Ten years of Sustainability Evaluation using the MESMIS framework: Lessons learned from its application in 28 Latin American case studies.

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Abstract:

Sustainability has become one of the leading targets of many organisations nowadays; simultaneously it has become one of the vaguest concepts difficult to operationalise, especially in complex systems such as peasant Natural Resource Management Systems (NRMS). The Indicator-based Framework for the Evaluation of NRMS (MESMIS, its Spanish acronym), developed in 1995, fulfilled a pioneers role by proposing an integrated multi-disciplinary approach to assess sustainability of peasant NRMS. The framework is unique in its kind, being developed in the developing world and tested extensively; currently more than forty studies have been documented in which the MESMIS was applied. This paper presents the results of a research reviewing the framework, ten years after its development, and seeking for improvement possibilities by a thorough analysis of twenty-eight selected MESMIS case studies; an analysis critical for the further development of the framework. Analysed case studies showed a great diversity in both the type of systems (i.e. cropping systems, forest systems, complex agro-silvo-pastoral systems) and the organisation that drove the evaluations (i.e. farmers organisations, research institutes, NGO's); demonstrating the wide range of systems and stakeholders to which the MESMIS appeals. Results showed the flexibility and easy applicability of the framework. MESMIS greatly assisted evaluation teams and stakeholders to assess sustainability of their current and alternative systems as well as it increased the understanding of the complexity of these systems, making the MESMIS a significant tool in sustainability evaluation of peasant NRMS. The degree in which MESMIS and evaluation in general was an effective tool in reaching more sustainable systems depended mainly on the type of participation applied; additional guidance and information on participation is therefore essential. Improvement possibilities are furthermore directed to the exploration and incorporation into the framework of 'new' tools that have proven valuable for the monitoring and integrating of indicators (i.e. simulation models, linear programming and trade-off analysis); tools capable of assessing effects of management on indicators on long term and increasing thereby the understanding of system's attributes.

Keywords:

Sustainability, Evaluation, Peasant NRMS, MESMIS, Case Studies, Latin America.

Introduction

Sustainability has, since the Brundtland report (1987), steadily gained importance as a critical concept in natural resource management. Today it is on the agenda of almost all research institutes, Non Governmental Organisations (NGO), and agencies related to development and natural resources. The application and operationalisation of the concept of sustainability is a challenging task, as the concept has become one of the vaguest paradigms of contemporary society (Bosshard, 2000) especially when approaching and designing alternatives for complex systems such as Natural Resource Management Systems (NRMS). In literature discussions on sustainable NRMS mainly focus on 'sustainable agriculture', but NRMS can be understood in a broader sense, including activities such as forestry, livestock production, fisheries, mining and eco-tourism activities (Masera et al., 1999). NRMS are commonly associated with peasants, who perform a wide range of activities within these systems, pursuing multiple goals such as food security, income and culture (Speelman et al., 2006). The diversification of activities is a characteristic of systems with limited resources in risk prone environments, as by diversifying activities risks are minimized (Ruben, 2001). Peasant NRMS are generally characterised by low input use (fertiliser and pesticides) and with poor living conditions of its producers; they are usually situated in fragile environments, where natural resources are under high pressure. As a consequence, these NRMS are usually highly complex systems. Peasant NRMS or peasant agriculture is however the primary source of staple food in developing countries, where perhaps as many as 1.5 billion people earn their livelihood from (Chambers, 1994; Rosset, 2001).

A general concern on the future of peasant NRMS and its economic, environmental and social degradation has led to the development of alternatives for more sustainable

NRMS by research institutes, development agencies, NGO's and peasant organisations during the last twenty years (López-Ridaura et al., 2002). Nonetheless, the need to understand, value and strengthen these peasant NRMS is still an issue highly relevant at this moment as it plays a critical role in the design of alternatives for more sustainable peasant NRMS.

Evaluation plays an important role in the process of strengthening NRMS; it is an effective tool to assess and design alternatives; by systematically evaluating current land use and alternatives, informed decisions about desired future land use can be made (Jordahl, 1984; Fresco et al., 1990; Dent, 1993; FAO, 1993a). However, conventional evaluation approaches have not been sufficient to capture sustainability to its full extent in complex NRMS as they mainly focused on a single dimension of sustainability (e.g. economic, environmental, technical, social). New interdisciplinary methodological approaches to evaluate current and alternative land use systems with respect to sustainability are therefore necessary.

Approaches that have been used in sustainability evaluation so far can be divided into three main groups as stated by Masera et al. (1999) and López-Ridaura (2005), namely approaches making use of lists or checklists of indicators, approaches using composite indices and approaches applying frameworks for sustainability evaluation. The use of indicators was originally focussed on economic sustainability, utilising indicators such as net income and gross margin. When the defining of indicators was extended to the field of environmental studies and environmental sustainability, the approach gained a strong influence in the field of natural resource management. Comprehensive lists of indicators were constructed, though little guidance for its users was at hand in relation to the criteria to select them in specific case studies and the strategy to integrate the information from their assessment. As a response to this, composite indices, where a specific set of indicators are assessed and integrated in a single value, were developed such as the Farmer Sustainability Index (Taylor et al., 1993), the Indicator of Sustainable Agricultural Practice (ISAP) (Rigby et al., 2001) and the Agricultural Sustainability Index (ASI) (Nambiar et al., 2001). Though using an index that reflects a specific set of indicators facilitates the integration of indicators in the process of sustainability evaluation, it goes beyond the fact that: a) every system is unique, meaning that indicators can be meaningful in one system but irrelevant in another, and b) the single numerical value given to different alternatives does not allow a transparent discussion on their specific strengths and weaknesses hampering the (re)design of more sustainable alternatives.

Frameworks for sustainability evaluation have been developed during the last ten years, e.g. the international Framework for Evaluation of Sustainable Land Management (FESLM) (FAO, 1993b), the Pressure-State-Response framework (PSR) (OECD, 1993), and the framework for Analytic, Reflective and Participative Mapping of Sustainability (MARPS, it's Spanish acronym) (IUCN-IDRC, 1995); yet these frameworks have not been able to fully assist stakeholders in the process of sustainability evaluation. Criticism on some of these frameworks has been that integration of indicators has been overlooked, ignoring the inter-relationships amongst indicators (Bell and Morse, 2003).

The Framework for Assessing the Sustainability of Natural Resource Management Systems (MESMIS, its acronym in Spanish) is an attempt to operationalise the concept of sustainability in complex NRMS. The MESMIS fulfilled a pioneer's role, being one of the first approaches to deal with sustainability of peasant NRMS in a multidimensional manner. In this framework, evaluation is solidly imbedded in the cycle of design of more sustainable alternative NRMS as, by effectively integrating evaluation into the decision making process, the likelihood of success in the design of alternatives and the implementation of development projects is improved (López-Ridaura et al., 2002). Contrary to other methodologies, MESMIS is primarily a planning tool for system's improvement towards sustainability; providing guidance through an indicator-based evaluation of system's sustainability in a systematic, participatory, interdisciplinary and flexible manner.

