed by, participatory methods. To be effective, sample quantitative surveys should be preceded by an initial qualitative overview of the community or context in which they are to be carried out. This will enable survey work to be much more precise and effective in verifying existing data. Qualitative methods, say,in-depth interview are very rich in detail. They put information in context, and are able to explain issues such as 'why'. Quantitative methods, such as questionnaires, can provide a large amount of information, relatively quickly, for the sample SHs, in ways that can be compared and aggregated. We suggest that the main instrument for assessing livelihood assets is a set of questionnaire based household surveys. Survey results can be analyzed using descriptive statistics and standard econometrics/statistical tools. For analyzing qualitative data, content analysis may be useful.

Step 3: Stratification and segmentation

At this stage, as we already have household income and expenditure related information for the sample SHs, the quantitative sample may be classified according to income criteria[10] and stratification is carried out,[11] and validated by the PWR exercise or household self-perception results. The households from each strata are allocated to four broad strategic options (Fig. 14):

- improve current farming system performance by means of innovations (yet to be identified),
- change current farming system and shift to another,
- progress along the value chain, for example by shifting from being farmer to working as agro-dealer,
- Diversifying income from the non-agricultural sector, or
- leaving the agricultural sector completely

This allocation of poor SHs from different strata is carried out in parallel with the livelihood assets and need

Table 3: Typical data requirements and collection for the livelihoods assessment

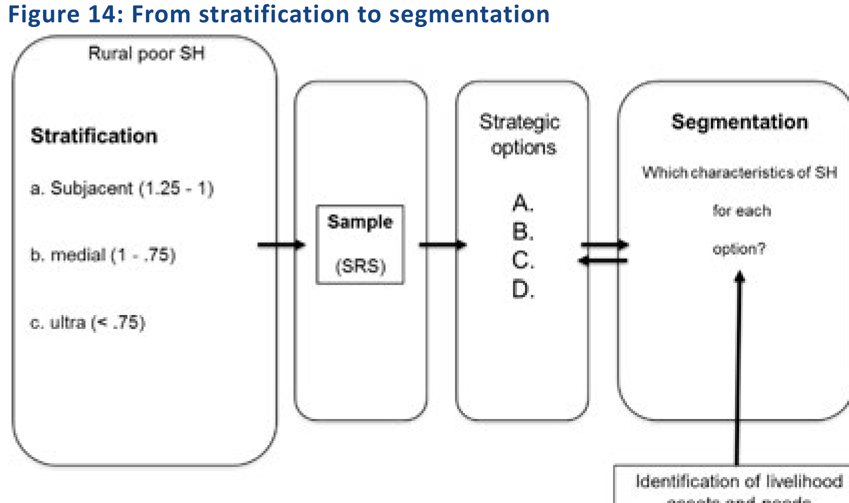
Livelihood Component	Data Requirements		Data Collection Tool (Qualitative)	Data Collection Tool (Quantitative)
	Indicator for Discussion and Analysis	Vulnerability Context		
Human Capital	Labor, Education, Health, etc.	Disease epidemics (malaria, cholera, dysentery) due to poor sanitary conditions	In-depth Interview	Household Survey
Financial Capital	Remittance, Deposit, etc.	Increased theft, Unemployment, tax	Wealth Ranking,Village workshops,	Household Survey, Community-level formal surveys
Natural Capital	Land, Irrigation water etc.	Drought, Flooding, Land degradation, Pests	Social mapping, participatory resource mapping, transect walks	Household Survey, Community-level formal surveys
Physical Capital	Machinery, Tools, Livestock	Stricter loan requirements, Price shocks, Rapid inflation	Wealth ranking, Village workshops	Household Survey, Community-level formal surveys
Social Capital	Claims, kinship networks, safety-nets etc.	Recurring environmental shocks, Breakdown ability to reciprocate, Morbidity and Mortality affect social capital	In-depth interview, Key Informant interviews	Household Survey, Community-level formal surveys

assessment done in the previous step. Allocating the poor SHs to the different strategic options could be done in a participatory manner and supported by agronomic calculations based on household data from the livelihood assets and needs assessment to ensure that the options are realistic (no wish lists) and economically viable for each of the actors from different strata. Trade-offs may need to be made between subjective and rational choices.

The SHs allocated to different strategic options come from different strata. By means of their characteristics the segments are defined for each strategic option. Segmentation is necessary to identify suitable innovations – innovations which match the characteristics of each segment and thereby contribute to achieving the overall goal of increasing productivity. For example, all SHs allocated to option A own land, or lease land or are sharecroppers and each belong to a different income category. Land and income (e.g.) define different segments which can be defined by additional characteristics, such as family members, level of education and social status. After this step in the assessment we know which strategic options are available for which strata of the poor and which characteristics the poor have in each option category (segment).

At this stage, in order to compare the stratification and segmentation with the real life strategic options, a strategic option (real life) choice cum segmentation model

Figure 14: From stratification to segmentation



can be developed with the form:

(1) $y_i = \beta_0 + \beta_1 W + u_i$

Where y_i is a categorical variable representing different strategic options the households already took; W is a vector of exogenous variables affecting the decision of choosing strategic option such as the SHs'/farms' characteristics, dummies for different strata, interaction of small holders'/farms' characteristics and poverty strata, AEZ dummies and u is the error term. The nature of the dependent variable suggests that a multinomial logit model may be appropriate. This level of analysis may be done at the membership level –those from the sample small holders are actually in the labor market. Finally, the extent of strategic option choice cum segmentation may also be modeled.

Finally, the quantitative sample survey data may also be analyzed using cluster analysis to evaluate different strategic options stemmed from all-inclusive assessment on livelihoods (combination of household attributes) and the aspiration and wants of the poor small holders. Cluster analysis may be performed using a sequence of a common hierarchal and exchange algorithm. Then the identified strategic options may be validated by demonstrating the correlation between them and independently reported options. For realistic and economically viable strategic options, SHs' economic, social and agro-economic characteristics need to be matched with each typical segment which is necessary to identify each suitable agricultural technology innovation.

Table 4: Stratification, characteristics and segmentation of the poor SHs for the assessment by TIGA partner study teams in South Asia and Sub-Saharan Africa

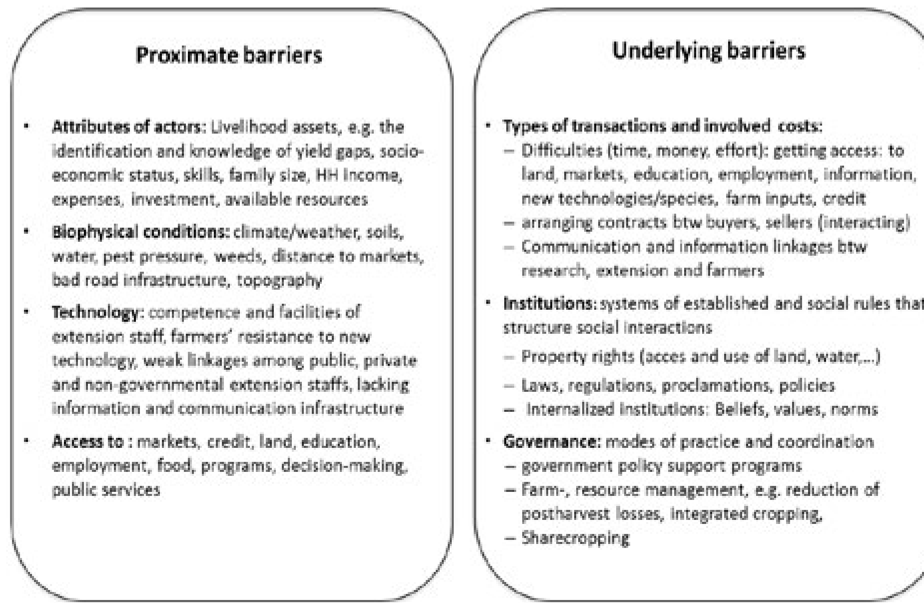
Country	Stratification, characteristics and segmentation of the poor SHs
Bangladesh	Sample poor SHs are stratified based on both US $ and PPP $ income criteria and found US $ income classification[12] of subjacent, medial and ultra-poor SHs is more reasonable and close to self-reported stratification. The population under poverty line in those sub-districts varies from 34-59%, while the national poverty line is 31% (HIES 2010). TIGA census results show that about 54% of total households (5,855) are the SHs- of them about 27% (which is equivalent to 15% of total) are the poor SHs. TIGA sample survey results show that the mean per capita income for the poor SHs is $0.60/day which is far below the poverty line income. The distribution of ultra, medial and subjacent poor SHs are 66%, 20% and 15%, respectively and the percentages of ultra-poor SHs varies from 58% -72% in different sub-districts. Results suggest that the poor SHs capital (physical, financial, natural, human and social) bases are very poor but these capitals quantitatively don't differ significantly across the strata (subjacent, medial and ultra-poor). However, the majority of the community defined ultra-poor SHs are differentiated from medial to subjacent poor in terms of landholdings/access to farm land, livelihood engagement, technology adoption, credit accessibility, using cell- phone, motivation and communication/networking skills, physical fitness, etc. - these dimensions needs to take into account for targeting poor SHs for any strategic growth productivity program for the poor SHs. Cluster analysis gives us meaningful segmentation of the poor SHs-ownership to the land, farm size, cropping intensity, agricultural crop sales, household durables, cereals income, other crops/non-crop farming income, business income, day laborers income, household savings, cereals' technology adoption, access to the agricultural market, etc. play decisive role in this regard. Among the five segments of the poor SHs, 'non-cereal crops/non-crop farming with day laboring'and'day laboring with business' could be strategic options for two segments and the other three segments' (34%, 31% and 13%, respectively) strategic options could be 'cereal and non-cereal crops/non-crop farming with day laboring', 'cereal crops', and 'business with cereal crops' – actually these three strategic options could be suggested for the poor SHs'growthproductivity improvement program. The meaning of these results: In addition to cereal crops, the strategic growth productivity program needs to include non-cereals crops, non-crop farming and related (backward and forward) non-farm business in the localities.

