Assessing Family Farm Sustainability using the IDEA method in the Saïs plain (Morocco)

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Abstract: The increase of irrigated crops in Saïs plain has led to an alarming aquifer over-exploitation and has contributed indisputably to price volatility related to the saturation of local and national markets. Consequently, these dynamics put the sustainability of farms at risk. Hence, to better evaluate how farmers consider the sustainability issue, responses were collected from a survey covering 40-farms related to farmers' perceptions and attitudes towards the sustainability concept. The environmental issues, taking into consideration that they are the responsibility of public bodies and policies, did not feature prominently as a key priority for farmers. In fact, to bring into focus the inherent weaknesses of farmer's agricultural practices, the IDEA method was adapted to evaluate the sustainability of 14 farms. Methodological changes concerns (i) score weighting, in order to highlight local issues (ii) removal of irrelevant indicators and (iii) addition of major local issues. The method enables each single type of farmers to better identify weaknesses that they can improve. Also, it arouses reflections regarding the technical reasoning as well as the value systems on the origin of the farmers' decisions. However, most farmers were not individually concerned by environmental issues addressed by IDEA. They were mostly concerned about economic aspects as key drivers for their decision-making processes and their perception of sustainability. The discussions of the IDEA results yielded two main reactions; (i) farmers intent to secure on-farm income through diversification of productions and (ii) farmers willingness to take economic risks, especially in speculative horticulture value chains.

1. Introduction

Since the emergence of the concept of sustainable development, local and international organizations have called for methodologies aiming to assess sustainability (ONU, 1992). This call had led to an expansion of assessment methods based on different tools such as indicators, multi-criteria analysis or assessment-based modeling. These three methods are applicable to different scales (Ness et al., 2007). Several authors have stressed the relevance of the farm scale, which takes into account all the practices (Thivierge et al., 2014), to assess agricultural sustainability (Häni et al., 2003; Pacini et al., 2003; Van Cauwenbergh et al., 2007). The farm overall perspective provides opportunities to improve sustainability and give useful tools helping (i) farmers to assess sustainability of their farms in order to identify weaknesses and areas for improvement in managing their future operations (Rodrigues et al., 2010); (ii) advisors to identify new skills and tools for addressing sustainability issues at farm level (Zahm et al., 2008) ; (iii) researchers to design innovations that can enhance agricultural sustainability in local contexts while supporting farmers in their evolution (Dogliotti et al., 2014; Ryschawy et al.,

2014); (iv) policy-makers to maintain and encourage environmentally-friendly systems through appropriate financial support (Van Calker et al., 2008).

Most of the evaluation methods of sustainability do not provide a transdisciplinary approach to farming and sustainability issues; they are principally assessing a ‘‘snapshot’’ state of agricultural systems (Duru & Therond, 2015) or discarding farmers' decision-making (Darnhofer et al., 2010). However, the farm in a systemic approach must be considered a unit composed of different subsystems; farmers, including their personalities, skills, long-term goals, values and lifestyles, (Gafsi & Brossier, 1997), and manifold subsystems including cropping and livestock systems (Fairweather & Campbell, 2003; Schmitzberger et al., 2005). Indeed, farm management is influenced by the farmer perceptions, preferences and risk aversion (Burton & Wilson, 2006); as well as, by his/her economic framework, social norms, local agro-ecosystem, and the farm structure (Slee et al., 2006).

Methods of sustainability evaluation have mostly been developed in northern agricultural contexts, for instance AGRO*ECO (Bockstaller et al., 1997; Girardin et al. 2000), MOTIFS (Meul et al., 2008), IDEA (Zahm et al. 2008) or EVAD (Rey-Valette et al., 2008). Only a number of these methods have been adapted and used in southern countries where there is a need for greater assessment of the farming systems sustainability (Fadul-Pacheco et al., 2013). Moreover, works that combine ecological, social and economic sustainability, with farmers’ perceptions of sustainability, are still lacking (Darnhofer et al., 2010). Based on a study involving 40 farmers in the Saïs Plain (Morocco), this paper aims to evaluate farmers' perceptions of the sustainability concept by using and adapting a formal evaluation tool called IDEA (Farm sustainability indicators). We outline how we approached the adaptation of the IDEA method, a tool based on a selection of indicators, originally designed for the French context. Also, we discuss the relevance of this method to the community of farmers by benchmarking their perceptions of sustainability and decision-making before and after IDEA was carried out.