The MESMIS framework is unique in its kind, as it has been developed in the developing world, whereas the majority of methodologies to evaluate sustainability have been developed in or by the developed world e.g. FAO, 1993b; OECD, 1993. Furthermore, the MESMIS framework is one of the few frameworks that has been extensively tested in case studies. Since the development of the framework, it has attracted considerable attention. At the moment, ten years after the development of MESMIS, it has been applied to more than forty case studies in Mexico, Latin America and Europe, with the highest concentration of case studies in Mexico. The development of the MESMIS framework has been part of a multi-institutional research effort directed to facilitate the design and adoption of more sustainable NRMS. As part of this effort an annual international course has been taught since the year 2000 (www.gira.org.mx), three books (Masera et al., 1999; Masera and López-Ridaura, 2000; Astier and Hollands, 2005), several international publications (e.g. López-Ridaura et al., 2002; Ortiz and Astier, 2003; Brunett Pérez et al., 2005), and many academic studies have been published. In addition, the framework has been included in fourteen academic courses both BSc and MSc courses in Mexico and Spain. Through academic discussions and analysing its case studies the MESMIS framework is a dynamic framework, constantly evolving.

Twenty-eight case studies of the MESMIS framework for sustainability evaluation of peasant NRMS were analysed in relation to their main findings and the manner in which the MESMIS was implemented as to discuss the strengths and limitations of the framework ten years after its development and to seek possibilities for improvement of the framework itself and its future applications; results of this analysis are presented in this paper. The paper begins with a description of the MESMIS framework, the theories it is built upon and its operational structure. The case studies and their main characteristics are then shortly explained; after which, results and discussion of the case studies analysis are presented. The paper ends with a section of conclusions, focussed on the use of the framework as seen from the case studies as well as on the role of evaluation in increasing sustainability in peasant NRMS, and a present series of recommendations directed to improving the MESMIS framework and its future applications.

The MESMIS framework and Case Studies

The development of the MESMIS framework started in 1995 by a multi-institutional team and was lead by GIRA A.C., the Interdisciplinary Group for Appropriate Rural Technology, a Mexican NGO. The framework was the methodological core of the Natural Resource Management Network, financed by the Rockefeller Foundation, in which many Mexican organisations and institutes joined forces on the research in NRMS. The development of the MESMIS framework was part of a larger project that embodied: (a) developing a interdisciplinary framework for sustainability evaluation,

(b) applying the framework to different case studies, (c) training of individuals and institutes in evaluating sustainability through the MESMIS framework (d) generating and disseminating of documents and data bases related to the evaluation framework, its theoretical basis and practical guidelines as well as its application to case studies. The MESMIS approach is based on the following four premises: (i) sustainability is defined by seven attributes based on a dynamic systems approach (Productivity, Stability, Reliability, Resilience, Adaptability, Equity and Self-Reliance), (ii) sustainability evaluations are only valid for a specific management system on a specific spatial and time scale, (iii) evaluation teams should include external and internal participants as the process of evaluation is participatory, and (iv) sustainability is assessed through the comparison of systems either at the same time or over time (López-Ridaura et al., 2002).

Attributes and Indicators

As suggested by Conway (1987) and Garcia (1992) in order for interdisciplinary analysis to be effective, it has to give insights that significantly transcend those of the individual disciplines involved. Therefore attributes or properties of sustainable NRMS that are valid throughout the different dimensions of sustainability (e.g. environmental, economic and social) need to be determined. Many research teams have defined attributes or properties for deriving sustainability indicators (Smith and Dumanski, 1994; Conway 1994; Mitchel et al., 1995; ICSA, 1996; Kessler, 1997; Masera et al., 1999; Bossel, 2000; Capillon and Genevieve, 2000). However, there is no general consensus on the attributes to be used in sustainability evaluation. MESMIS defined seven attributes relevant to sustainable NRMS, especially in the context of peasant

NRMS, based on a systemic approach, namely productivity, stability, equity, self-reliance, reliability, resilience and adaptability.

The attributes productivity, stability, equity and self-reliance describe the functioning of the system itself, excluding the impact of its environment and are defined in the context of MESMIS as follows. The productivity of a system is the yield of a system in terms of services and goods at a certain point in time; the capability of a system to maintain this specific yield of goods and services at a stable dynamic equilibrium indicates the system's stability. The attribute equity represents the system's ability to distribute all costs and benefits fairly over its stakeholders. Self-reliance or self-empowerment shows the capability of a system to regulate and control interactions with outlying systems and at the same time keeping its own values and identity.

The behaviour of a system in relation to its environment and its ability to return to a (new) stable dynamic equilibrium in a changing environment is described using the attributes reliability, resilience and adaptability. The attribute reliability shows the system's capacity to maintain its desired output level near its equilibrium when facing normal disturbances in its environment. The resilience of a system shows system's competence to return to a state of stable equilibrium after a non-structural perturbation. The system's aptitude to adjust and to find a new state of equilibrium to a long-term change in its environment expresses system's adaptability.

These seven pre-defined attributes are used to guide the derivation of diagnostic criteria and indicators in the sustainability evaluation process; linkages between attributes, criteria and indicators within the framework are shown in Figure 1. Diagnostic criteria are defined as standards on which a judgement or decision may be based. Indicators are defined within the framework as quantitative or qualitative measures that reflect diagnostic criteria.

Figure 1

Structure of the framework

The MESMIS operational structure consists of six steps, as shown in Figure 2, and it is conceived as a cyclic process. In the first step of the cycle, the evaluation object is defined. The MESMIS builds upon the premise that sustainability can only be assessed in relative terms i.e. comparing two or more alternative situations; therefore several management systems are defined and described. Depending on the type of comparison used, either at the same time (transversal) or over time (longitudinal), a characteristic reference management system, which is prevailing in the region and one or more alternative systems are defined. As a systems approach is adopted for the evaluation, MESMIS suggests the use of flow charts to clearly describe and highlight the differences between the systems, their subsystems, components, and systems relationships (internal and external).

Critical features of a system concerning system's sustainability are determined in step 2 of the evaluation cycle. These critical features reflect important factors that weaken or strengthen system's sustainability in relation to the proposed attributes. Critically looking at the system and asking questions such as 'which aspects of the system present problems?' and 'what makes the NRMS vulnerable?' can identify these characteristics.

After making a list of these critical features, the features need to be linked to system’s attributes in order to make sure all attributes addressed.