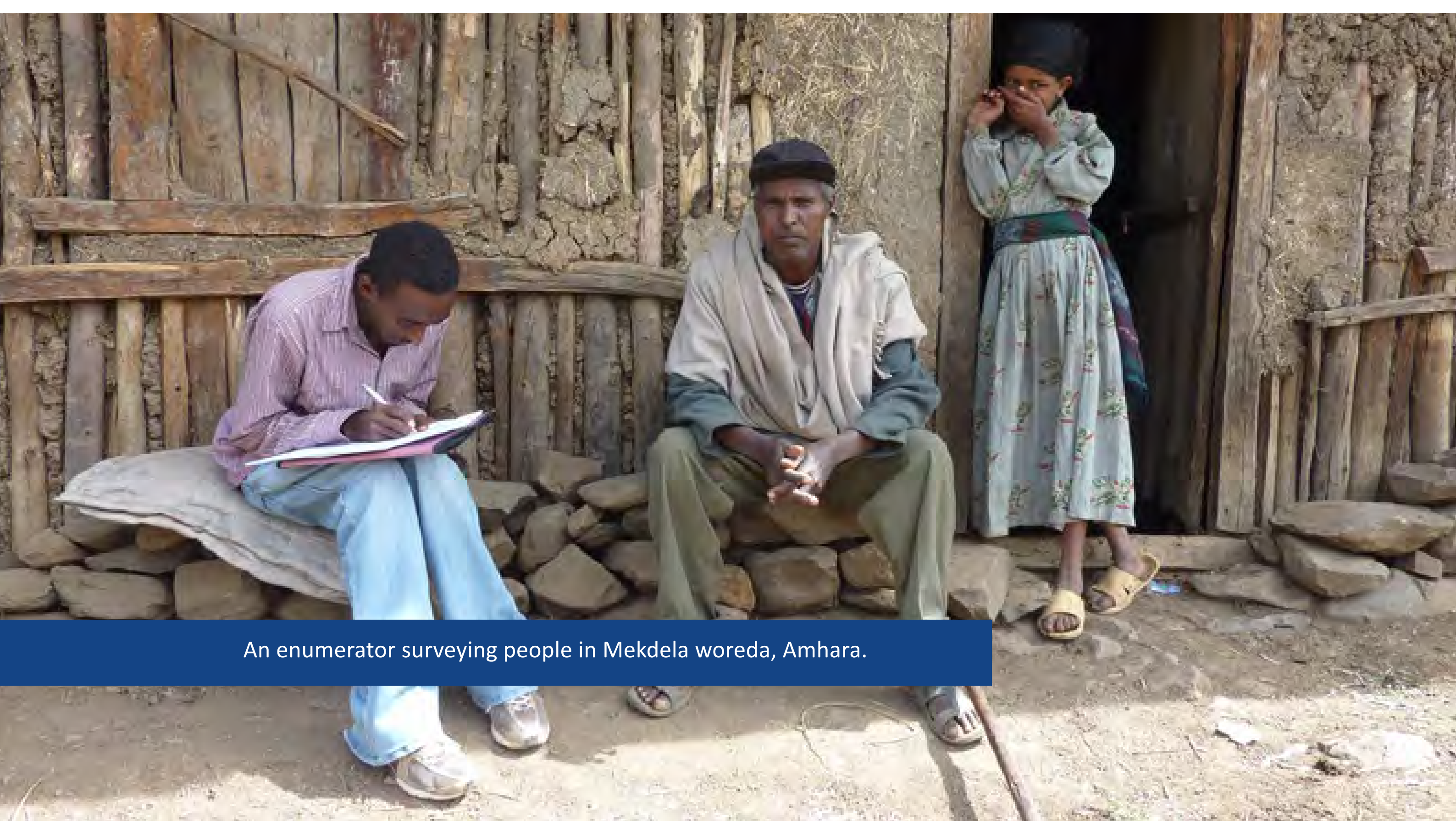
Country	Stratification, characteristics and segmentation of the poor SHs
India (Bihar and Odisha)	More than 40 percent farmers in Bihar are also engaged in maize production. Maize as a crop has not been on the frontline in Odisha with less than 4 percent of the farmers in our survey cultivating it. Maize and pulses stands out as the crop both in Bihar as well as in Odisha where a large proportion of farmers want to get involved. The awareness about technologies is also stratified along socio economic lines. Smaller farmers and farmers belonging to the lowest caste fare badly both in the awareness as well as adoption of technologies. In Odisha a large number of farmers want to adopt horticulture conditional on being not engaged with it currently.
Ethiopia	Four strata based on income level: 1) better-off : those who earn a PCI of at least $1.92/day; 2) subjacent poor: those with income between $1.54/day and $1.92/day; 3) medial poor: those with income between $1.15/day and $1.54/day 4) ultra-poor: those who earn less than $1.15/day About 10% of the households were categorized as better-off while the rest were considered as poor. Ultra-poor households constitute 71.4% of the total households whereas the subjacent poor and the medial poor account for about 5.3% and 13.1%, respectively. The mean per capita income for all households is $1.26/day which is far below the poverty line. The poor at each strata where categorized according to: land holding, livestock holding, human capital (number of adults in a household and the mean level of education of adult family members), other assets (residential house, household equipment, perennial crops, household consumables, farm equipment), food self-sufficiency (number of months in a year in which they could feed their members from own stock), degree of commercialization (market orientation index (MOI) and market participation index (MPI)), use of yield increasing technologies, and productivity (land and labor).
Ghana	Since income is not be the only relevant factor in determining poverty a categorization of the poor based on community acceptable definitions and attributes of the poor was carried out by means of cluster analysis. Four clusters were identified: extremely poor, poor, rich, very rich. Poor SHs were segmented using composite poverty measures which serve to rank them based on three key variables identified through focus group discussions. A cross-classification of poverty and marginality was also performed to further segregate the smallholder farmers into those that are poor but not marginalized, poor and marginalized, and marginalized but not poor. Across the various segments, female headed households were found to be poorer than their male counterparts as most females are risk-averse, and hence fail to take up any new, presumably risky ventures Access to markets and to extension services among the poor is low Natives were poorer than settlers Characteristics considered were socio-economic, farm level access to resources and institutions, and socio-ecological characteristics of the poor in each stratum and segment. Males and younger farmers often explore and take up new challenges and opportunities, and thus have high tendencies to innovation

Step 4: Identifying proximate and underlying barriers to technology adoption

Achieving the goal of productivity growth by means of each strategic option is hindered by various proximate and underlying causes (barriers) which are identified in the next step. The differentiation is not always straightforward and sometimes overlapping. Proximate barriers are immediately evident and can be, for example, problematic biophysical conditions, lack of livelihood assets and agricultural technologies, low competence of agricultural extension staff, or lacking access to markets, credit, land, food, or employment. Underlying barriers refer to the main elements of our conceptual framework and theory of change: types of transactions and the costs they involve, institutions – in particular property rights - and modes of governance (Fig. 15).

Figure 15: Proximate and underlying barriers





An enumerator surveying people in Mekdela woreda, Amhara.

Table 5: Barriers that hinder the spread of tech innovations for the poor SHs in South Asia and Sub-Saharan Africa

Country	Barriers that hinder the spread of tech innovationsfor the poor SHs
Bangladesh	The adverse agro-ecological vulnerability- almost all five areas facing, to some extent, water management and irrigation problem derived from the natural calamities (say, flood, drought, salinity by tidal flow, etc.) and limited connectivity with the main growth centers, poor physical, irrigation and extension/communication infrastructure, power shortages, etc. constraint innovative development interventions by the development actors in the locality. With those bio-physical conditions, the poor capital bases of the poor SHs also discourage them from thinking innovative process and technology useful for agricultural production and livelihoods. However, the tabulation of strategic segments' specific results from perception study shows that the generalized barriers for the poor SHs for adopting any technology/innovations are their low level of motivation for the poor SHs, lack of appropriate information, technical knowledge and extension services, lack of credit and liquid money, access to the electricity, etc.Other barriers are access to the land, labor shortages, distance to GC, cellphone, corruption,social and cultural obstacles, etc.) .
India (Bihar and Odisha)	Reasons behind slow or poor adoption of available technological innovations through a household survey in some of the marginal districts of Bihar and Odisha In both Bihar and Odisha the farm gate prices for grains are far below the minimum support price (MSP). The markets in Bihar and Odisha are extremely thin. Constraints in adoption of technology differ but commonly almost all technologies have been inhibited because of lack of adequate extension services High capital costs Liquidity constraints SRI: complementary inputs and risks Choices that were offered to the farmers for the possible factors affecting technology adoption Constraint 1: Adoption of technology expensive, faced credit constraints Constraint 2: The inputs required for this technology not available in the market or not economically available in general Constraint 3: Failure is risky did not have coverage of downside risk because if technology fails the losses are likely to be large. Constraint 4: High production possible but there is no markets for increased production Constraint 5: Information about technology is complex and hard to comprehend Constraint 6: Technology is new and I do not want to lead experimentation Constraint 7: I have observed this technology and it has failed many times Constraint 8: The realization from this technology much lower than promised
Ethiopia	Access of the farm households to formal credit is limited. Only 16.9% of the sample households have access to formal credit for input purchase. Low farm gate prices and prices at local markets Input prices are exorbitantly high Lack of row planting technology for teff. Labor and time intensive. Low soil fertility Lack of oxen as a source of power
Ghana	Barriers generally fell into two categories: *conditional* and *positional*. The main conditional barriers to adoption of crop technologies were financial constraints and high input cost: Financial constraints High cost of inputs Lack of availability of technological equipment and input Poor knowledge of technology application and use lack of irrigation or dependence on rainfall Health implications of chemical applications due to lack of protective equipment The main positional challenge was corruption and bureaucracy. Particularly among tree or cocoa farming households, most farmers were unhappy about the bureaucracy of government officials in distribution of subsidized farm fertilizers. The major barriers to spread of innovation from the supply side: lack transportation facilities such as vehicles and motor bicycles, poor access to roads, lack of credit and farm inputs to support farmers, lack of personnel due to poor service conditions and lack of incentives to motivate postings into hinterlands.