2. Context and methodology

2.1. The Saïs plain context

Prior to the drought of 1980, Saïs' farming systems were dominated by rainfed agriculture (cereals, legumes, olive and almond trees) associated with small herd livestock (sheep and cattle). Following this period, farmers progressively turned to the use of groundwater through individual wells and irrigated crops; in which, horticulture emerged (onions and potatoes) followed by orchards (peach, plum, and grapes). Today, Saïs displays a huge diversification of farms depending on resources availability and individual farmer’s strategies. Three types of farms have been identified based on a 40-farms survey. T1 farms are close to the initial traditional system farms combining rainfed crops and livestock on land without water access. T2 farms have access to irrigation while maintaining production diversity based on rainfed crops, irrigated crops, and livestock. T3 farms are specialized in various orientations (irrigated vegetables, irrigated fruit trees or milk production). Furthermore, the extension of irrigated crops had led to over-exploitation of the aquifer (Quarouch et al., 2014). The increase in production (vegetables and recently fruits) and the lack of farmer associations and low long-term storage capacities led to price volatility and saturated local and national markets (Lejars & Courilleau, 2014). This situation threatens not only the sustainability of the aquifer but also the viability of farmers' activities (Bekkar et al., 2009). Moreover, in other countries, the adoption of irrigated crops showed an intensification process causing irreversible negative impacts on the environment. These issues make Saïs plain, as an open-air laboratory, an interesting case study of the sustainability concept that can be exported to other regions of Morocco or Southern countries where sustainability is threatened.

2.2. The assessment methodology

This assessment study is a continuum of a previous study analyzing the dynamics leading to the regional diversity of family farms. It was applied to a limited sample of 40 cases reflecting the diverse production systems in the studied area. To evaluate how farmers consider their farm sustainability, first we collected farmers’ perceptions of the sustainability concept on the 40-farms sample; we asked

an open-ended question to farmers about the meaning of farm sustainability. The word sustainability in Arabic is "daymouma, al estidama" which refers to a wide sense. Thus, for a more accurate sense of farm sustainability, we have embedded these words in a question (What does "sustainable farm" mean to you, in the sense that your farm continues to produce in the long run?). Since the study is still in progress, we started by assessing the sustainability of 14 farms. IDEA (Indicateurs de Durabilité des Exploitations Agricoles) method was applied to assess the sustainability of family farms (Vilain et al. 2008; Zahm et al. 2008). This method was developed in France and used in countries such as Tunisia (M'Hamdi et al. 2009) and Mexico (Salas-Reyes et al., 2015). Since it provides a holistic and integrated view of farm sustainability, IDEA takes into account the three dimensions of sustainable development represented by agroecological, socioterritorial, and economic dimensions (Table 1). The sustainability value is given by the lowest score of the three dimensions (Hansen, 1996). The score of each dimension is obtained by summing up components' scores that can be up to 100 points. In the same manner, the score of each component is obtained by adding up indicators' scores. A theoretical framework can be found in Vilain et al. (2008) and Zahm et al (2008) or by consulting IDEA website (http://www.idea.chlorofil.fr/).

Table 1: Dimensions, components and indicators of the IDEA method

Dimensions (3)	Components (10)	Indicators (42)
Agroecological	Diversity	Diversity of annual and temporary crops (A1), diversity of perennial crops (A2), animal diversity (A3) and animal biodiversity (A4)
	Organization of space	Crop rotation (A5), dimension of fields (A6), management of organic waste (A7), ecological buffer zones (A8), contribution to environmental challenge of the territory (A9), improvement of the space (A10) and fodder area management (A11)
	Farming practices	Fertilization (A12), manure management (A13), pesticides (A14), veterinary products (A15), soil protection (A16), water management (A 17), energy dependency (A18)
Socioterritorial	Quality of products and the land	Quality process (B1), valorization of the building patrimony and landscape (B2), non-organic waste management (B3), access to the property (B4), social involvement (B5)
	Employment and services	Short trade value chains (B6), autonomy and enhancement of local resources (B7), services and multiple activities (B8), contribution to employment (B9), collective work (B10), probable farm sustainability (B11)
	Ethics and human development	Dependence on commercial concentrates (B12), animal welfare (B13), training-education (B14), labour intensity (B15), quality of life (B16), isolation (B17), quality o f buildings (B18)
Economic	Viability	Economic viability (C1), economic specialization rate (C2)
	Independence	Financial autonomy (C3), sensibility to government subsidies (C4)
	Transferability	Transferability (C5)
	Efficiency	Efficiency of the productive process (C6)

The original method was adapted to the Moroccan context through incorporating context elements and modifications highlighting issues pointed out by farmers and key resource persons. Thereby, methodological changes concern: (i) Score changing, respecting the principle of scoring attribution linked to the original method. This means that the weight of indicators is organized by priority; indeed, the most fundamental and general are those having more weight than the most specific ones. For instance, water management score (A17) was increased to benefit farmers who preserve water resources. (ii) Deleting items or indicators, due to the absence of some settings in Saïs such as "permanent grassland" that appears in the diversity of perennial crops (A2) and fodder area management (A11); or the absence of standards and regulations such as "approved spreading effluents plan" linked to manure management (A13). (iii) Addition items, in order to emphasize specific setting in Saïs such as share-farming (collective work (B10)), which allowed many farmers with

resource constraints to produce and to value family manpower; or to implement some logics such as the balance between transmissibility and attractiveness of farm needed for a future buyer. Consequently, this latter led us to add the 'potential income' item to transferability (C5). (iv) Modification items or indicators, to adjust threshold values according to the standards prevalent in the study area, such as crop rotation (A5) indicator; or to replace non-existing elements with others having the same scope. For example, quality labels and standards (B1) indicator was changed by the valorization of products having a value linked to the territory (onions).