In step 3, indicators are derived and selected by using a two-level approach. This two-level approach consists of defining diagnostic criteria that link attributes, critical points and indicators, these diagnostic criteria form, at the same time, a level of analysis more detailed than the attributes, but more general than indicators. After defining diagnostic criteria, a list of potential indicators must be composed covering all attributes and diagnostic criteria. As opposed to diagnostic criteria, indicators have specific units of analysis for their assessment. A selection from the list of potential indicators is required to make the final set of indicators robust and not exhausting (De Camino and Muller, 1993). Only measurable or quantifiable indicators vital to show critical features of the system should be included in this final selection of indicators.

Step 4 of the cycle comprises of measuring and monitoring indicators selected in the previous step. Monitoring the behaviour of indicators over time is essential when evaluating sustainability, a concept that focuses on the behaviour of a system over time. Depending on the evaluation teams and their available economic resources and time constraints, several techniques can be used for measuring and monitoring indicators such as surveys and interviews, field measurements and models.

Results obtained by monitoring indicators are synthesised and integrated in step 5. Since the indicators used are highly diverse and expressed in both qualitative and quantitative ways, this is not an easy task. An technique that has proven very useful for graphically integrating different indicators and which is promoted by MESMIS is the AMOEBA diagram (Brink Ten et al., 1991; Gomiero and Giampietro, 2005). This diagram shows in a snapshot to what extent indicator values of the reference and alternative systems reflect optimum indicator values.

In the last step of the cycle, results of the previous steps are recalled, and system's sustainability is analysed. With use of the AMOEBA diagram different features of the system in terms of sustainability are discussed between the evaluation team and stakeholders and recommendations made. With the recommendations of this last step the first evaluation cycle is finished, initiating, at the same time, the first step of a new evaluation cycle.

Figure 2

Case studies

From the more than forty MESMIS case studies, twenty-eight were selected to undergo a comprehensive analysis; the selection of case studies was based on the detail and quality of available information of the case studies and came from internal reports, articles and book publications. The majority of case studies originated from Mexico, the country in which the MESMIS framework was developed. The remainder of case studies came from countries in South America, i.e. Argentina, Bolivia, Brazil and Peru; Table 1 shows the locations, evaluation teams, evaluated systems and references to all case studies.

Table 1

The type of systems analysed ranged from cropping systems and forest systems to more complex agro-silvo-pastoral systems. Agro-silvo-pastoral systems formed the biggest group of analysed systems with 36% of all analysed systems, followed by cropping systems (32%) and cropping-cattle systems (18%) (Figure 3-A). The main objective for little more than half of the systems studied were production for subsistence; 32% were recognised as being commercial systems, whereas the remainder were producing for subsistence and commercial objectives in equal amounts (Figure 3-B). Organisations that initiated and carried out the various MESMIS case studies consisted for the greater part of Universities or Research Institutes (61%) mainly in the form of MSc and PhD researches.

The main participatory approach used in the analysed case studies was 'consultative research' as defined by Lilja and Ashby (1999), in which evaluation teams make decisions with organized communication with other stakeholders. Stakeholders included in the evaluations were mainly farmers. However, also case studies were seen in which all decisions were made by the evaluation teams with little or no input from other stakeholders; in almost half of the cases no participants were included in the research at all.

Figure 3

In order to make recommendations for the improvement of the MESMIS framework and its implementation in the future, the main findings of the case studies and the way in which the methodological steps of the MESMIS were implemented were qualitatively and quantitatively analysed.

Results and Discussion

The MESMIS case studies contained a great diversity of evaluated systems, mainly systems in which numerous activities were performed and multiple goals pursued, coinciding with the type of systems the framework is aiming for, namely peasant NRMS characterised by small-scale mainly subsistence farmers carrying out a wide range of activities. Furthermore, the large quantity of case studies initiated and driven by Universities and Research Institutes shows the academic popularity of the subject of sustainability evaluation in complex NRMS and the relevance of the framework in this context.

The MESMIS framework promotes a participatory research approach, in order to increase the success rate of designed alternatives, as has been recognized by many authors e.g. Biggs, 1990; Lilja and Ashby, 1999; Sumberg et al., 2003. The type of participation is left open to be chosen by the users of the framework. As stated earlier, little participation was seen in the case studies; stakeholders included in the evaluations were mainly farmers. The MESMIS and the case studies focus hereby only on one scale of analysis, mainly farm scale, which leaves out other stakeholders of peasant NRMS at other scales, such as researchers, consumers groups, decision-makers at regional or municipality scale including environmental and agricultural officers. A reason for the absence of participants could be found in the purpose for which case studies were carried out; in many cases it was solely an academic exercise. However, also in the context of an academic exercise the participation of different NRMS stakeholders is crucial in the evaluation process as in the academic learning process. More information on different participatory approaches and how to apply them would increase the awareness of MESMIS users of the necessity of these tools in the process of sustainability evaluation.

In the first step of the cycle, the systems under research were defined. As explained earlier, a distinction can be made between comparing systems at the same time (transversal evaluation) or over time (longitudinal evaluation). The large majority of the case studies studied were transversal comparisons. This could be the result of the difficulty to assess long-term data and to capture the dynamic aspect of peasant NRMS. However, a temporal scale larger than the present one is inherent to concepts as sustainability and system's attributes like stability, reliability, resilience and adaptability and thereby of great importance within sustainability evaluation. Computer simulation models could assist on this aspect to simulate system's behaviour on a longer term. The greater part of the case studies assessed and compared sustainability of 2 systems, but the number of systems evaluated ranged from 1 to 6. The case study of Nuevo San Juan Parangaricutiro, Mexico (case study no. 13 in Table 1) assessed sustainability of one system in comparison to optimal indicator values rather than comparing sustainability of two or more systems. Flowcharts clearly illustrated the different subsystems of the NRMS and indicated flows (i.e. product, money and labour flows) between the (sub)systems in the various case studies. This method, as advised by MESMIS, was implemented by all case studies and helped to visualise and increase the understanding of the system as well for stakeholders as for the evaluation teams; an example of such a flowchart is shown in figure 4 of the case study in Chullpakasa, Bolivia (case study no. 4 in Table 1). Most flowcharts showed similar features such as subsystems and input-output flows common to peasant NRMS. A few flowcharts stood out by including an unusual subsystem or by including critical points of the system in the flowchart.

Figure 4

Step 2, the identification of system's critical points, was applied by all but 5 case studies. These 5 case studies left out the identification of critical points and proceeded straight to the identification of indicators. A striking feature within the group of identified critical points was that, even tough these characteristics could be either debilitating or enhancing sustainability, most identified points were negative points that constrained system's sustainability. This is coherent with the fact that the general objective of the MESMIS framework is to improve sustainability; therefore it is commonsense to look for points that constrain sustainability and that can be improved. However, the identification of positive critical points of systems is of equal importance as to acknowledge the strengths of a system and maintain these features in the design of alternatives.