5 Identifying and estimating innovation potentials and packages

Step 1: What we actually mean by Innovation potentials and systems?

Ex-ante agricultural technology innovation assessments often look at the impact of one specific innovation whereas the ex-ante assessment under TIGA aims at matching available technology packages with human potentials which exist or can be developed. In an evolutionary sense the search for technological innovations which are suitable, resembles "a search across a space of possibilities on complex multi-peaked "fitness", "efficiency", or "cost" landscapes." (Kauffman & Macready 1995).

Instead of the traditional top-down 'pipeline' approach the TIGA ex-ante assessment takes a bottom-up approach by matching available agricultural technologies with the circumstances in which the poor live and the lives they want to live. For that reason no particular productivity enhancing technology is being pre-selected or promoted. Whether agricultural technology innovations are what the rural poor want and which ones suit which segment of the poor will be identified during the process of this assessment.

Bundles or packages of innovations, integrated innovation measures or systems include the innovation itself and the enabling conditions. Enabling conditions refer to the livelihood dimensions and can refer to the legal environment and institutional infrastructure (e.g. property rights) or knowledge required to make use of the innovation. Communication and transport infrastructures can also be necessary enabling environments. The starting point of identifying potential productivity enhancing innovation packages should be with current farming/management practices and technologies or newly introduced goods and services or machineries/equipment to be required; and those innovation packages should be for majority of the poor SHs and to be readily available in the locality (say, despite having exploitable potentials some areas are adopting some tech innovations, others are not; in the similar context few SHs are getting very good returns close to exploitable potential yields from those innovations, others are getting very less; etc.). It could also include institutions or policies and include in many forms such as new products, production processes, cheaper inputs, improved distribution and marketing and even improved ways of innovating. It could stress the value of linking 'old and new' or traditional knowledge and practice and new, externally introduced ones.

Step 2: Which innovations match with options and barriers (cost effective)?

Identifying innovation potentials means identifying changes of causes and barriers, introducing new technologies, practices, or rules which are most cost effective, match with the options of the poor SHs and are most likely to achieve productivity gains (Fig. 17). Innovations are newly introduced goods and services, practices, institutions or policies. Through changes of transactions and the costs they involve, institutions and the livelihood attributes of the poor (e.g. providing credit, education), more favorable incentive structures are created, new opportunities evolve and thereby the potentials of the poor SHs are unleashed.

Innovations are identified by responding to the characteristics of each segment of the poorSHs. Segmentation has been carried out in previous steps in order to adjust innovations to the main characteristics and demands of each segment of the poor SHs(who can be viewed as customers of the innovation). Different segments of the poor SHsrequire different innovation bundles, adjusted to the respective proximate and underlying barriers each strata of the poor smallholders face. Innovations can be understood as products which need to match the demands of the customers (segments of the poorsmall holders). Therefore, innovations need to be cost effective, have immediate and long-lasting impacts, and show a high likelihood of substantial productivity gains.

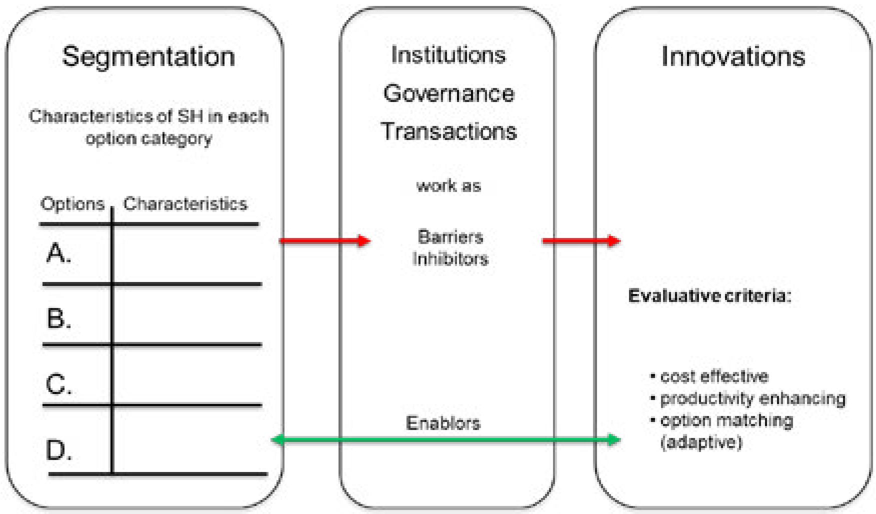
To see whether underlying barriers affect choice of innovation, we can regress choice of innovation on the barriers the poor small holders report.

The model takes the form:

(2) $y_i = \beta_0 + \beta_1 W + u_i$

Where y_i is a categorical variable representing the choice of technology adoption; W is a vector of exogenous variables affecting the decision of whether to

Figure 16: Innovations adapted to options and barriers



adopt the technology or not such as small holders'/ farms' characteristics, different types of barriers, interaction of barriers and Strata, AEZ dummies and u is the error term. Choice of innovation, which is the endogenous variable in which we are particularly interested, is a dummy variable which takes a value of 1 if the small holders choose the particular innovation and 0 otherwise. The dichotomous nature of the dependent variable suggests that either a probit or a logit model is appropriate.

Also, adoption of innovation is not necessarily a binary decision. Rather, the intensity of adoption may change over time, e.g. as a result of learning or through better access to farm resources. The extent of ag-tech innovation adoption can be measured by intensity of cultivation e.g. cultivated area under the ag-tech innovation adoption, etc. Then we may suggest some model for estimating the extent of innovation adoption. Heckman's two step selection model/Cragg double hurdle model may be applicable for the estimation.

Step 3: Estimating innovation potentials- Selection of methods for ex-ante evaluation of likely impact

This sub-section gives an overview of available methods used in the ex-ante agricultural technology assessment studies so far to estimate likely productivity growth and livelihood improvement potentials in the different countries (giving priority on marginal areas located in poor developing and emerging economies). The likely impact of innovations for each segment of the poor SHs may be assessed e.g. by modeling (economic, ecological, systems, or other) or expert consultations. The selected methods for the overview are economic surplus model approach, minimum data approach, cost/benefit analysis approach, parametric modeling approach/graphical approach, economic modeling approach, partial budget approach, bio-economic modeling, etc. A summary matrix incorporating some basic and useful information about their applications in different countries' contexts is given in appendix 4.

Economic surplus model approach

This model uses a partial equilibrium single market analysis. This partial equilibrium framework is the most common approach for the evaluation of commodity-related technological progress in agriculture (Norton & Davis 1981; Alston et al. 1995). It is used to determine how benefits are distributed amongst consumers and producers. The benefits received by each group will depend on the behavior of farmers and consumers. Key questions raised in this method are -where the impact is likely to occur, by whom the impact would be felt, by which impacts will have an effect, and what is the value of these impacts. The data requirement for this model is quite detailed. This model requires the amount of productivity increase generated by the new technology, equilibrium price of the assessed product, adoption rates and adoption costs, timeframe between research and adoption and the price elasticity of supply and demand. Therefore, the estimation provided via this model is expected to be a detailed overall picture of the outcome of introducing a given technology. However, the data requirement of this model is also its limitation since it requires good information on price responsiveness of producers and consumers that is not always available; non-marketed benefits and hidden costs (e.g. social) that is usually difficult to incorporate; and also the reliability of the available data. Few literature where the methods have been used are Pray,Huang and Qiao(2001); Qaim (2003); Hareau, Mills and Norton(2006);Krishna and Qaim (2008);Napasintuwong and Traxler (2009).

Minimum data approach

This approach measures the feasibility of adopting agricultural technology by estimating the rate of adoption of alternative practices based on their economic feasibility. It characterizes the distributions of returns from the actual and potential alternative technologies. This model can be implemented with the kinds of bio-physical and economic data that are available in most parts of the world. This method provides a preliminary basis on which to assess adoption potential. Antle and Valdivia (2006) argue that this approach can be implemented at low cost in a timely manner to provide a good first-order estimate of adoption potential that can be used to support informed decision making by researchers and policy decision makers.The related empirical literature is Akroush (2012) and Claessens, Stoorvogel and Antle(2008).

Cost/benefit analysis approach

Of the several ex-ante assessment approaches (e.g. scoring models, mathematical programming models, a production function and systems approach, benefit-cost methods),the cost-benefit analysis approach is considered to be the most practical and widely used methods as well(Rendleman& Spinelli 1994; Harrison 1996)This model assesses the measurable gains and losses from introducing new technology. The data requirements for the model are total acreage affected by the technology, the expected percentage change in net production per ton, net reduction in price discount, pesticide cost, and net decrease in storage loss, expected price per ton of particular crop and price per unit of crop. This method is useful for estimating annual gross benefits and projecting the present value of the flow of annual gross benefits from a technology adoption in the future. The suggested literatures that used cost benefit analysis approach are Afari-Sefa et al. (2010); Wiebelt (2000); Robertson et al. (2007).

