How to pick the right technologies? Assessing high potential agricultural innovations for sustainability

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Abstract
The world today faces many challenges. Population growth, malnutrition, and poverty, exacerbated through climate change, increasing water scarcity, land degradation, pandemics like HIV/AIDS to mention only a few are on the daily agenda of policy makers, researchers, and development agents. The identification of practicable technologies throughout the food system to sustainably improve the food and nutrition security for rural and urban populations in the Asia Pacific region is an issue. Agricultural extension agents and field workers find it difficult to get reliable information about innovations and technologies that are sustainable, productivity enhancing and suitable for poor and vulnerable target groups that is detailed enough to start experimenting, rebuilding, adapting or adopting high potential innovations. To respond to this need, the SATNET Asia project collects agricultural technologies, evaluates their sustainability and suitability for poor and vulnerable people, and makes detailed information about these technologies available publicly. Once assessed and published, the knowledge of these successful technologies will be disseminated to other farmers and regions.
An analytical framework was developed to identify potentially suitable technology options and best practices. It assembles three distinct tools for the collection and evaluation of technology options as well as for the validation of the evaluation results. The literature was reviewed to identify important criteria to assess the sustainability of technologies in the field of environmental, economic, and social sustainability as well as criteria that pertain to the technology itself. Main criteria were selected, integrated into the framework, and assigned weights of relative importance. To do this, the methodology of the Analytical Hierarchy Process (AHP) was tested. Information about the sustainability criteria are collected for different technologies. The framework and first results are presented. The first two tools of the framework so far implemented pose challenges that are discussed.

Keywords: best practice, evaluation, indicator, innovation, multi criteria decision making, sustainable technologies

1) Introduction

Rural poverty, malnutrition, gender inequalities as well as environmental degradation are widespread in South and Southeast Asia where the majority of the world's poor people reside. The region has the highest proportion of undernourished people worldwide. Agriculture (including fisheries, aquaculture, horticulture and forestry) remains the economic backbone of most of these countries, yet growth within the sector, especially in less favoured environments, has remained low. The South and Southeast Asia region is characterized by high levels of heterogeneity, with a wide variation of agroecological zones, biodiversity, levels of social and economic development and human capacity. The region's ecosystems range from highly fertile irrigated land to drylands, from vulnerable mountain cultivation areas to coastal zones.

Although the Green Revolution has spurred growth in the agricultural sector during past decades, too little of this growth has benefited the poorest and most vulnerable. This has questioned the effectiveness and efficiency of the original scientific approach to innovation generation and dissemination. This approach was a linear one with knowledge being generated by research, communicated by extension services and received by farmers. However, practitioners in the field of rural development successfully implemented participatory approaches to involve the concerned people into decision making about their own future. Subsequently, more multifaceted scientific approaches like the Agricultural Knowledge and Information System (AKIS) and the Innovation Systems approach were developed that better reflect and explain the complexity of reality (World Bank, 2007).

Knowledge and information management within agricultural innovation systems is still a challenge. The current organization of knowledge, science, and technology cannot adequately deal with the challenges to sustainable food systems because information on food, health, agriculture, forestry, landscape management, rural areas, environment, climate, ecology, and policy trends continue to reside in separate 'knowledge silos' (Weinberger et al 2009). Agricultural extension agents and field workers find it difficult to get reliable information about innovations and technologies that are sustainable, productivity enhancing and suitable for poor and vulnerable target groups that is detailed enough to start experimenting, rebuilding, adapting or adopting high potential innovations (Jaenicke and Spisiakova, 2012). This has implications for the degree to which lessons learnt within an innovation system in one region can be adapted and applied to other regions. But it also provides considerable scope to identify factors for success through cross-regional research and development activities and networks.

The present work is part of the SATNET Asia project, the 'Innovation Network for Food Security and Poverty Reduction'. The objective of the project is to support innovation by strengthening South–South dialogue and intraregional learning on sustainable agriculture technologies and trade facilitation. The project establishes a network and brings together key stakeholder groups by region, by discipline and by function to open "knowledge silos" and to allow better information exchange amongst groups that have a stake in agricultural innovation systems in South and Southeast Asia.