During the third step of the MESMIS, strategic indicators reflecting diagnostic criteria and system's attributes were identified in the case studies. In two case studies newly defined attributes were found. In the case of Xohuayán-Mexico (case study no. 25 in Table 1), the attribute 'collective identity and social welfare' was added to the seven pre-defined attributes; in this indigenous Maya community much weight was attached to the role of the community. The attribute 'adoptability' was included in the case study of Sureste de Mexico-Mexico (case study no. 18 in Table 1), as to emphasise the importance and evaluation of the adoptability of innovations. Evaluation teams in a slight majority of case studies were not able to link their identified indicators to all seven attributes; some case studies even did not connect their indicators to the attributes at all. An explanation for this could be found in the fact that the description of attributes is somewhat vague and difficult to conceptualise, where as evaluation teams are more accustomed to the use of concrete indicators. Almost twice as many indicators were linked to the attribute ‘productivity’ in comparison to the other attributes. This shows the relative simplicity to quantify this attribute using indicators as well as the strong interest in this attribute amongst NRMS stakeholders and the importance of peasant NRMS in the context of food production and the role these systems take on in earning a livelihood as stated by Chambers (1994) and Rosset (2001).

The evaluation teams selected a great variety of both quantitative and qualitative indicators reflecting the different aspects of the sustainability of their systems. Indicators were clustered according to their main focus for instance indicators e.g. ‘maize yield’ and ‘wood yield’ were grouped into ‘output’ linked with the attribute productivity; Table 2 shows indicators per attribute frequently used in the case studies. Indicators most widely defined throughout the case studies reflected the ‘output’ and ‘(agro)biodiversity’ status of a system; another group of indicators often used focused on the ‘soil properties’ of a system. The larger quantity of defined indicators reflecting a system’s environmental aspects in comparison to ‘social’ indicators indicates the interest of stakeholders and evaluation teams, but at the same time it could be the result of a better understanding of these parts of the system as the majority of the evaluation teams had a background in environmental of biological studies.

Table 2

Many different ways to measure and monitor indicators were seen in the case studies during step 4 of the framework. Measuring methods included direct measurements in the field, literature review, surveys, simulation models, technical coefficient matrixes, semi-structured and open-ended interviews. The type of required data was the determining factor for the measuring method used; it was seen that for obtaining socio-economic data mainly surveys and interview techniques were used. For data of environmental indicators people mainly relied on direct measurements or literature. Only a few case studies used simulation models. The possibilities of this option for longitudinal evaluation of systems deserves more exploration, as it gives the opportunity to assess management effects on indicators and system's attributes on longer term, greatly improving the understanding of system's dynamics concerning attributes. In a study done by Speelman (2004), stakeholders responded enthusiastic to the insight knowledge gained from long term model output, showing the effects of different management options on system's attributes. Within the MESMIS, more emphasis on the different available simulation models, their application and their role in sustainability evaluation would improve the guidance given to MESMIS users.

The main technique used for the integration of results, step 5 of the framework, was the AMOEBA-diagram. This diagram presented an easy and yet comprehensive integrated presentation of the performance of the analysed systems in relation to an optimum for the various indicators originating from different dimensions of sustainability (e.g. environmental, economic and social). This technique allowed thereby a comparison between the analysed systems and the way they reflect the optimum indicator values; an illustration of this is shown in Figure 5 of the study in Valle de Toluca, Mexico (case study no. 26 in Table 1). Indicator values of the analysed systems are situated along the axes of the radial AMOEBA diagram that has a standard scale running from 0 to 100, corresponding to the worst (0) and best (100) indicator values; the outer ring of the diagram thereby represents the optimum values of all indicators.

In 5 case studies, conclusions and recommendations were directly drawn from indicator values without integration and thereby leaving out important features of step 5. In some cases, a table was used to integrate or accompany the AMOEBA-diagram. Exploring and adding information on relatively new tools developed for the integration of indicators such as the multi-scale multiple goal linear programming model developed by López-Ridaura (2005) to the MESMIS, would create new opportunities for understanding and assisting stakeholders in sustainability issues in NRMS. Hardly any further research into relationships (synergies and trade-offs) between attributes or between indicators was executed in the case studies; leaving open a large field of opportunities to gain more in depth knowledge on system's sustainability. As shown in Speelman et al. (2006), further research into these relationships, even more so into trade-offs, can add valuable information to the decision-making process in peasant NRMS, as it can identify the level in which alternative management will (negatively) affect other indicators to an for stakeholders acceptable level. For example, a proposed management change to improve soil properties is most likely to influence other indicators such as labour properties and income; performing a trade-off analysis can show to which extent the proposed management can be executed while keeping the level of income and labour at an for the stakeholder acceptable level. These insights are especially interesting when evaluating several management options with the goal of implementing one, as is the case with MESMIS, and can assist farmers in their decision-making of alternative management of their systems to a larger extent. Hence, more information on trade-offs and synergies will help users of MESMIS in better understanding consequences of alternative management.

It was seen that the majority of the case studies did not present or discuss their results with stakeholders, showing a low level of participation and involvement of stakeholders. This issue, as addressed earlier, requires more investigation and assistance for MESMIS users.

Figure 5

In the last step of the cycle, conclusions were drawn and recommendations were made. Conclusions focused on the compared sustainability of the researched systems and on describing specific factors that debilitated or enhanced their sustainability. It was seen that most systems had indicators for which they performed well and indicators for which they performed less well. This helped case studies to note the complexity and multi-dimensionality of sustainability and of their systems and the trade-offs involved in making changes to their existing systems as can be seen for example from Brunett Pérez et al. (2005) (case study no. 26 in Table 1; Figure 5). Results of their evaluation of a conventional and a modified cattle system showed that the modified system resulted in increased milk yields and higher nitrogen and energy efficiencies, but consequently it also revealed lower maize yields and poorer soil properties. Main factors considered to debilitate system's sustainability in the case studies were: a) high dependency on external resources, b) degradation of local resources, c) low production, d) low level of organisation and/or participation of producers and e) low grade of (agro-)biodiversity. Factors enhancing system's sustainability were also pointed out. These factors mainly reflected the opposite of the factors mentioned to negatively affect sustainability of a system, namely high production, independence of external resources, conservation of local resources, high diversity, and high level of organisation and/or participation.