Parametric modeling approach/graphical approach

The parametric approach to model heterogeneity in measuring the ex-ante value of bio-technological innovations was introduced by Dillen et al. (2008). Modeling heterogeneity is essential since heterogeneity among potential adopters of a new technology is an important determinant in the outcome of impact assessments of new technologies. Heterogeneity arises from two sources, temporal and spatial.While in ex post impact studies, the heterogeneity is endogenous to the real adoption data, in ex-ante impact assessment, however, the heterogeneity has to be modeled explicitly. Dillenetal. (2008)developed a two dimensional framework to assess the ex-ante benefits of an innovation, that explicitly models heterogeneity of technology valuation among adopters under scarce data. The conventional direct approach to model heterogeneity among producers is through a probability density function (PDF) (Just et al. 2004). Dillen et al. (2008)used this modeling approach for heterogeneous adopters. In the hypothetical case of perfect information, the PDF could be constructed in a non-parametric way. However, in ex ante impact assessments imperfect information is endogenous to the problem. Therefore, missing data are replaced by estimations, assumptions and theory. Hence, parametric approaches are usually preferred due to small samples. Using this framework one can simulate different corporate pricing strategies and evaluate the benefits generated under changing heterogeneity.

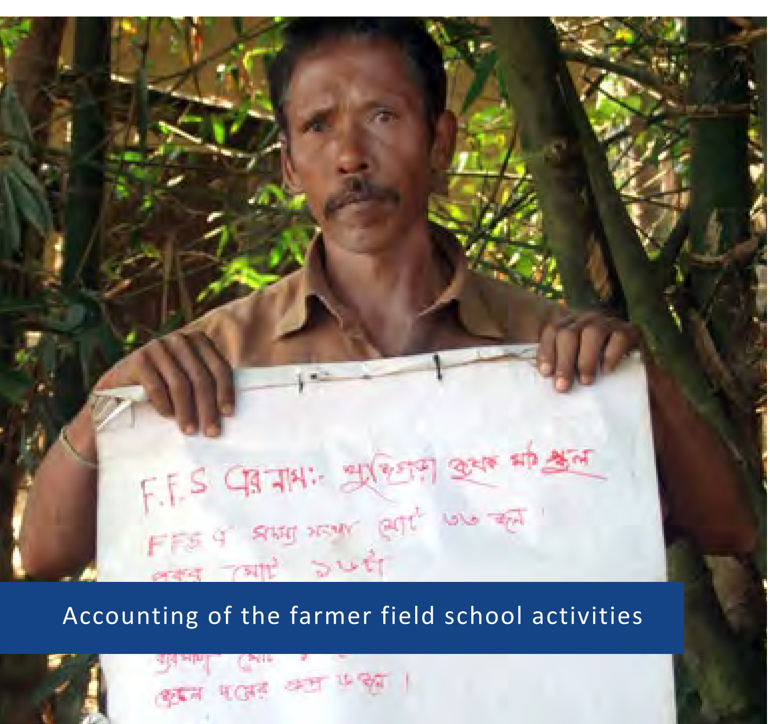
Demont et al. (2009) estimated the economic impact of planting Hybrid Resistant (HR) rice in comparison with the use of conventional weed management analogously to Demont et al. (2008).They analyzed spatio-temporal heterogeneity of weed pressure of irrigated-rice farmers in the Senegal River Valley (SRV) through a panel dataset by developing a simple, graphical rule of thumb for predicting adoption and profitability of HR rice if HR technologies were made available in rice varieties adapted to agronomic conditions in the SRV and farmers were able to make choices about whether to plant HR rice according to technical and agronomic performance criteria. Since for parametric modeling in ex-ante impact assessment it is important that the fitted PDF correctly incorporates the skewness of the original data, Beta-General, Gamma, Lognormal and Log-logistic PDFs are better suited for modeling heterogeneity of weed management costs because they are more flexible and skewed. Therefore, Demon et al. used the Pert PDF which is a special case of the Beta General PDF and is widely used in the literature on decision- making and subjective estimation (Lau et al. 1998).

Economic modeling approach

Viaggi and Bartolini (2008) developed a complete ex-ante evaluation procedure to support decision makers in designing efficient and effective agri-environmental contracts, combining elements of private and public decision making, through the use of economic modeling tools. Ex-ante comparison of policy design options (different contract lengths and level of payments) requires both simulations of farmers' behavior and evaluation of the farms simulations outcomes. Therefore this methodology is divisible in two levels: first, analysis of farmers' behaviors in front of new contract design options for the provision of landscape elements; second, public analysis of the choice, in order to identify dominated policy alternatives. Combining both elements of private and public decision making it is possible to outline strategies to improve the efficiency and effectiveness of agri-environmental contracts. Farm level analysis is realized using a land allocation model, based on a real options approach including in the simulations the timing of choice and the uncertainty in the future about price and decoupled payments. Public analysis is based on the evaluation of the aggregate farms' impacts of several contract alternatives based on interactive multi-criteria analysis, where weights are elicited using the Multiple-Criteria Robust Interactive Decision Analysis (MCRID) approach.

Partial budgeting approach

As reviewed by Babu and Rhoe (2003), this approach evaluates the economic effects of minor adjustments and changes in fix resources by comparing the costs and returns of alternative farm plans. In this method the changes in profit or loss is calculated through measuring income and returns given the resource constraint. However, the assessment of risk provided by this method is quite limited although it suggests a range of prices and costs at which a technology becomes profitable. The benefit of this model is that it is not very demanding in terms of data. However, since the data required normally varied according to the changes that are estimated the results can also vary depending on the changes estimated. The basic data requirements are input and output quantities, input prices, productivity levels of alternative technologies and output prices. Few empirical literatures where partial budget approach has been used are Dalsted and Gutierrez (2001)and Alston, Hyde and Marra (2002).



Accounting of the farmer field school activities

Bio-economic modeling (BEM)

Review of Bio-Economic Models (Brown 2000; Quaranta & Salvia n.d.) shows that one extreme of the BEM are primarily biological process models to which an economic analysis component has been added and the other are the economic optimization models which include various bio-physical components as activities among the various choices for optimization. In the middle are the integrated bio-economic models which is the most difficult and challenging area of the BEM field. In recent years major advances have been made in capturing the essential features of an integrated bio-economic model-from both ends of the continuum towards the middle as they increase in their sophistication and ability to model both of these aspects simultaneously. Integrated BEM attempts to capture the interaction between the bio-physical/agro-ecological and socio-economic processes (Ruben et al. 2001) whether at the household or regional level of aggregation. A truly integrated BEM needs to include the major characteristics of models at the two extremes, that is, it must include the socio-economic features of the economic optimization models on the one hand and the process simulation features of the primarily biological process models on the other (Brown 2000). A major prerequisite to develop such a model is an extended database for calibration and validation, covering all key issues over a long period of time (Quaranta & Salvia n.d.)

Step 4: Business plan for agricultural technology business promotion

A business plan is critical for the creation or expansion of any business. Wikipedea.org states that business plan is a formal statement of a set of business goals, the reasons they are believed attainable, and the plan for reaching those goals. It may also contain background information about the organization or team attempting to reach those goals. Business plans may also target

Table 6: Identification of technology innovations and their likely impact for the poor SHs for the assessment by TIGA partner study teams in South Asia and Sub-Saharan Africa

Country	Identification of technology innovations for the poor SHs and their likely impact
Bangladesh	Study team followed a bottom up process for identifying potential technology innovations for the poor SHs- by matching available agricultural technologies with the circumstances in which the poor live and the lives they want to live. Most of these technologies are already in use by majority of the farmers in advanced areas of the country and few progressive/model farmers in those sub-districts but not yet adopted on a large scale by poor SHs in those sub-districts. Based on the literature review/published documents, expert consultation and researchers' field visit and consultation with technology experts/local stakeholders, the study team made a lists of about 52 technology innovations from all stages of pre-production, production, harvesting, processing and marketing primarily focusing on cereal crops and then conducted a perception study to know farmers' existing knowledge, adoption, aspiration, barriers, etc. The study team also investigated the non-cereal crops, non-crop framing, non-farming livelihood innovations for the poor SHs in the localities. Perception study including qualitative investigations includes the extension, credit and other support system available/to be required for adopting those technologies. Potential gains for the suggested technologies using economic surplus model have been considered. Final lists are fine-tuned by experts and local stakeholders including farmers -some technologies are common for all sub-districts but some are area specific. The lists of common technologies are given below: Intensive crop system technologies and changing cropping pattern Seed Technology: Hybrid and short duration rice varieties, quality seeds; Technology related with water management/saving practice; Mechanical Innovations: Power tiller, power tiller operated seeder, thresher (both paddle and mechanical), rice miller Non-crop innovations (non-crop farming, non-farm enterprise/business): livestock and poultry rearing, seasonal crop business, agricultural machineries workshop/service business. Area-specific technologies are below: **Rajibpur:** 1)Maize+chili, Chili+vegetable, maize/wheat instead of Boro rice; 2) Hybrid maize and stress tolerant wheat varieties; 3) Improved fita pipe; 4) Power tiller, thresher (both paddle and mechanical), rice miller; 5) Business/enterprise: seasonal crop, livestock and poultry rearing, fishing, boat, rice milling **Dowarabazar:** 1)Rice fish farming 2) Flash flood tolerant rice varieties, 3)Pond digging or re-excavation, LLP, STW, rubber dam, 4)Power tiller, thresher (both paddle and mechanical), rice miller, 5)Business/enterprise: seasonal crop, livestock and poultry rearing **Porsha:** 1) Wheat/maize (instead of Boro rice) +orchard, 2) Maize and stress tolerant wheat varieties through shifting from Boro rice. Drought tolerant short duration aman rice varieties, 3)Pond digging or re-excavation, 4)Power tiller, thresher (both paddle), rice miller, 5) Business/enterprise: Mango cultivation/orchard, water harvesting/mini-pond digging/re-excavation **Damurhuda:** 1)Maize+chili+vegetable, maize+ sugarcane+chili, 2)Maize and hybrid vegetables, 3) STW, AWD4)Handy USG (Guti urea) applicator, power tiller, power tiller operated seeder, thresher, 5)Business/enterprise: seasonal crop/vegetables business, beef fattening, poultry, small scale fruit gardening, goat farming, power tiller and threshing service; agro-machineries **Bhandaria:** 1)Rice fish farming, rice + lentil, pumpkin/water melon along the plot-line; 2) Hybrid rice varieties, saline resistant rice varieties, sun flower, hybrid vegetable seeds, 3)LLP, STW, AWD, 4)Handy USG (Guti urea) applicator, power tiller, power tiller operated seeder, thresher, 5)Business/enterprise: seasonal vegetables, fruit gardening, fishing + poultry, livestock and poultry, agro-machineries