Afterward, adjusted minimum and maximum ratings were made based on tests that allow maximum distinction between farms. After the assessment, the outputs of IDEA were discussed with the farmers in order to understand their strategic choices and their perception of farm sustainability.

Table 2: Adaptations made to IDEA indicators to meet Saïs context

Indicators	Adaptations
Diversity of annual and temporary crops (A1), diversity of perennial crops (A2), animal diversity (A3), and animal biodiversity (A4), quality process (B1), valorization of the building patrimony and landscape (B2), non-organic waste management (B3), access to the property (B4), social involvement (B5), autonomy and enhancement of local resources (B7), services and multiple activities (B8), economic viability (C1), economic specialization rate (C2)	Score changed
Diversity of perennial crops (A2), fodder area management (A11)	Item linked to permanent grassland removed
Contribution to environmental challenge of the territory (A9)	Deleted
Crop rotation (A5); dimension of fields (A6), economic viability (C1), transferability (C5)	Thresholds values adjusted
Sensibility to government subsidies (C4)	Indicator modified to "possibility of financing investments"
Transferability (C5)	Item linked to income potential added
Efficiency of the productive process (C6)	Item linked to ability to generate value added by MWU added

3. Results

3.1. Initial farmers' perceptions of sustainability

According to farmer's perception of sustainability, environmental issues do not represent a top priority for them, whatever their production system is .This does not mean that they are not aware of local environmental issues; for instance, 75% of farmers are aware of the over-exploitation of the aquifer. But only farmers affected by this problem (2 answers) or by soil fertility degradation (6 answers) link sustainability to environmental issues (Figure 1). However, their main position is characterized by the economic aspects of sustainability linked to the economic viability of the farm expressed by "an adequate income" (13 answers). This position is directly related to their own specific context. For instance, 30% of farmers state that they would be unable to continue farming if the volatility of vegetable prices persists. Environmental issues are considered to be the responsibility to be shouldered by public bodies and policies. Indeed, some farmers consider that environmental issues are not the unique responsibility of the farmer but of all the community. Others wonder why farmers would care about the environment as long as the government itself does not care about the overexploitation and depletion of the ground water reserves – As a matter of fact, the government subsidizes irrigation water access and grants licenses for even more well-digging in the area.

For farmers, sustainability also depends on their own personal values. Thus, answers such as motivation and labor (6 answers), preparing sons to succeed (6 answers) or building a legacy (7 answers) reflect the social values of the farmers. Answers linked to the good quality of life (3 answers)

or to reducing drudgery (3 answers) reflect farmers' preferences, while answers linked to technical know-how (2 answers) reflect farmers' expertise.