Depending on stakeholders' interest for a specific indicator recommendations were made, as indicators used in the evaluation refer to non-commensurable criteria and attributes and the visualisation of the analysed systems in a AMOEBA diagram allows comparison between the systems and the optimum value per indicator, but does not give information on the relative importance of specific indicators to the stakeholders (Gomiero and Giampietro, 2005). Recommendations uttered in the various case studies could roughly be categorised into three main groups, namely (i) recommendations aimed at a modification in management strategies of a specific resource, (ii) recommendations aimed at designing an alternative system and (iii) recommendations aimed at initiating more research by the institute involved. Little information was available on the implementation of the conclusions and recommendations of the studies. However, 80% of these case studies implemented recommendations made during the MESMIS evaluation cycle.

With recommendations made in step 6 of the framework, the MESMIS cycle is completed as at the same time by implementing these recommendations the new evaluation cycle is initiated. Through the cyclic structure of the evaluation framework a continuous process of evaluating and design is aspired. Nevertheless, after defining recommendations for a new management system, time is required for the implementation of recommendations, the so-called design-action-design cycle, and for the reviewing of effects of changes to the system as a result of the implemented recommendations; making the continuous cycle a lengthy process. This can also be seen from the case studies; only the first MESMIS case study executed by GIRA A.C. has reached a second evaluation cycle. This shows the particularly importance of making long term investigations into sustainability of peasant NRMS, as not only concepts as sustainability and systems attributes imply and require a long temporal scale of analysis, but also the design-action-design cycle of the sustainability evaluation process requires long term investments.

Conclusions and Recommendations

In this paper, twenty-eight case studies of the sustainability evaluation framework, MESMIS, were analysed to find trends in its application and space for improvements within the framework.

The six steps of the framework showed to be a good structure applicable in a flexible manner. However, in step 4 and 5 of the framework some important opportunities to increase insights in system's sustainability and improve sustainability evaluation were left open in most cases. Incorporation of information on the role of simulation models and guidance for its use in step 4 of the framework, the phase in which indicators are measured and monitored, would greatly assist MESMIS users in the evaluation of their systems. More emphasise should be put on insights gained from simulation tools, as seen from Speelman (2004), to improve longitudinal evaluation and assess behaviour of system's attributes and indicators on long term; especially, as a long-term temporal scale is inherent to concepts as sustainability and system's attributes stability, reliability, resilience and adaptability.

During step 5 of the framework, it was seen from the case studies that hardly any further research into relationships between attributes and between indicators was performed. Knowledge on these relationships and in particular on trade-offs will provide valuable information on consequences of management and on the level in which a management change can be implemented with maintaining other indicators and system's attributes at a for the stakeholders acceptable levels as shown in a study by Speelman et al. (2006).

Furthermore, more awareness to other tools developed to assist the integration of indicators such as the multi-scale multiple-goal linear programming as developed by López-Ridaura (2005) should be encouraged. Including more assistance in the use of these methods will enhance the sustainability evaluation of MESMIS.

The degree to which evaluation is an effective tool to increase system's sustainability depends to the larger extent on the type of participatory application of this tool and the type of stakeholders included, originating from one scale or multi-scales. More information and guidance concerning participatory approaches, the involvement of stakeholders and the purpose this serves within sustainability evaluation is recommended to be included in the framework in order to go beyond the scale of gaining knowledge of the sustainability of systems to designing applicable alternatives. As stated in one of the four main premises on which MESMIS is based, involvement from different stakeholders is essential for increasing the likelihood of designing successful alternatives. Learning from and incorporating existing knowledge on the integration of multi-scale stakeholders in the MESMIS evaluation process will greatly complement the existing (re)design of alternative systems.

During the ten years since its development, the MESMIS framework, being one of the pioneers for approaching sustainability of complex peasant NRMS in a integrated multi-disciplinary approach, has proven to be a useful tool for an integral evaluation of current and alternative systems and the identification of their advantages and disadvantages concerning their sustainability greatly assisting the decision making process in sustainability evaluation; making it a significant tool for sustainability evaluation in complex NRMS. The case study experiences analysed in this paper show the great diversity of biophysical and socio-economic conditions in which the MESMIS has been applied. Similarly, the evaluation teams also showed a great diversity, ranging from peasant organisations to Universities and Research Institutes (Table 1); all engaged in the development of alternatives for more sustainable peasant NRMS. Moreover, in three case studies the evaluation was driven by an organisational mixed evaluation team, showing the strength of the MESMIS in bringing together different stakeholders (i.e. peasants, researchers, NGO's) in the evaluation of more sustainable alternatives.

Systems evaluated were largely complex peasant NRMS, such complexity derives from the fact that several objectives are being simultaneously satisfied by NRMS such as the production of food for securing food self-sufficiency, the production of marketable products for income generation, the satisfaction of cooking energy needs, risk minimization and resource conservation. The MESMIS, suggesting a systems approach and an interdisciplinary perspective, has showed to be appealing for evaluation teams to capture such complexity of NRMS (Figure 3).

The systematic application, documentation and analysing of MESMIS case studies and reviewing the lessons to be learned from these case studies, highlighting the frameworks main strengths and weaknesses, as done in this study, is essential for the frameworks further development, as well as critical for allowing MESMIS users to learn from other evaluation experiences.

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FIGURES AND TABLES TITLES:

Figure 1: Overview of the MESMIS structure showing the relationship between Attributes, Diagnostic Criteria and Indicators.

Figure 2: The MESMIS evaluation cycle (López-Ridaura et al., 2002).

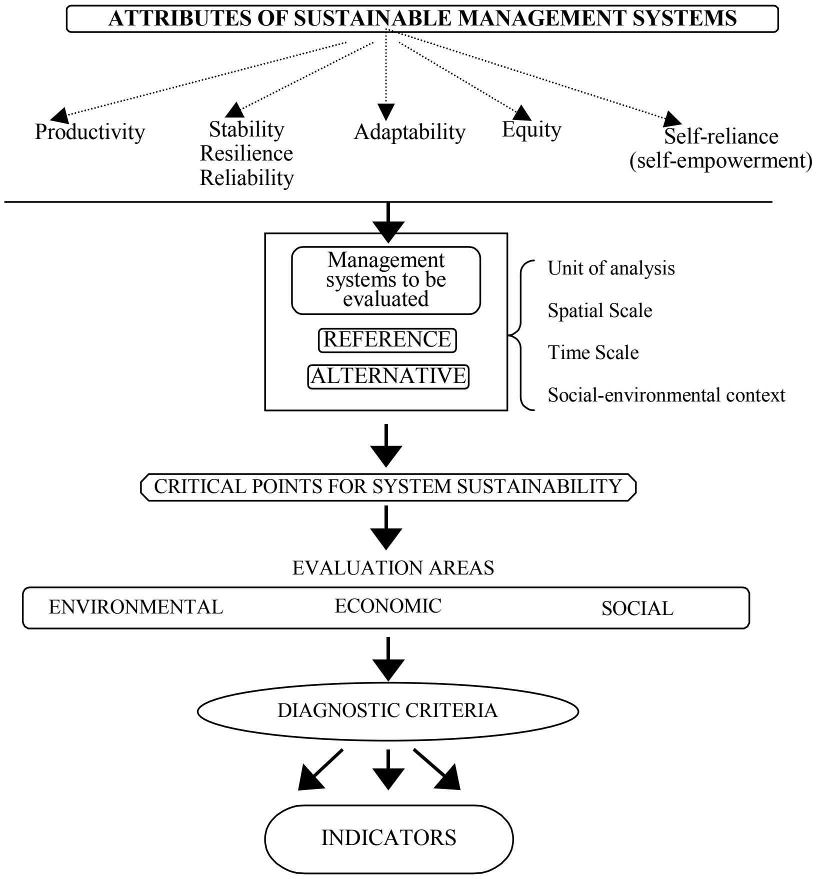
Figure 3: Main characteristics of case studies showing both percentages and absolute numbers of type of systems (A), main objective for production (B) and organisation initiated case studies (C).