Country	Identification of technology innovations for the poor SHs and their likely impact
India (Bihar and Odisha)	Based on secondary research, workshop findings and other interactions with scientists and technology experts, suitable technologies were identified with the potential for raising agricultural productivity, mainly in the marginal districts. Most of these technologies have been tested in the fields, both by research-institutions and sometimes by the innovative/progressive farmers. However, they are yet to be adopted or adopted on a large scale by farmers of the marginal districts. Marginal effects for trying those technologies have been considered. **Rice:** Varietal substitution towards (climatic) stress-tolerant, high-yielding varieties Promotion of mechanized Direct Seeded Rice (DSR) technology for rice-cultivation Promotion of the self-propelled paddy trans-planter machine. Establish custom hiring centers in rural areas and machinery-hubs in KrishiVigyanKendras (Agriculture Science Centers). Integrated nutrient management, involving use of both organic and inorganic fertilizers. System of Rice Intensification (SRI) technology in conjunction with organic treatment can in principle give significantly better results in terms of high yield and superior nutrient-use efficiency in some of the districts cultivating rice. Complementary inputs required. **Maize:** Promotion of hybrid maize cultivars, in particular the single cross hybrid, developed for specific agro-ecological ecosystems/zones Timely availability of hybrid-seeds by strengthening seed-supply and enhancing seed-production Raised bed planting of maize **Wheat:** Surface seeding technique for rice-wheat systems Zero tillage wheat with Resource Conserving Technologies (RCTs) Laser land leveling **Pulses:** Stress-tolerant high-yielding varieties Inter-cropping of pulses Line sowing/seed drill/zero till Use of Rhizobium culture and phosphatic fertilizers Use of micro-nutrients Infrastructure for marketing and storage
Ethiopia	Based on their survey data and nationally available data, the study team compared the cereal's yield gaps between SHs and commercial farmers of different technologies and suggested the following for the SHs in marginality hotspots: Improved seeds. Improved seeds constitute only 5.6% of the total land cultivated. Use of inorganic fertilizer. The rate of application of chemical fertilizers among smallholders is low as compared to the recommended rates Row planting techniques. Among improved crop management practices the row planting method is the most promising technology to boost productivity. Teff productivity can be doubled. Lending technology. Government is not promoting credit to smallholders. A basket of saving products should be presented to the farmers from which they would make a choice.
Ghana	Technologies work best when it is adapted to the specific conditions of the intended beneficiaries and has optimum adoption rate. Six technologies were chosen which have the highest positive welfare impact, ranked after a stochastic dominance test was carried out: Vegetable farmers in Afigya-Kwabre District: Inorganic fertilizer; Irrigation; Zero tillage Cocoa farmers in Amensie West District: Zero tillage; Irrigation; Inorganic fertilizer; Pesticides (against weeds) Ginger farmers in Kintampo South District: Marketing; Irrigation; Maize farmers in Atebubu-Amantin District: Storage facilities; Inorganic fertilizer Tolon District of the Savanna zone: Pesticides; Improved seeds Gonja-East District: Improved seeds (Yam minisetts); Agroforestry

changes in perception and branding by the customer, taxpayer, or larger community. When the existing business is to assume a major change or when planning a new venture, a 3 to 5 year business plan is required, since investors/donors will look for their annual return in that timeframe. An effective business plan could be derived if it comes through a shared understanding of all relevant stakeholders of what a business model actually is(Osterwalder et al. 2010).It could come through discussion, meeting, or workshop on business model innovation with the active participation of all relevant stakeholders.

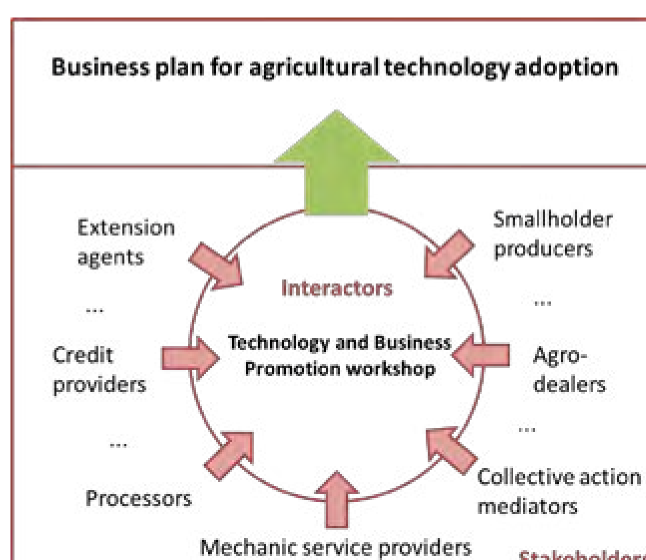
This part of the manual builds on the results of the TIGA project outcomes described at the previous part of the manual and aims at grasping the identified opportunities by coming up with a business plan with prospects of being realized in each partnering country. More specifically, the business plan discusses about how the selected (most promising) agricultural technology innovations identified at the earlier part of the assessment could be adopted in those marginal areas of the partner countries. The business plans rolls out on

- for which purpose selected stakeholders will collaborate (e.g. maize business promotion)
- who will collaborate (e.g. particular smallholders, breeders, seed/input providers, extension agents, mechanic service providers and credit providers)
- how they will collaborate (e.g., activities of each, advance and intermediate investments, simple financial plans and simple contracts)

The business plan needs to elaborate on the requirements and prospective outcomes of adopting particular technology innovations by poor SHs. There should be minimum consent that the adoption of selected innovations is in the interest of the farmers and that it has potential to increase productivity and household income. Among others, the business plan will provide answers to the questions: 1) Where is the SHs' business now (in terms of productivity, livelihood indicators)? This is an assessment of the current state of the SHs' business. 2) What is the objective (e.g. improving productivity by adoption of the innovation)? 3) How to achieve the goal (the strategy and plan)? Which market demand is met; which resources are required (labor, finance, production inputs); which strategy is proposed and revenues are expected? The business plan will comprise of the parts which are usually found in a business plan: Marketing plan, Production plan, Management plan, financial plan, and the implementation plan.

For that purpose, relevant stakeholders which have an interest in promoting SHs' productivity (typically those within the value chain but not yet linked) might be brought together in Technology and Business Promotion (TBP) workshops. Alternatively, a business consultant may interview the relevant actor, agree on a set of technologies they would focus on and make informed estimates about the number of farmers reached, the technology applied, the outcomes and the output of the technology (see table). Stakeholders/actors are e.g., farmers, technology providers and producers, credit providers, knowledge providers, input providers (agro-dealers), collective action facilitators (mediators), processors, and wholesalers/purchasers. The business consultant jointly with TIGA partners/local collaboratorswill select representatives of each stakeholder group for TBP workshop/interview. TIGA project partners have already worked with their local collaborators in the previous phase. In this workshop, stakeholders become interactors (Figure 17). The workshops are about putting on the table what each stakeholder can offer and which investments can be made by whom, given the collective endeavor of promoting most promising business plans related to the previously identified technology innovations. The

Figure 17: Stakeholders become interactors in a collective action process towards eliciting business opportunities and designing business plans



experiences show that the NGOs are usually better equipped to work with the smallest and most marginalized farmers. Extension agencies, like KVK in India, may work better with farmers who have more land to cultivate. Although the actors providing public services in agricultural development partially work with the same type of farmers the business plan we want to come up with should make sure that each actor applies a bundle of different types of technologies, e.g. the NGO focuses on vegetable seeds, vermin-compost and organic pesticides; KVK focuses on m-services and seeds, etc. The goal for each actor should be an increase in the productivity of the smallholdings which apply the technology and an improvement in the outreach (e.g. no. of farmers receiving seeds, or training). Productivity growth can be achieved, e.g., by fetching a higher price on the market, by reducing farm input or labor costs, or by increasing yields/area.