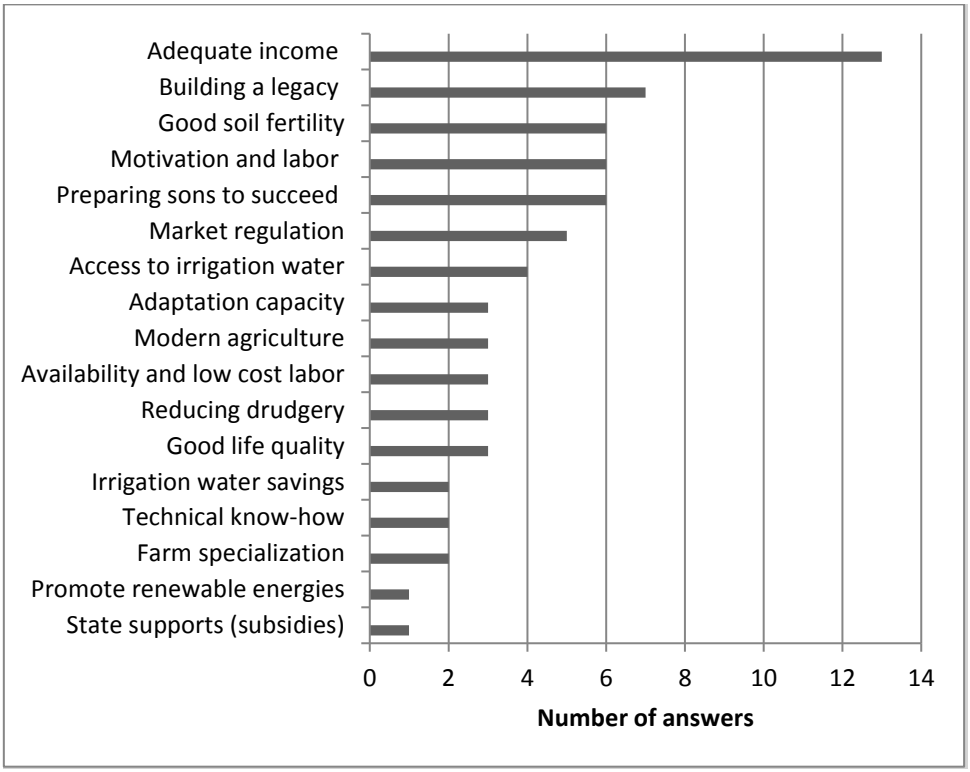

Figure 1: Meanings of sustainability perceived by the 40 farmers surveyed in the Saïs plain

3.2. Enriching farmers' and researchers' perspective by using IDEA

IDEA method favors diversified farms, since the absence of diversification leads to technical weaknesses (preservation of soil fertility, dependence on purchased inputs and on markets), which may result in environmental and economic concerns in the long term. Hence, diversified farms are considered more sustainable than the specialized ones. The three cases of farms show that sustainability and weaknesses differ from one to another (Figure 2). For example, T2 has poor agricultural practices relating to high nitrogen balance due to strong fertilizer and high pesticides use. T1, in opposition, has extensive practices but a space mismanagement related to the large acreage of land. Lack of diversification of T3 and the low score of agricultural practices gives it a low agroecological sustainability but better economic sustainability corresponding to the good viability of this system. The socioterritorial dimension does not depend on the farm type. As a matter of fact, this score depends on several parameters related to the personality of the farmer and his/her preferences. Thus, using IDEA method has allowed us to comprehend farmers' sustainability position by refocusing the discussion on the concrete weaknesses of agricultural practices (nitrogen balance, lack of diversity, or space mismanagement) and their impact on the environment.

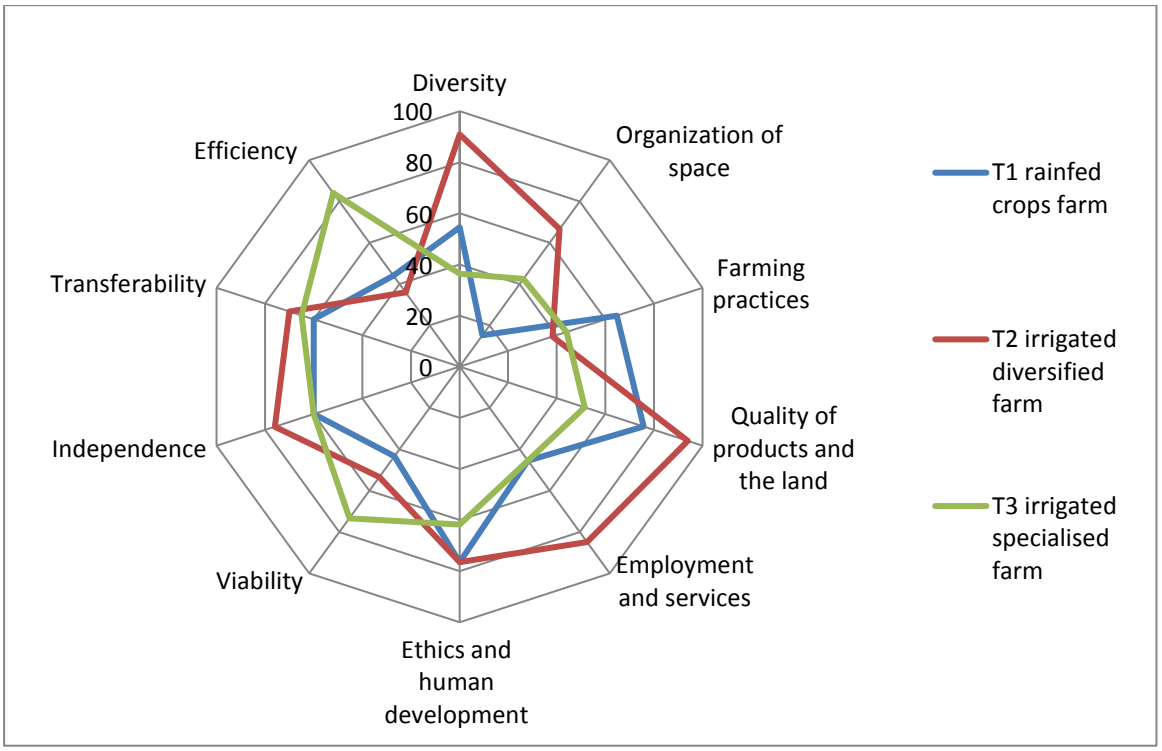

Figure 2: Three farm assessment results (one of each type) representing the elements discussed with farmers

Although the method did not raise any new issues that farmers were not already aware of, as they mentioned, it stimulated reflections regarding the technical reasoning; as well as, the value systems underlying farmers' decisions. The 14 farmers attest that, in their decision-making, only economic aspects are taken into account. Actually, environmental concerns are minimized regardless of their expected future impacts. Faced with their sustainability scores, (10/14) farmers acknowledged environmental limitations of their farms and justified their stand on economic grounds. Indeed, they aim to maximize their income and sustain their family, which imply the use of intensive farming practices in a context of constrained sale prices. Thus, intensification is implemented regardless of its eventual environmental impacts.