Figure 4: Flowchart showing the reference system of the case study Chullpakasa, Bolivia, no. 4. (SOURCE: Modified from Delgadillo and Delgado, 2005).

Figure 5: AMOEBA-diagram showing the cattle system evaluated in the case study of Valle de Toluca, Mexico, no.26 (SOURCE: Modified from Brunett Pérez et al., 2005).

Table 1: Main features of the case studies included in this study, showing location, organisations initiated the case study, the type of system analysed and reference.

Table 2: Indicators most frequently used in the case studies, clustered according to their main focus; illustrated with concrete indicators used in the case studies.



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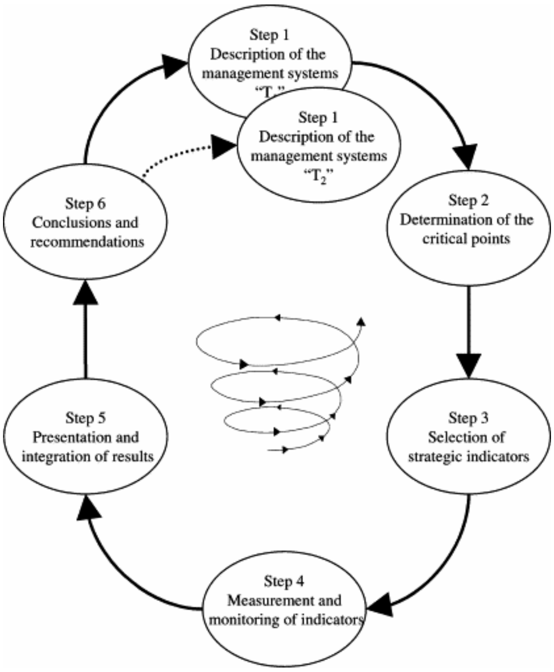

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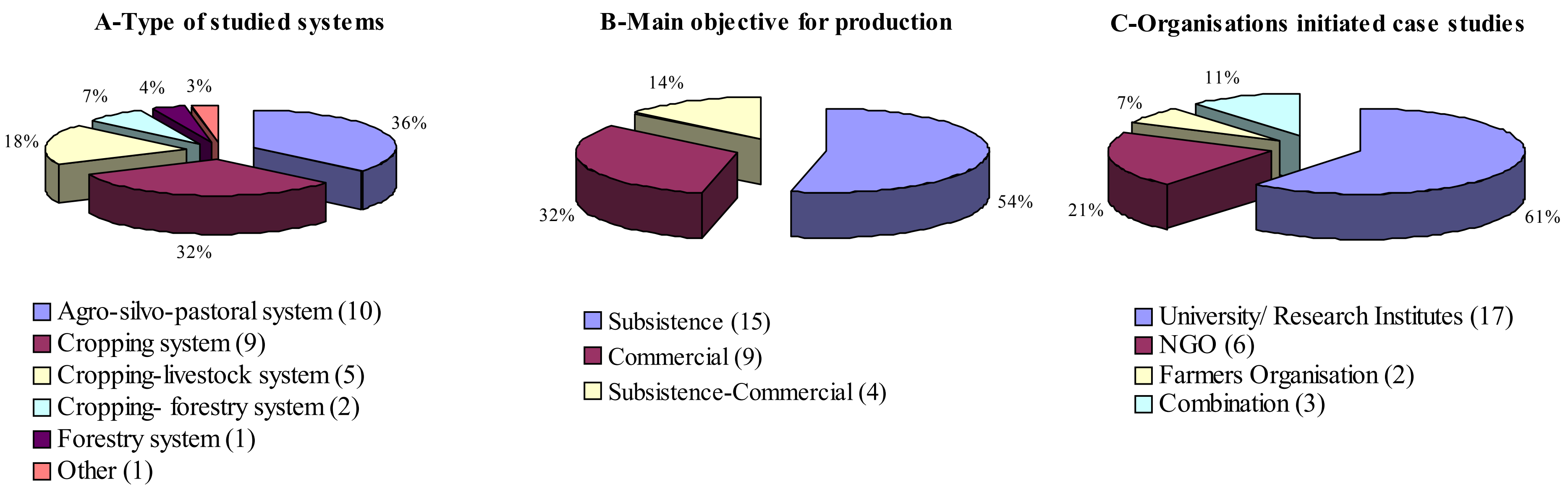