Table 7: Components of a typical business plan output

Actor	No. farm HH reached	Crop	Technology (e.g. improved seeds, other farm inputs, machinery, improved practices)	Main activities (required for technology promotion)	Output (e.g. yield increased by …/ha, products certified, seed replacement rate increased)	Outcome (e.g. livelihoods improved)
e.g. Kaushalya Foundation	10,000			Year 1		
				Activity 1.1 …add rows as required		
				Year 2		
				Activity2.1 …add rows as required		
				Year 3		
				Activity 3.1 …add rows as required		
e.g. KVK Nalanda	30,000			Year 1		
				Activity 1.1 …add rows as required		
				Year 2		
				Activity2.1 …add rows as required		
				Year 3		
				Activity 3.1 …add rows as required		
…	…			Year 1		
				Activity 1.1 …add rows as required		
				Year 2		
				Activity2.1 …add rows as required		
				Year 3		
				Activity 3.1 …add rows as required		

Note: Cost calculation: Provide a cost estimate and narrative for each activity. Cost categories are: Personnel; Travel, workshops, meetings; Capital equipment (>5,000 USD and useful life > 1 year) and other costs

Obviously, the more funds are available, the more farmers can be reached and the more technologies can be promoted. Therefore assumptions need to be made on the budget constraint, which could be e.g. 1,000,000 USD. That budget would need to be distributed to the actors in a way which matches their current capacities. That means, the NGO may need to recruit another field officer, however the transfer and adoption of technologies should mainly take place within its current capacities. That means, with an available budget of 1 million USD one should not think of increasing the capacity of an NGO, rather work with the current capacity. The same applies to the other actors. The budget can be used for personnel, travel, training, and equipment (below 5000 USD). How to distribute a budget of approximately 2-30,000 USD for one actor to different activities would need to be worked out by the consultant in communication with the actors. The technologies being chosen should be those in which the actors are experienced and good at. They can refer to those technologies identified in the marginality hotspots and/or those recommended in current agricultural development strategies of the country.

The business plan is a local clearing house activity for technology adoption and business promotion. The potential outcomes can be formulated as:

1. Stakeholders have insufficient interests, capacity and opportunity overlap and therefore cannot come to a collective business plan for technology adoption.
2. Stakeholders have intermediate interest, capacity and opportunity overlap and therefore need additional support for coming up with a collective business plan for technology adoption.
3. "Best case scenario". Stakeholders have strong interest, capacity and opportunity overlap come up with a collective business plan for technology adoption and expect funding for implementation.

The best case scenario outputs would be natural candidates for submitting proposals to any development donor/philanthropic organization for funding implementation.

A consultation meeting with public sector extension workers/officers at Bhandaria(representing coastal region) Sub-district (Upazila)

The consultant (responsible to develop the business plan) needs to keep in mind that technological innovations can fail to be adopted and scaled up because of the following general reasons:

1. The innovation calculus is uneconomic at smallholder level, i.e. from the perspective of the smallholder (prospective innovator) it is too costly or costly to adopt an innovation for productivity growth
2. Related to 1). Institutions and property rights or absence thereof lead to an inconvenient cost/benefit allocation or inhibit the appropriation of sufficient benefits for the smallholder make the adoption worthwhile.
3. Uneconomic innovation calculus at scale. Some smallholders may decide to adopt the innovation. Most are however not in the position to be able to adopt the innovation.

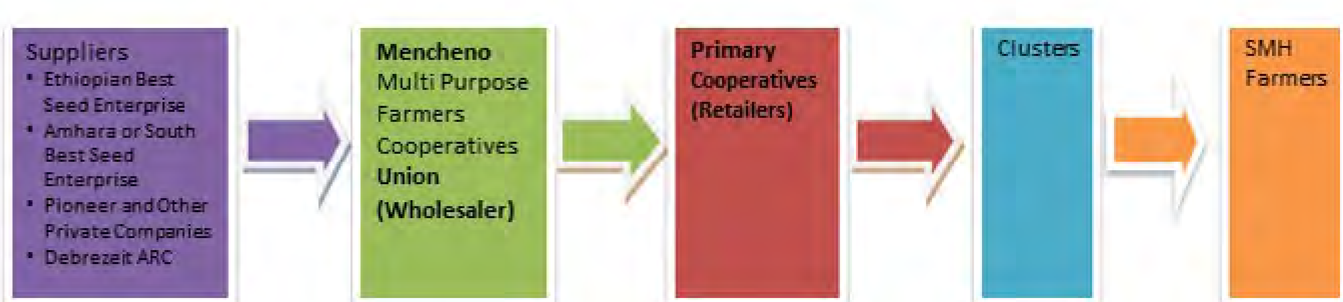
Table 8: Information required for a business plan to be given by each country partner

1. Region Geographical location and characteristics of smallholders	2. Farming system and type of smallholding	3. Technological innovation	4. Institutional innovation	5. Innovation calculus for specific actor	6. Adoptability	7. Scalability
EXAMPLE						
Bihar, India Province, district, village	Rice with vegetables 1 ha …	Vermiculture …	Government subsidy. Support by NGO Collaboration with association, enterprise, extension service,…	Cost, benefits, risks, time	Likelihood of adoption	Suitable to be up scaled and adopted by …no. of smallholders in the region.
… add rows as required						

Therefore, a business plan for agricultural technology business promotion for each country partner should be able to provide the following information (Table 8).

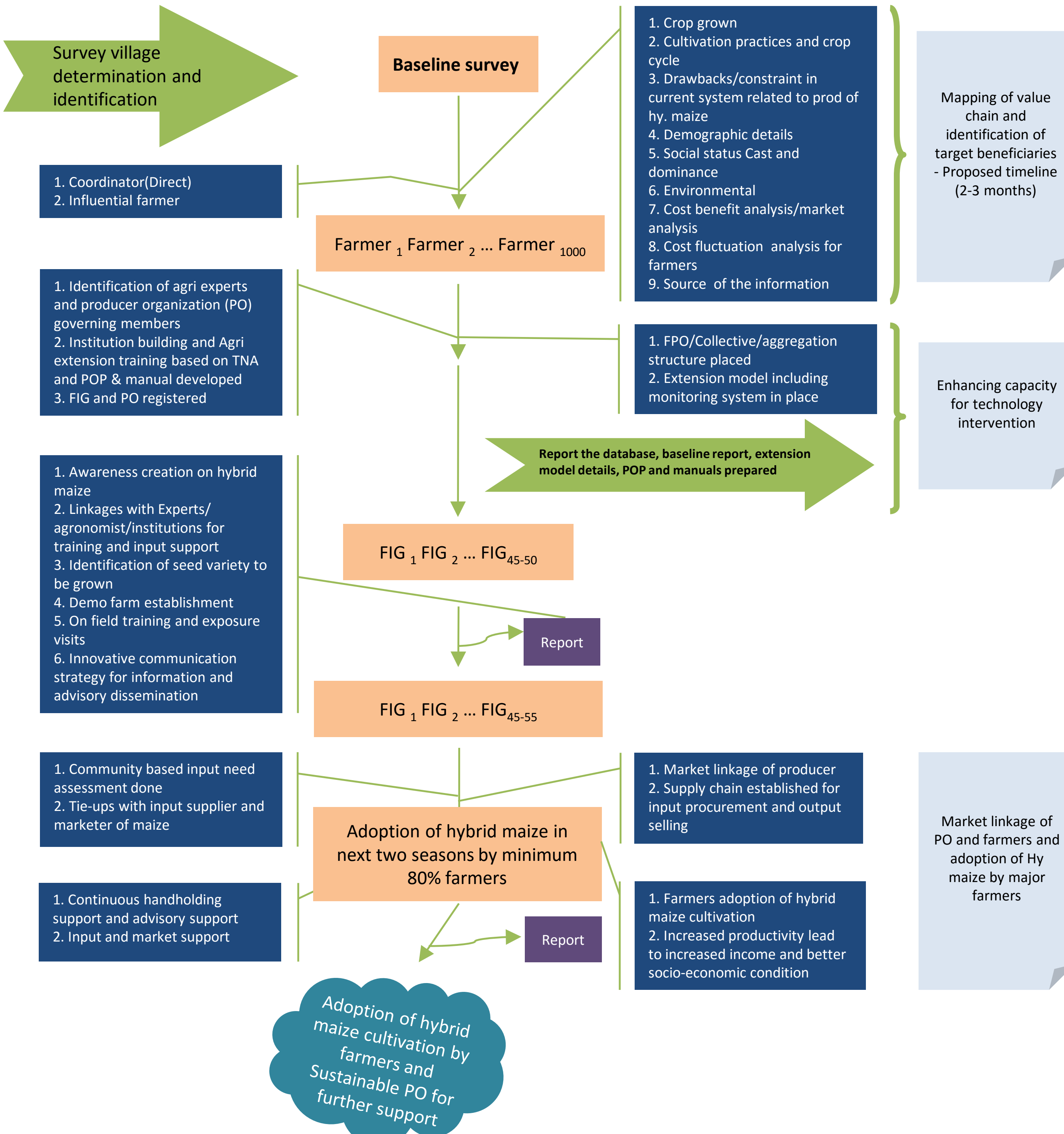
In the following figures 18A and 18B, and table 9 show different perspectives of business plan being developed by business consultant in three different partner countries (Bangladesh, Ethiopia and India).

Figure 18A: Technology supply chain for implementation of business plan in Halaba Special Woreda, Ethiopia



Source: Ethiopian Economic Association TIGA Project Report 2013

Figure 18B: Activity plan of three years business plan for hybrid maize technology promotion in Araria district of Bihar



Source: IFPRI TIGA Project Report 2013.