- Mohamed, farmer (March 2016) *"Farming is my only source of income, I have no other alternative. I have neither a retirement pension scheme nor a health care insurance. So I have to think about several things at the same time, such as meeting my family's basic needs, coping with diseases and health risks, the hazards of everyday life (...) I find myself forced to enhance productivity to earn more. If I engage in preserving the environment (...), what I might earn, will not even allow me to meet the basic needs of my children."*

(4/10) farmers ignore the impact of their practices on the environment, but their purely economic motivations lead to a significantly increased use of inputs.

- Abdelali, farmer, (May 2016) *"we do not know exactly the crop needs, but the lack of fertilizers is easily noticeable on crop conditions (...) if I increase the input of fertilizers, the crop grows faster, allowing me to shorten its production cycle and sell more quickly (...). Based on my personal experience, the more fertilizers you give to a crop, the more important is crop performance (...) but I don't really think that this could affect groundwater or soil quality."*

Aiming to ensure greater productivity, farmers seek to maximize the factors they have been able to harness (chemical inputs and irrigation), then aspire to a good market cash crop. For instance, it is the case for onion production, which uses many chemicals and water irrigation in order to get a high yield

that will provide insurance in a context of unstable market prices. Instead, the rainfed productions, that prices remain more or less stable in the market, push farmers to engage in tinkering depending on climate variations. Tinkering refers to the capacity of finding the best combination holding between rainfall and inputs that would allow highly increase of the yield. For example, subsequent to the drought recorded in the first quarter of 2016, several farmers neither treated nor applied fertilizers to cereals and legumes, given the low expected yield due to the drought.

- Rachid, farmer (May 2016) *"The reduction in production costs related to a reduction of inputs for the onion crop is insignificant compared to the earnings in production (...) If I decide to reduce inputs, this individual change will be negligible since other farmers will continue intensive practices (...) to preserve the environment, we need alternatives such as those taken by developed countries, whereby states encourage adoption of environment- friendly practices through payments extended to farmers. But here, as long as there are no safeguards to ensure a good income, we are obliged to support our family by all means."*

However, several farmers, who are aware of their intensive practices, consider that environment issues must be supported by the state. They think that the sociopolitical context in which they operate, encourages the adoption of intensive practices. The public bodies aim to increase production, so they promote directly (by irrigation subsidy) or indirectly (by importing and manufacturing of fertilizers and crop protection products) the intensive practices. According to farmers, the State is responsible for the effects on the environment. Thus, it appears that it is the only part who can act on environmental issues. This could begin by sensitizing farmers about the negative effects of their practices and, thereafter, by adopting appropriate policies.

Moreover, the discussion with the farmers concerning the IDEA method and its relevance resulted in two main reactions: (i) Farmers secure their income through diversification of productions (4/14 of farmers), although this has a primarily economic aim, it provides other benefits not targeted in priority but appreciated by farmers, such as synergies between productions, food security, and livestock as savings. Besides, these farmers see themselves sustainable and align with the principle of sustainability expressed by IDEA. (ii) Farmers are ready to take an economic risk (5/14), especially in speculative horticulture value chains. The success story of precursors in orchards and the preconceptions motivate, in a strong way, farmers' decisions to develop horticulture. Moving forwards tree fruits farming represents to these farmers a qualitative evolution; an emancipation of agricultural of hard work and an aspiration for better living. They have a project to planting orchards without consideration for the current and future issues of fruits prices and water availability. These threats seem to be distant in time for some of them, who believe in finding the adequate solutions at the moment when the actual threat happens. Faced with these threats, a number of farmers think of leaving tree fruit cultivation adventure and be back to vegetables. In contrast, other farmers are more reactive and think of developing product valorization strategies (spreading productions in time, transformable fruits, selling in short circuit),or water resource security strategies (security drill, basin).

Furthermore, only farmers already embedded in the adventure of fruit growing, ask for greater state intervention in order to regulate the prices. They thought that avoiding over-production must be managed by the State by imposing crop areas for these speculative productions. However, in opposition with the IDEA outputs, these farmers consider themselves more sustainable according to their own criteria; such as the better viability of the farm, the higher quality of life and the reduction of working time. These farmers state that the lack of diversity of productions and the weak agroecological sustainability do not worry them.