The objective of this study was to identify agricultural innovations that are sustainable, productivity enhancing and appropriate for the poorest and most vulnerable populations of South and Southeast Asia. Technologies that fulfil these criteria are called suitable in this document. Sustainability can be assessed at several levels, from international and national levels (UN Commission on Sustainable Development, 2007), down to farm level and technology level (DANTSIS et al., 2010; RIGBY et al., 2001; KRAJNC and GLAVIČ, 2004; AZAPAGIC, 2004; VELEVA and ELLENBECKER, 2001; KRIESEMER, 2009). At farm and technology levels, the authors identified over 100 criteria and three to six facets of sustainability from the literature that are used to assess sustainability. Three of these facets represent the classical pillars of sustainability: environment, economy and society.

The gathered knowledge will ultimately be prepared and organized in fact sheets that provide a comprehensive and detailed overview about the technologies. Fact sheets will be communicated within the project network and will be made available on the project's web page. This will enable potential users of the information to understand and adopt the technology or to adapt it to their particular needs and circumstances.

2) Material and Methods

To identify the most suitable technologies, an analytic framework was developed (Figure 1). The framework contains three distinct tools to collect and evaluate information on appropriate innovations based on relevant criteria: (1) the application phase, (2) the selection process, and (3) the validation of the selection results.

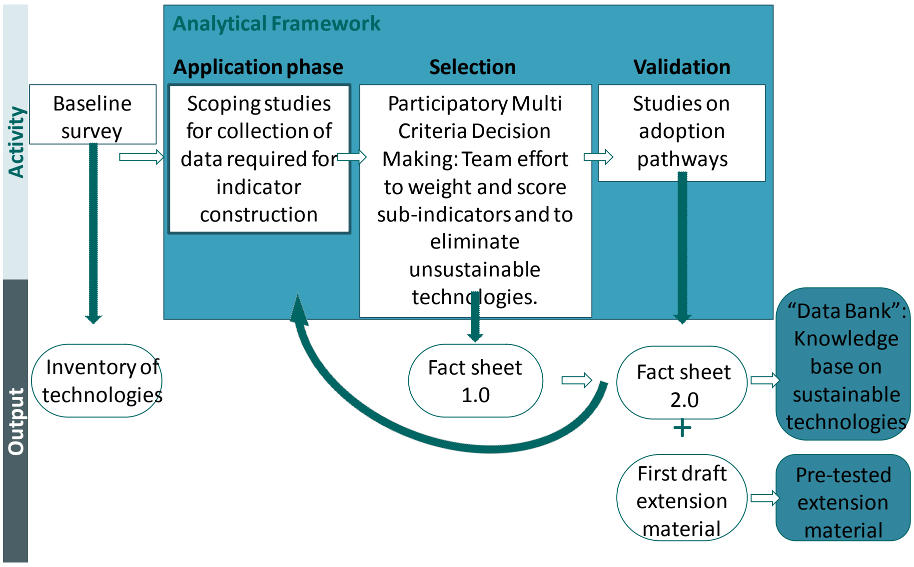

Figure 1: Analytical Framework for SATNET Asia

The problem of identifying suitable technologies was decomposed into a hierarchy with three levels with an overall objective, sub-objectives, and criteria (Figure 2). In particular, the overall goal was to identify suitable technologies. The sub-objectives correspond to the three pillars of sustainability and comprise criteria on environmental, economic, and societal sustainability. A fourth sub-objective covers criteria relating to the technology itself.