Table 9: 3 years period Technology promotion business plan for Bhandaria sub-district of Bangladesh

Technology Innovations	Institutional Innovations & Key Actors	Key Activities	Innovation Calculus	Output & Outcome
Extension Service	Extension farmers, BRAC-Extension officers, GOB-Department of Agricultural Extension (DAE)	• Appointing and training of extension officers. • Selection of two poor farmers from each village. • Training of agricultural extension farmers. • Follow-up by extension officers. • Monthly meeting with extension farmers. • Relaying popular theatre.	• Monthly compensation to extension officers. • Financial incentive to extension farmers. • Training cost for the extension officers and farmers. • Incentive for popular theatre. • Extension service at the doorstep of farmers.	• Sustainable extension service. • Smallholder farmers will be able to protect themselves from tentative productivity or financial losses due to lack of on time access to information.
Sunflower	Extension farmers, BRAC-Extension officers,authorized input dealer, seed enterprise, community empowerment program, tenant farmer development program, Private Oil seed processing company, GoB-DAE	• Forming farmers' cooperative. • Providing training to farmers. • Field day for demonstration. • Creating awareness through popular theatre.	• Estimated production cost for producing sunflower in one acre land is $257. • 30 mound yield/1 acre land. • Estimated revenue from selling seeds of one acre land is $539. • Net profit per acre is $282.	• Producing and selling sunflower oil seed commercially will utilize the fallow lands thereby increasing income by 2 to 2.5 times.
Power tiller	Extension Farmers, BRAC-Extension Officers, Private Power tiller selling company, bKash payment platform	• Forming farmers' cooperative • Three member maintenance team. • Credit purchase with equal monthly installment payment over bKash. • Fortnightly cooperative meeting.	• Power tiller costs Taka 135,000. • Each of 25 Farmers has to pay 12 monthly installment of Taka 450. • Tilling cost will be paid by farmers to the common fund. • Installments, maintenance, fuel costs etc. will be paid from the common fund. • BRAC can charge 13.5% flat interest for credit sale. • Availability of power tillers to the poor farmers at an affordable installment price. • Surplus amount after meeting expenses will be deposited to a bank account	• Availability of power tillers to the poor farmers at an affordable price. • Utilization of fallow land, which were left uncultivated due to high tillage cost.

continue →

Technology Innovations	Institutional Innovations & Key Actors	Key Activities	Innovation Calculus	Output & Outcome
Low lift pump	Extension farmers, Extension officers, Low lift selling company, bKash payment platform	• Forming farmers' cooperative • Two members' maintenance team. • Credit purchase with equal monthly installment payment over bKash. • Fortnightly cooperative meeting.	• Low lift pump costs Taka 20000 (Engine+ Pump+ Boring). • Each of the five farmers has to pay installments of Taka 334 for12 months. • Farmers will pay for the irrigation on hourly basis and will be deposited to the common fund. • Installments, maintenance, fuel costs etc. will be paid from the common fund. • BRAC can charge 13.5% flat or 27% declining interest for credit sale. • Low cost access to irrigation for smallholders • Surplus of common fund will be deposited to a cooperative bank account.	• Low cost access to irrigation for smallholders. • 'Boro' rice and other winter crops can be irrigated during dry season.

6 Lessons learnt from business/implementation plan

- Technology innovations identified at previous phase and validated during preparing business plan have adoption feasibility in the marginal areas in the partner countries. Business planners also find that the adoption of selected innovations is necessary in the interest of the SHs and the SHs have strong potential to increase productivity and household income(For example, cultivation of hybrid maize in Araria district of Bihar, India is more than twice as beneficial; Commercial producing and selling sunflower oil seed can utilize the fallow lands thereby SHs' increasing income by 2 to 2.5 times in Bhandaria sub-district of Bangladesh).
- It is also found that to implement the business plan in each partner country, different stakeholders/actors e.g., farmers, technology providers and producers, credit providers, knowledge providers, input providers (agro-dealers), processors, and wholesalers/purchasers, government departments, NGOs, etc. need to collaborate and it is also found that the relevant stakeholders in those areas have strong interest to collaborate but lacks for a common platform/coordinating bodyandsufficient; capacity for implementing those business plan and funding as well
- Thus, to create the platform for the stakeholder ***a capacity and network building initiative for technology adoption for marginal areas for South Asia and Sub-Saharan Africa***[13] could be initiated for 3-4 years. Capacity building of local stakeholders and creating platform (at different level, say, village, sub-district/district, national and international) would be the major component of such an initiative. To see the impact of different components under such initiative, some experimental researches (quasi-experimental or randomized control trials) could be conducted. Successful implementation of such an initiative makes all relevant stakeholders along the value chain able to collaborate each other, build their capacities and work together. At the end, all stakeholders are benefited and able to sell their different products/services at the respective markets/communities.

Endnotes and References

1 See Ruben et al. (2007), Renkow (2000) for review about poverty, productivity and production environment relationship in the less favored/marginal/laggard areas.

2 Such zones are endowed with less private and public infrastructure, are more distant from markets, and have less favorable climates for agriculture.

3 Institutions are understood as different forms of rules at different levels of decision making (e.g. norms, conventions, laws, regulations, rights) which are put into play by governance structure, e.g. the market, the state, or particular arrangements to manage the land, like e.g. sharecropping.

4 Transaction costs arise as an effect and they are either externalized under segregative institutions, or internalized or fairly shared under integrative institutions.

5 Tools and Formats mentioned within this section are more or less referring to the GIS software ArcGIS of ESRI. For further information: http://www.esri.com/software/arcgis

6 Small area estimation combines detailed household survey information with population census data.

7 Wereda-level is the third administrative level after the regional (first level) and zone level (second level).

8 Agro-ecological suitability is classified into the following 8 classes: 1=very high; 2=high; 3=good; 4=medium; 5=moderate; 6=marginal; 7=very marginal, 8=not suitable

9 Involved with primary farming production either part-time or full-time either in owned land or rented in land, farm size<1 hectare, permanent res.> 3 yrs, farming exp.> 3 yrs, etc.

10 e.g. subjacent poor are those with incomes btw 1.25 and 1 $/day, medial poor: 1 and .75 $/day and ultra-poor: below .75 $/day

11 This stratification needs tobe adjusted to national/regional poverty lines in each study country.

12 subjacent poor are those with incomes btw 1.25 and 1 $/day, medial poor: 1 and .75 $/day and ultra-poor: below .75 $/day

13 One similar initiative supported by Gates Foundation is Ethiopian Agricultural Transformation Agency (http://webcache.googleusercontent.com/search?q=cache:qz5dn-mYMZYJ:www.ata.gov.et/initiatives/technology-access-adoption/&hl=en&gl=de&strip=1) could be initiated for marginal areas for partner countries.

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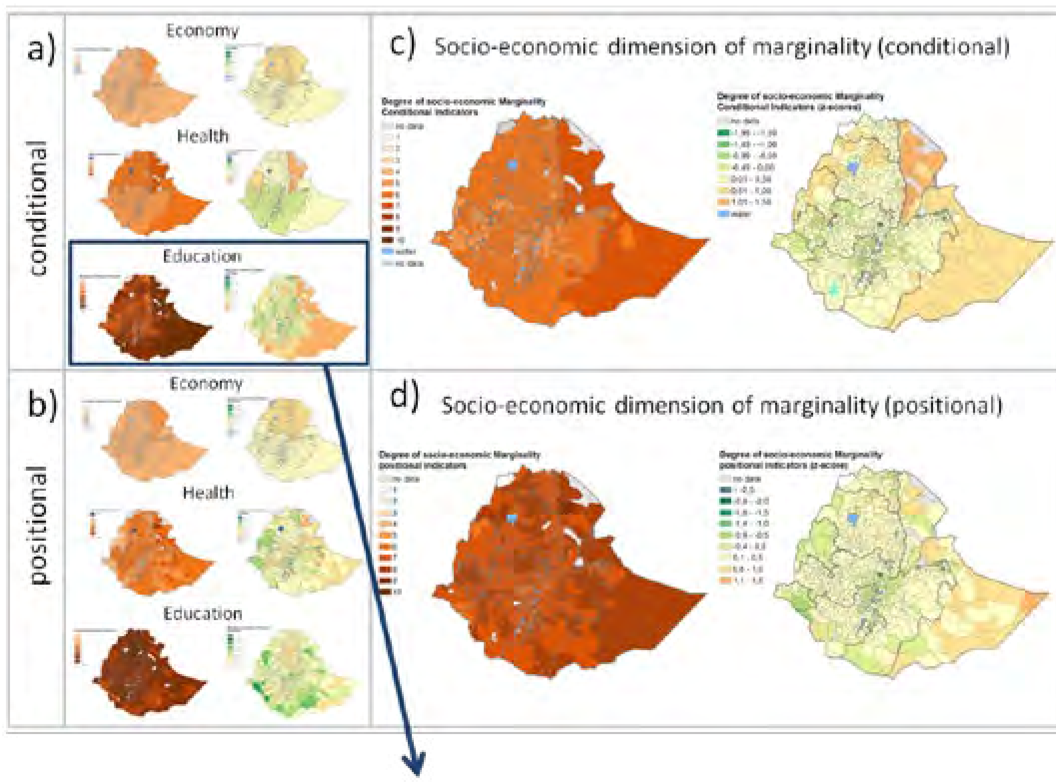
Appendices