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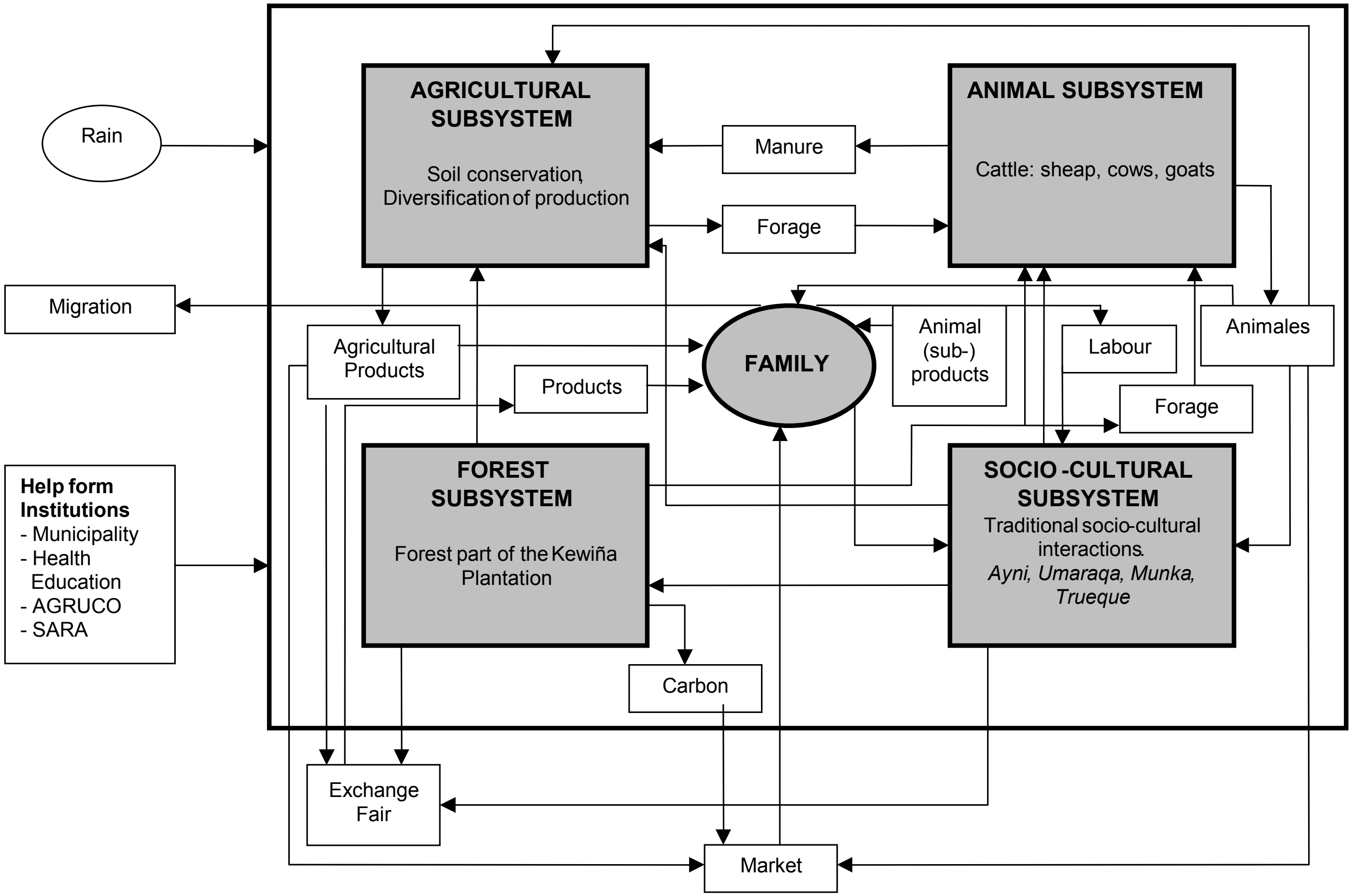

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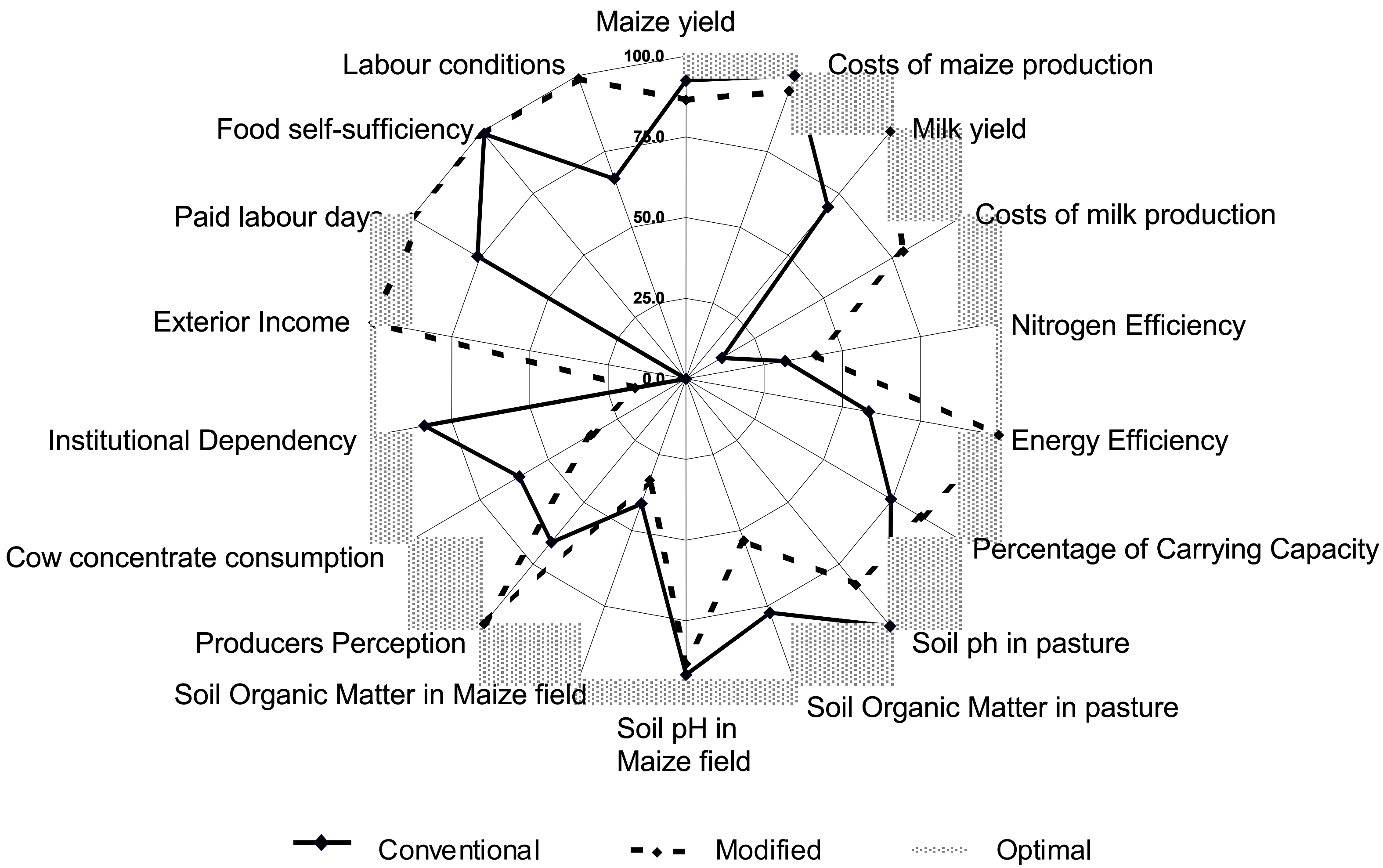