4. Discussion

IDEA and assessment:

The method has achieved its purpose; it allowed each type of farmers to better identify weaknesses on which they can act if they engage in a process of evolution towards sustainable agriculture. But,

some aspects of the farmers' perceptions of sustainability have not been integrated into the adaptation of the IDEA method in order to respect its principles and generic design, although that would have been more compatible with the concept of sustainability as perceived by farmers. For example, fluctuations in market prices are a factor that can impact the long-term sustainability of farms according to several farmers. This is not represented in the economic dimension. Besides, score calibration by expert makes the method closely related to the local context. Giving maximum scores to salient aspects, reflect the importance of the given aspects in this context. Some difficulties related to the scoring were mitigated through the weights in the tests of 14 farm cases. The tests also showed that the method allowed productive exchanges with farmers, which led to an experimental validation of its use value. The case of Saïs confirmed the effectiveness of the method in warning users about the weaknesses of farms as it has been shown in Tunisia (M'Hamdi et al. 2009), Mexico (Fadul-Pacheco et al., 2013; Salas-Reyes et al., 2015) or France (Zahm et al. 2008). However, the progresses towards sustainability at the farm level, considered by the method (organic farming, alternative agriculture, conservation agriculture) were not measured in this case study due to their absence.

To a certain level, the farmers can develop appropriate management strategies by themselves, considering their own priorities and conditions and based on the provided indicator descriptions or calculation methods (Meul et al., 2008). Moreover, a number of cognitive difficulties such as illiteracy or language push farmers to be reticent approaching the method. The need to be assisted by a professional is a condition for those farmers. Contrariwise, other farmers claim not needing any method to evaluate their farms, since they acknowledge their strengths and weaknesses.

Furthermore, the method does not prescribe a specific change, but it gives indications for improvement, which encourage; on the one hand, farmers to discuss with professionals the different ways to improve their situation and; on the other hand, the advisory professional to suggest improvements or changes. For this reason, concerning these methods, focus groups show interesting results; farmers can discuss the background of their indicator results with other farmers and experts. As a result, farm experiences and management practices together with expert opinions, motivate and stimulate farmers to improve their sustainability (Van Passel & Meul, 2012).

Post-assessment:

Farmers do not seem to be individually concerned by environmental issues addressed by IDEA. They are more concerned with the economic aspects which drive their decision-making processes and orient their perception of sustainability. They think that no agriculture is sustainable if it is not first and foremost a profitable agriculture. They consider the environmental impacts of their practices and their management to be the responsibility of the State. Indeed, in this context of market opening, sustainable practices are considered less profitable than that currently farmers do. This could be explained by the fact that environmental issues are not yet alarming farmers in the Saïs region and do not disturb the farmer or the state. Thus, the rationality of farmers to maximize their income, whatever the effect on resources, could lead to a tragedy of the commons (Hardin, 1968). In contrast, environmental concerns have already become critical by strongly impacting the farm and the farmer decision-making processes in other regions (in European countries for instance). In these countries, governments encourage the agricultural change by influencing farmers directly or indirectly by policies and actions, such as trade policies, price supports, taxes, research and development, various forms of compensation, marketing boards, and land use incentives and controls. But even in these contexts where these issues are socially recognized and accepted, farmers regularly face conflicts between economic and environmental issues, especially when market prices decrease or when public or private regulations push for more environmental-friendly practices (Dobbs & Pretty 2008). Thus, it shows that sustainable farming is not only the problem of farmers but concerns also consumers and all the society through public policies (Cembalo et al., 2013). Indeed, actions encouraging farmers to sustainable change must be effective to be adopted (Kheiri, 2015). It must be compatible with the sociopolitical environment within which it operates and considers their societal values. This study

showing the perceptions and preferences of farmers regarding sustainability could be a good entry for those actions.

Using an evaluation method of sustainability such as IDEA, which promotes a production model based on multifunctionality of agriculture, does not appear to be directly applied to farmers in emerging economy contexts such as Morocco, where there are specific issues and challenges. The use of IDEA helped to address environmental aspects that farmers did not mention during the first interviews and to better understand their strategies and decisions. The case of Saïs illustrates the contrast of sustainability apprehension between researchers and farmers. For the former, it was illustrated by the method and for the latter by their perceptions of sustainability and their value systems. Sustainability concept implies a way of thinking, consequently, people's beliefs and values will continue to mold public understanding of the concept and what sustainability means and how it can and should be achieved. Which we return to the old affirmation of MacRae et al., (1990): we cannot expect to have a sustainable agriculture unless all of us adopt a fundamentally different way of thinking about agriculture, which will require major changes in personal beliefs, values, and lifestyles. Indeed, it proves to the state that there is no absolute definition of agricultural sustainability and that there is a need for contextualization.

Although these results are put into perspective in relation to a small sample, they allowed establishing a stocktaking of the farm sustainability and understanding the strategies of farmers in a context of market competition. The need to be competitive pushes farmers to have a perspective of "now" and not "forever."