Annex 1: The work flow of marginality mapping of the socio-economic dimension

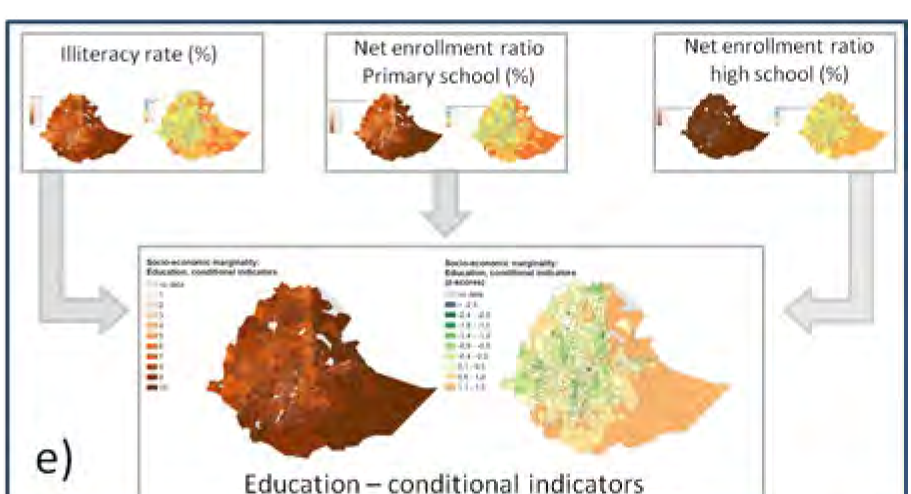
Dimension			Indicator	Source	Cut-off point	Temporal resolution	Spatial resolution
Socio-economic	Economy	conditional	Regional Poverty headcount index	Ministry of Finance + Economy Development (2012)	< 3781 birr	2010/2011	Region
			Food poverty headcount index	Ministry of Finance + Economy Development (2012)	< 1985 birr	2010/2011	Region
			Wealth index	CSA (2012): EDHS	< middle wealth quintile	2011	Region
		positional	Access to markets (travel time to next city > 50.000 capitals)	CSA (2007): PHC	no cut-off point	2007	Wereda
			Transportation infrastructure (road density)	CSA (2007): PHC	no cut-off point	2006	Wereda
			Information infrastructure (households with telephone)	CSA (2007): PHC	no cut-off point	2007	Wereda
	Health	conditional	Child mortality rate (<5 years)	CSA (2012): EDHS	death	2011	Region
			Nutritional status of children (stunting < 5 years)	CSA (2012): EDHS	-2 SD from median of WHO reference population	2011	Region
			Nutritional status of adults	CSA (2012): EDHS	BMI < 18,5	2011	Region
		positional	Access to drinking water	CSA (2012): EDHS	no protected drinking source	2007	Wereda
			Vaccination coverage (children 12-23 month)	CSA (2012): EDHS	Not all basic vaccinations	2011	Region
			Access to health service (health service coverage)	Ministry of Health (2011)	no cut-off point	2011	Region
	Education	conditional	Illiteracy rate (male / female, age 15-49)	CSA (2012): EDHS	not able to read + write	2007	Wereda
			Net enrolment ratio primary school	CSA (2007): PHC	Not enrolled	2007	Wereda
			Net enrolment ratio high school	CSA (2007): PHC	Not enrolled	2007	Wereda
		positional	Access to education (no. of primary schools related to population density)	Ministry of Education (2004) In: Atlas of the Ethiopian Rural Economy	No cut-off point	2004	Wereda
			Access to information (% of households with radio)	CSA (2007): PHC	No radio	2007	Wereda
			Access to information (% of households with tv)	CSA (2007): PHC	No television	2007	Wereda
Agro-ecological	Bio-physical conditions	conditional	Agronomic suitability for rainfed crops (based on climate, soil and slope data)	Fischer et al. (2002)	No cut-off point	2002	10 km (pixel size)
	Socio-economic (farmers)	positional	Access to technology (% of farmers applying inorganic fertilizer)	CSA (2002)	Not applying inorganic fertilizer	2001/2002	Wereda
			Access to knowledge (% of farmers utilizing advisory services)	CSA (2002)	Not using advisory service	2001/2002	Wereda
			Access to credit (% of farmers utilizing credit services)	CSA (2002)	Not utilizing credit service	2001/2002	Wereda

Annex 2: Overview of all indicators used to map the socio-economic and agro-ecologyical dimension of marginality



Annex 3: Work flow of marginality mapping (socio-economic dimension, example of education)

The socio-economic dimension of marginality is defined by three conditional (a) and positional (b) indicators, respectively, for the economic, health, and educational sphere. The upper figure shows marginality results of all three groups (a, b), and the final degree of marginality in the socio-economic dimension (c, d) (mean of all three sectors). The mapping of conditional indicators of the educational sphere is shown in the lower figure e). All results are shown in absolute values and z-scores (always displayed on the right).



Annex 4: Summary matrix of ex-ante methods for evaluating agricultural technology innovations

Model/tools/approach	Author	Technology	Methodology	Data Requirement	Limitations
Economic surplus model	Pray, Huang and Qiao 2001; Qaim 2003; Hareau , Mills & Norton 2006;	Genetically Modified (GM) Crops	• Most commonly approach used for the evaluation of commodity-related technological progress in agriculture (Norton and Davis 1981; Alston, Norton and Pardey 1995). • The effects of interventions that have measurable impact on the production and price of commodities are investigated.	Productivity increase generated by research, equilibrium price of assessed product, adoption rate and costs, timeframe between research and adoption, and price elasticity of supply and demand	• Requires good information on price responsiveness of producers and consumers that often is not available; non-marketed benefits and hidden costs (e.g. social) difficult to incorporate • Reliability of data
	Krishna and Qaim 2008	Bt Eggplant			
	Orachos and Traxler 2009	GM Papya			
	Thorne et al. 2002.	• Use of collected weeds of the maize crop for livestock feeding programmes • improved management of green maize Stover for feed use • improved feeding systems incorporating dry maize Stover • chopping/soaking of dry maize Stover • use of replacement fodder crops • intercropping • improved manure management strategies and • Selection and/or breeding for improved digestibility of maize Stover. • Timeline:1999-01			

continue →

Model/tools/approach	Author	Technology	Methodology	Data Requirement	Limitations
Minimum-Data (MD) Approach	Akroush 2012.	Water Harvesting Technique in the Jordanian Badia	Provides an estimate of the rate of adoption of alternative practices based on their economic feasibility, i.e., on the differences in returns between the observed practices and the alternative practices.	Quantities and prices of inputs (such as seeds, labor, fertilizer and manure) and outputs (crop yields, land areas)	Actual adoption and household decision making is influenced by numerous other factors besides economic feasibility.
	Claessen, Stoorvogel and Antle 2009.	Dual-purpose sweet potato in the crop–livestock system of western Kenya			
Cost- Benefit Approach	Victor et al. 2010.	Sustainable Certified Cocoa in Ghana	Most widely used method of evaluating long-term public disease control programmes	Input & output prices, labor estimates, production (yield) data, price elasticity of supply and demand	
	Wiebelt 2000.	Integrated pest management (IPM) Technology in Nepal			
	Robertson, Carberry and Brennan 2007	Precision agriculture in Australia			
Parametric modeling approach/ Graphical approach	Dillen, Demont and Tollens 2008	Biotechnology innovations (HT Sugar beet)	Focused on farmer heterogeneity as the adopting and non-adopting farmer segments that are not directly observable to the researcher and homogeneity bias arises can be used by breeders, crop protectionists and bio-safety regulators to estimate the value of such technologies	Survey data on Herbicide product and application cost	
	Demont et al. 2009	Hybrid resistance rice		Survey data on weed management cost.	

Model/tools/approach	Author	Technology	Methodology	Data Require-ment	Limitations
Economic modeling ap-proach	Viaggi and Bartolini 2008	Agri-environmental Con-tracts	The mythology is divisible in two levels: • Farm level analysis is realized using a land allocation model based on a real options approach. • Aggregate policy impact is identified through the quantification impacts at territorial level and the weights are elicited with MCRID methods.	Secondary data was used to simulate the ex-pected outcome.	
Partial Budgeting Ap-proach	Alston, Hyde and Marra 2002	Rootworm resistant corn	Estimate the likely economic impacts in the US if the commercial adoption of such technology. • estimate the adoption pat-tern. • project adopti-on =f(expected agrology spe-cific yields and cost of the new technology)	Experimented on 11 Corn produc-tion regions. Data based on actual incidence ->Calculate the pecuniary and non-pecuniary benefit. Experimental data on the impact of alterna-tive options.	• Assumed that all farmers would adopt the technology given higher expected profit. • Does not allow for responses by suppliers of competing technologies.

Model/tools/approach	Author	Technology	Methodology	Data Require-ment	Limitations
Integrated bio-economic modeling (BEM)	Brown 2000; Quaranta and Salvia, undated		• It is based on two extreme models: one is BEM that is primarily biological process models to which an economic analysis component has been added; and the another one is economic optimization model that includes various bio-physical components as activities among the various choices for optimization. • Thus, integrated BEM captures the interaction between the bio-physical/ agro-ecological and socio-economic processes whether at the household or regional level of aggregation.	An extended database for calibration and validation, covering all key issues over a long period of time	The type of data required for this model is hardly available

The manual is based on the experience and draw out the collected lessons learnt with regard to the design and implementation of TIGA project in the South Asia and Sub-Saharan Africa. As such, this builds on and expands existing guidelines and documentation for agricultural technology assessment. It adds the perspective of technology assessment of including the cross section of segments of the rural poor characterized by varying degrees of overlapping human capabilities and agro-ecological potentials rather than the technology-driven approaches that tend to favor those with better adoption capabilities. The manual also gives the reader a well-documented experience of bottom-up approach for technology assessment. The ultimate goal of the manual is to contribute to the inclusion of all poor small farming communities in agricultural technology innovations by presenting the improved way of understanding of the interactions between technology needs, farming systems, ecological resources and poverty characteristics in the different segments of the poor, and to link these insights with productivity enhancing technologies in order to guide action to overcome current barriers to technology access and adoption.

ISBN 978-3-00-054594-8