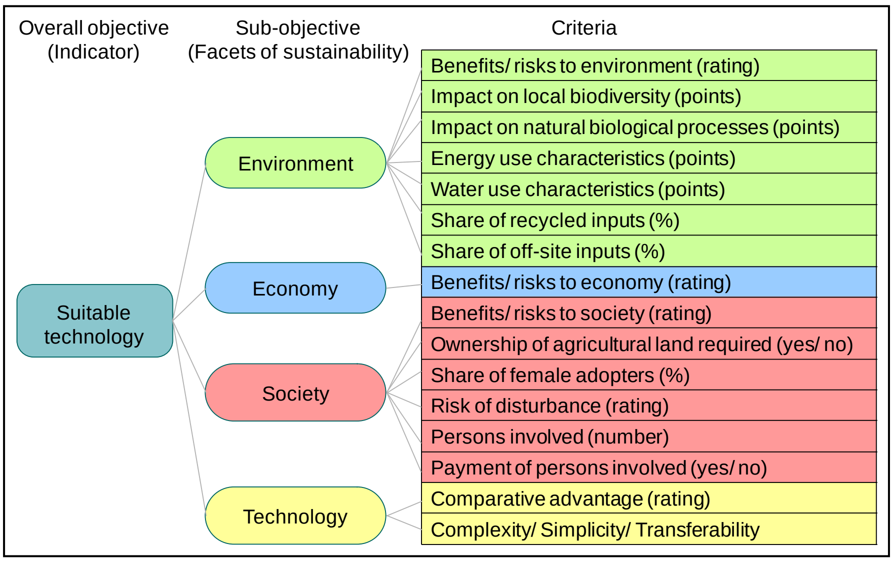

Figure 2: Problem hierarchy scheme
Note: *suitable here means: sustainable, productivity-enhancing and appropriate for the poorest and most vulnerable people in South and Southeast Asia

The framework's first tool was designed for the collection of information on potentially suitable technologies. The collection of technology options started with a first open call for applications using a questionnaire format between mid-August and mid-September, 2012 followed by a second call between mid-November and the end of December 2012. The application form contained sections to gather information about environmental, social, and economic sustainability, as well as on important properties of the technology itself. The calls for applications were sent to 213 and 332 contacts: participants of the SATNET Asia project, directors of international, regional and national public organizations, international and national research centres, international and national Non-Governmental Organizations (NGOs), and the private sector. All contacts were encouraged to forward the call throughtheir respective professional networks.

Technologies will be compared with each other in two ways: a calculated indicator will allow selecting the most suitable technologies but a visual representation of all criteria values and rated qualitative criteria using spider web diagrams will enable potential users to quickly assess the individual technologies.
For the construction of a composite sustainability indicator, the framework suggests three successive steps: (1) assigning weights to criteria; (2) rating of qualitative criteria; and (3) indicator calculation.
To decide on the relative importance of the criteria under consideration, experts assigned weights using the Analytical Hierarchy Process (AHP) (SAATY, 1990). This approach is a multi criteria decision making process that is suitable for involving a group of experts. It was implemented via an online survey that asked experts to compare all criteria in a pairwise manner. For each pair of criteria within the same sub-objective, experts were first asked which criterion is more important or if they are of equal importance. If one was selected to be more important, experts were then asked how much more important the criterion was. Fifty one experts were invited to participate in the online survey. All expert judgements were compiled in a comparison matrix and the consistency of expert judgements was evaluated using the consistency ratio (SAATY, 1990).
The rating of qualitative criteria and indicator calculation are currently in process.
The third tool of the framework consists of validation studies which will be conducted between March and Mai 2013.

3) Results and Discussion

The first two rounds of the application process yielded 19 technology options from six countries (Table 1). Eight technologies were suggested by experts from Nepal, four technologies came from Bangladesh and India, respectively, and experts from Thailand, Sri Lanka and Bhutan suggested one technology, each.