References

Bekkar, Y., Kuper, M., Errahj, M., Faysse, N. &Gafsi, M. (2009).*On the difficulty of managing an invisible resource: Farmers' strategies and perceptions of groundwater use, field evidence from Morocco. Irrigation and Drainage* 58, 252–263. doi:10.1002/ird.527.

Bockstaller, C., Girardin, P., & Van der Werf, H.M.G. (1997). *Use of agro-ecological indicators for the evaluation of farming systems. European Journal of Agronomy* 7, 261–270.

Burton, R. J. & Wilson, G. A. (2006). *Injecting social psychology theory into conceptualisations of agricultural agency: towards a post-productivist farmer self identity, Journal of Rural Studies* 22, 95–115.

Cembalo, L., Migliore, G., & Schifani, G. (2013). *Sustainability and New Models of Consumption: The Solidarity Purchasing Groups in Sicily. Journal of Agricultural and Environmental Ethics* 26, 281–303. doi:10.1007/s10806-011-9360-0

Darnhofer, I., Fairweather, J., & Moller, H. (2010). *Assessing a farm's sustainability: insights from resilience thinking. International Journal of Agricultural Sustainability* 8(3), 186–198. doi:10.3763/ijas.2010.0480

Dobbs, T. L., & Pretty, J. (2008). *Case study of agri-environmental payments: The United Kingdom. Ecological Economics* 65(4), 765–775. http://doi.org/10.1016/j.ecolecon.2007.07.030

Dogliotti, S., García, M.C., Peluffo, S., Dieste, J.P., Pedemonte, A.J., Bacigalupe, G.F., Scarlato, M., Alliaume, F., Alvarez, J., Chiappe, M., &Rossing, W.A.H. (2014). *Co-innovation of family farm systems: A systems approach to sustainable agriculture. Agricultural Systems* 126, 76–86. doi:10.1016/j.agsy.2013.02.009

Duru, M., &Therond, O. (2015). *Livestock system sustainability and resilience in intensive production zones: which form of ecological modernization? Regional Environmental Change* 15(8), 1651–1665. doi:10.1007/s10113-014-0722-9

Fadul-Pacheco, L., Wattiaux, M.A., Espinoza-Ortega, A., Sánchez-Vera, E., &Arriaga-Jordán, C.M. (2013). *Evaluation of Sustainability of Smallholder Dairy Production Systems in the Highlands of Mexico During the Rainy Season.Agroecology and Sustainable Food Systems* 37, 882–901. doi:10.1080/21683565.2013.775990

Fairweather, J., & Campbell, H. (2003). *Environmental beliefs and farm practices of New Zealand farmers: opposing pathways to sustainability. Agriculture and Human Values 20, 287–300.*

Gafsi M., & Brossier J. (1997). *Farm management and potection of natural resources: Analysis of adaptation process and the dependence relationships. Agricultural Systems* 55, 71–97.

Girardin, P., Bockstaller, C., & Van der Werf, H.M.G. (2000). *Assessment of potential impacts of agricultural practices on the environment: the AGRO*ECO method. Environmental Impact Assessment Review*20,227–239.

Häni, F., Braga, F., Stämpfli, A., Keller, T., Fischer, M., &Porsche, H. (2003). *RISE, a tool for holistic sustainability assessment at the farm level. International Food and Agribusiness Management Review* 6,78–90.

Hansen, W.J. (1996). *Is agricultural sustainability a useful concept? Agricultural Systems* 50,117–143.

Hardin, G. (1968).*The tragedy of the commons. Science* 162:1243–1248

Kheiri, S. (2015). *Identifying the barriers of sustainable agriculture adoption by wheat farmers in Takestan. International Journal of Agricultural Management and Development* 158-169. http://doi.org/10.5455/ijamd.175275

Lejars, C.&Courilleau, S. (2014). *Impact du développement de l'accès à l'eau souterraine sur la dynamique d'une filière irriguée. Le cas de l'oignon d'été dans le Saïs au Maroc. Cahiers Agricultures* 24, 1-10. doi:10.1684/agr.2014.0729.

MacRae. R.J., Hill, S.B., Henning, J., & Bentley, A.J. (1990). *Policies, programs, and regulations to support the transition to sustainable agriculture in Canada. American Journal of Alternative Agriculture* 5(2): 76-92.

Meul, M., Van Passel, S., Nevens, F., Dessein, J., Rogge, E., Mulier, A., & Van Hauwermeiren, A. (2008). *MOTIFS: a monitoring tool for integrated farm sustainability. Agronomy for Sustainable Development* 28,321–332.