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Case	*Location*	*Organisation*	*Systems evaluated*	*Reference*
1	Misiones, Argentina	UIA[1)]	6 different management systems for small-scale agro-silvo-pastoral farming	Rosenfeld (1998)
2	Colónia Güemes, Argentina	UNLP[1)]	Five different tobacco systems	Sarandón (2001)
3	Comunidad Tres Cruces, Bolivia	AGRUCO[1)]	Traditional agro-silvo-pastoral system vs. Modified agro-silvo-pastoral system based on agro-ecological principles	Frías and Delgado (2003)
4	Comunidad Chullpakasa, Bolivia	AGRUCO[1)]	Cropping system with traditional soil conservation methods vs. Cropping system with improved soil conservation methods	Delgadillo P. and Delgado B. (2003); Delgadillo and Delgado Burgoa (2005)
5	Remígio, Brazil	AS-PTA[2)]	Traditional agro-silvo-pastoral system vs. Modernised agro-silvo-pastoral system based on agro-ecological principles	Gomes de Almeida et al. (2002)
6	São Mateus do Sul, Brazil	AS-PTA[2)]	Traditional cropping-forestry system vs. Modernised cropping-forestry system based on agro-ecological principles	Gomes de Almeida and Bianconi Fernandes (2003 and 2005)
7	Municipio San Juan	UACh[1)]	Three different maize management systems	Narváez (1996)

	Guichicovi, Mexico			
8	Municipio San Juan Guichicovi, Mexico	UACh[1)]	Large agro-silvo-pastoral system vs. Small agro-silvo-pastoral systems	Narváez (1996)
9	Municipio San Juan Guichicovi, Mexico	UACh[1)]	Agro-silvo-pastoral system with good soils vs. Agro-silvo-pastoral system with poor soils	Narváez (1996)
10	Álvaro Obregón, Mexico	UMSNH[1)]	Conventional wheat system vs. Alternative wheat system including a cover crop	Hernández and Rodriíguez (1998)
11	San Pedro Pareo (Cuenca lago Pátzcuaro), Mexico	UMSNH[1)]	Conventional vegetable system vs. Organic vegetable system	Cruz Jiménez et al. (1998)
12	Valle Morelia-Queréndaro, Mexico	UMSNH[1)]	Different agro-silvo-pastoral management systems	Hernández (1999)
13	Nuevo San Juan Parangaricutiro, Mexico	UMSNH[1)]	Traditional indigenous agro-silvo-pastoral system	Pulido Secundino (2000)
14	Jalisco, Mexico	UL[1)]	Leased land agro-silvo-pastoral system vs. Self-owned agro-silvo-pastoral system	Rodriguez i Toha, (2000)
15	Los Altos de Chiapas, Mexico	Unión de Ejidos Majomut[3)]	Organic coffee system vs. Conventional coffee system	Pérez-Grovas Garza (2000)
16	Zona Maya de Quintana Roo, Mexico	OEPFZM[3)]	Forest system before 1985 vs. forest system after 1985	Negreros-Castillo et al. (2000)

17	Región Sur de Sinaloa, Mexico	CESSI/INIFAP[1)], UACh[1)]	Extensive agro-silvo-pastoral system vs. Alternative system using forage	Perales Rivas et al. (2000)
18	Sureste de México, Mexico	Proyecto Pachuca[1) 2)]	Traditional maize system vs. Alternative maize system using rotation maize-‘macuna’	Guevara et al. (2000)
19	Cuenca alta del lago de Zirahuén, Mexico	GIRA A.C.[2)]	Traditional maize system vs. Commercial maize system	Astier et al. (2000)
20	Norte del Valle de Toluca, Mexico	UAE M[1)]	Extensive agro-cattle system vs. Intensive agro-cattle system	Hernández (2001)
21	Zona alta del Mezquital, Mexico	UACh[1)]	Cropping-forestry system without water harvesting system vs. Cropping-forestry system with water harvesting system	Sánchez (2001)
22	Tenango del Valle, Mexico	UAE M[1)]	Vegetable system vs. Vegetable-milk system	Villa Mendez (2002)
23	Cuenca alta del lago de Zirahuén, Mexico	GIRA A.C. [2)]	Traditional maize-bean system vs. Diversified system	Astier et al. (2003 and 2005)
24	Los Altos de Chiapas, Mexico	ECOSUR[1)]	Extensive agro-silvo-pastoral system vs. Intensive agro-silvo-pastoral system	Alemán Santilán et al. (2003 and 2005)
25	Xohuayán, Mexico	EDUCE[2)], MAC[2)], K-ET XIIMBAL[2)], ME’HIMAAC S.C. [3)], UAY[1)], INAH[1)],	Traditional maize system vs. Modified maize system with diversified crop and conservation measures	Moya García et al. (2003 and 2005)

		UACh[1)]		
26	Valle de Toluca, Mexico	CICA[1)], UAE M[1)]	Conventional agro-cattle system vs. Modified agro-cattle system including technical innovations and intensive grazing	Brunett Pérez et al. (2005)
27	Capachica, Peru	CIED[2)]	Resilient agro-cattle system vs. Non-resilient agro-cattle system	Claverías (2000)
28	Solo and San Miguel de Sisa, Peru	RAAA[2)]	Traditional cotton production vs. Organic cotton production	Gomero Osorio and Velásquez Alcántara (2003 and 2005)

[1)] University/ Research Institutes

[2)] NGO

[3)] Peasant Group/ Organisation

Table 2: Indicators most frequently used in the case studies, clustered according to their main focus; illustrated with concrete indicators used in the case studies.

Attribute	*Frequently used indicators*
Productivity	▪ Output e.g. maize yield (kg yr^{-1}; kg ha^{-1}), wood yield (g yr^{-1}) ▪ Income e.g. net income (\$ yr^{-1}), net income per subsystem (\$ yr^{-1}) ▪ Efficiency e.g. cost/benefit ratio (-)
Stability, Resilience and Reliability	▪ (Agro)biodiversity e.g. number of species, type of biodiversity conservation management ▪ Soil properties e.g. soil organic mater content ([OM]), nutrient contents ([N], [P],[K]) ▪ Erosion e.g. type soil conservation management, soil loss (Mg ha^{-1} yr^{-1}) ▪ Use of agrochemicals e.g. fertiliser (kg^{-1} ha^{-1} yr^{-1}), pesticides (kg^{-1} ha^{-1} yr^{-1})
Adaptability	▪ Innovation adoption e.g. number of farmers adopted innovations, capacity to adopt to changes ▪ Knowledge of innovation e.g. access to education, mechanisms to diffuse knowledge
Equity	▪ Stakeholder involvement e.g. participation of women, ratio participation men/women number of beneficiaries, distribution of benefits
Self-Reliance	▪ Organisational issues e.g. level of participation in decision-making, organisation structure ▪ Dependency on external input e.g. use of external input, costs of external input (\$ yr^{-1}), level of dependency on external input ▪ Financing issues e.g. level of auto-financing (-), access to credit

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