Table 1: Technology options collected through open calls for application by January 2013

Technologies	
Distiller for essential oils	Riverbed farming
Floating cultivation	Soil testing kit
Herbal pesticide	Tomato grafting
Jeevatu (biofertilizer)	Vegetable pool
Maize stabilization (Kharif)	Vegetable production sack
Multiple use water system	Open cultivation of off season tomato
Non-chemical IPM technology package for tomato cultivation	Tomato seed production and tomato production
Rebloom (biofertilizer)	Vermitechnology
Paddy stabilization (Kharif)	Windmill
Treadle pump – micro irrigation technology for smallholder farmers	

Figure 3 shows an exemplary spider web for selected criteria of the technology ‘vegetable pool’ that were rated preliminarily – for illustrating purposes. Representing criteria in this format follows the style of the Response-Inducing Sustainability Evaluation (RISE) tool, which was developed by HÄNI et al. (2007) to assess sustainability at farm level.

The ratings and weights of all criteria will be used to generate a composite sustainable technology indicator comparable to DANTSIS et al. (2010) and KRAJNC and GLAVIČ (2004).

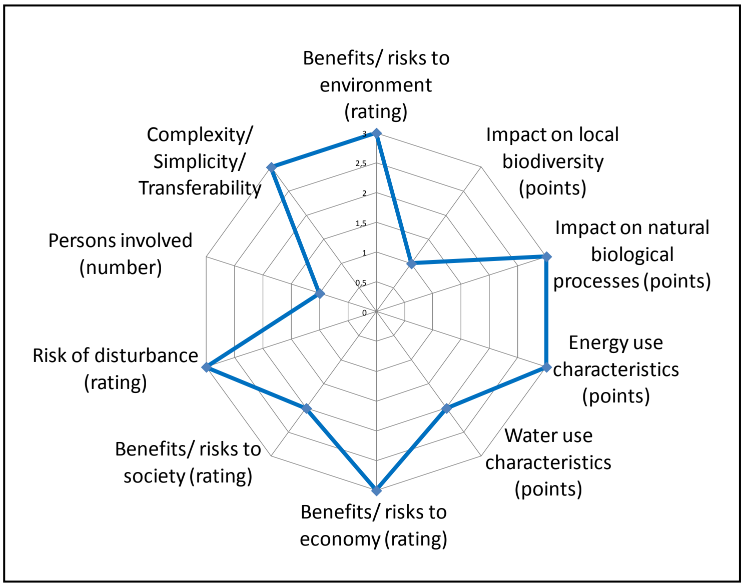

Figure 3: Example of graphical representation of criteria ratings using a spider web diagram

Overall, 23.5 % per cent of invited experts participated in the online survey to assign weights to the framework criteria. The initial results point to two challenges that are linked with this type of methodology. The first challenge is the fact that human judgment is always prone to error. This is especially the case in a complex situation like the case at hand, where experts were asked to make a total of 38 pairwise comparisons. Consequently, only five out of twelve experts had a consistency ratio below or slightly above the recommended threshold (CR < 0.1) (Xu, 2000). The second challenge encountered was that experts had contradicting view points about the importance of some criteria. Because of the online format of the weighting exercise, experts could not discuss their viewpoints directly to come to a common agreement.

4) Conclusions and Outlook

To build consensus on the relative weights of criteria, selected experts will be consulted in a face-to-face meeting. This discussion will build on the results of the online survey based weighting method and overcome its shortcomings in assigning consistent and concurring criteria weights.
Regular calls for applications will be launched four times per year throughout the duration of SATNET Asia, so that the pool of available technologies can be enlarged successively. In addition to collecting technologies via the calls for application, other online knowledge platforms providing information about agricultural technologies that could potentially be relevant for SATNET Asia are being screened. It is planned that technologies from other online sources as well as technologies identified from the literature will be integrated into the SATNET Asia knowledge base.
All gathered technologies will be integrated into this knowledge base containing fact sheets, descriptions of typical enabling environments, extension material, recommendations for dissemination strategies, as well as links to regional experts.
The design and format of the database is crucial for the impact that it will have on targeted end users. The easier the database is to use for finding relevant information and the more regularly up-to-date information is posted, the more likely it will outlive the duration of the SATNET Asia project.

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