M'Hamdi, N., Aloulou, R., Hedhly, M., & Ben Hamouda, M. (2009). *Évaluation de la durabilité des exploitations laitières tunisiennes par la méthode IDEA. Biotechnologie, Agronomie, Société et. Environnement* 13: 221–228

Ness, B., Urbel-Piirsalu, E., Anderberg, S., &Olsson, L. (2007). *Categorising tools for sustainability assessment. Ecological Economics* 60, 498–508. doi:10.1016/j.ecolecon.2006.07.023

ONU (1992). *Le sommet "planète terre", couronnement d´une réunion historique, définit les orientations du développement durable*. http://www.un.org/french/events/rio92/rioround.htm

Pacini, C., Wossink, A., Giesen, G., Vazzana, C., &Huirne, R. (2003). *Evaluation of sustainability of organic, integrated and conventional farming systems: a farm and field-scale analysis. Agriculture, Ecosystems & Environment* 95,273–288.

Quarouch, H., Kuper, M., Abdellaoui, E.H. &Bouarfa, S. (2014). *Eaux souterraines, sources de dignité et ressources sociales : cas d'agriculteurs dans la plaine du Saïss au Maroc. Cahiers Agricultures* 23, 158–165.

Rey-Valette, H., Clément, O., Aubin, J., Mathé, S., Chia, E., Legendre, M., Caruso, D., Mikolasek, O.,Blancheton, J.-P., Slembrouck, J., Baruthio, A., René, F., Levang, P., Morissens, P., &Lazard, J. (2008). *Guide to the Co-construction of Sustainable Development Indicators in Aquaculture.* EVAD, Montpellier.

Rodrigues, G.S., Rodrigues, I.A., Buschinelli, C.C. de A., & de Barros, I. (2010). *Integrated farm sustainability assessment for the environmental management of rural activities. Environmental Impact Assessment Review* 30, 229–239. doi:10.1016/j.eiar.2009.10.002

Ryschawy, J., Joannon, A., Choisis, J.P., Gibon, A., &Le Gal, P.Y. (2014). *Participative assessment of innovative technical scenarios for enhancing sustainability of French mixed crop-livestock farms. Agricultural Systems* 129, 1–8. doi:10.1016/j.agsy.2014.05.004

Salas-Reyes, I. G., Arriaga-Jordán, C. M., Rebollar-Rebollar, S., García-Martínez, A., &Albarrán-Portillo, B. (2015). *Assessment of the sustainability of dual-purpose farms by the IDEA method in the subtropical area of central Mexico. Tropical Animal Health and Production* 47(6), 1187–1194. http://doi.org/10.1007/s11250-015-0846-z

Schmitzberger, I., Wrbka, T., Steurer, B., Aschenbrenner, G., Peterseil, J., &Zechmeister, H. (2005). *How farming styles influence biodiversity maintenance in Austrian agricultural landscapes. Agriculture, Ecosystems and Environment* 108, 274–290.

Slee, B., Gibbon, D., &Taylor, J. (2006). *Habitus and Style of Farming in Explaining the Adoption of Environmental Sustainability-Enhancing Behaviour,* Final Report, Countryside and Community Research Unit, University of Gloucestershire.

Thivierge, M.-N., Parent, D., Bélanger, V., Angers, D.A., Allard, G., Pellerin, D., & Vanasse, A. (2014). *Environmental sustainability indicators for cash-crop farms in Quebec, Canada: A participatory approach. Ecological Indicators* 45, 677–686. doi:10.1016/j.ecolind.2014.05.024

Van Calker, K.J., Berentsen, P.B.M., Giesen, G.W.J., &Huirne, R.B.M. (2008). *Maximising sustainability of Dutch dairy farming systems for different stakeholders: A modelling approach. Ecological Economics* 65, 407–419. doi:10.1016/j.ecolecon.2007.07.010

Van Cauwenbergh, N., Biala, K., Bielders, C., Brouckaert, V., Franchois, L., Cidad, V.G., Hermy, M., Mathijs, E., Muys, B., Reijnders, J., Sauvenier, X., Valckx, J., Vanclooster, M., Van der Veken, B., Wauters, E., &Peeters, A. (2007). *SAFE – a hierarchical framework for assessing the sustainability of agricultural systems. Agriculture, Ecosystems & Environment*120,229–242.

Van Passel, S., &Meul, M. (2012). *Multilevel and multi-user sustainability assessment of farming systems. Environmental Impact Assessment Review* 32(1), 170–180. http://doi.org/10.1016/j.eiar.2011.08.005

Vilain, L., Boisset, K., Girardin, P., Guillaumin, A., Mouchet, C., Viaux, P., & Zahm, F. (2008). *La méthode IDEA, indicateurs de durabilité des exploitations agricoles, 3 édn*. *Guide d'utilisation.* Educagri Éditions, Dijon.

Zahm, F., Viaux, P., Vilain, L., Girardin, P., &Mouchet, C. (2008). *Assessing farm sustainability with the IDEA method - from the concept of agriculture sustainability to case studies on farms. Sustainable development* 16, 271–281. doi:10.1002/sd.380