Social and Technological Transformation of Farming Systems:

Diverging and Converging Pathways

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Workshop 2.4: Temperate agriculture sustainability assessment beyond the individual farm level

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There are already in excess of 50 schemes attempting to measure ‘sustainability’ via metrics for different objectives (e.g. ethical food production, environmental impact of production). A complementary workshop evaluated use of these frameworks and measures at the whole farm level to encourage individual farmers to change their practices and values. This workshop primarily focused on the uses and constraints on scaling and interpretation of the metrics at catchment, regional, national and global biome levels beyond the individual farm level. Farm-level sustainability is not only shaped on the farm, so information about beyond-the-farm influences (e.g. water scarcity, infrastructure, governance, economic instruments) is also needed to guide local, national and international land use decisions and policy. ‘TempAg’ (Collaborative Research Network on Sustainable Temperate Agriculture) is a recently formed coalition of agricultural researchers and policy makers from across temperate and high altitude production areas of the OECD (www.oecd.org/sti/sci-tech/tempag.htm). The workshop began with a brief description of TempAg’s raison d’être, long term goals, governance and the way it proposes to secure the resilience and sustainability of temperate agriculture, in part by comparing sustainability performance at country and agricultural sector levels. Contributions were invited from producers, industry, policy makers and researchers from throughout highly seasonal agro-ecosystems to explore opportunities and limits for comparing sustainability and resilience of temperate agriculture. Firstly, the workshop focused on methods for prioritisation, scaling and aggregation of indicators beyond the farm level. Useful questions included: Which tools can best help designers of sustainability assessments set priorities about what to measure in local, regional and global contexts? Should metrics be aggregated into fewer composite indicators at higher levels of sustainability frameworks, and if so, how can composite indicators be calculated that remain sensitive and interpretable? How can measurements based on very different scales of measurement, or representing very different knowledge systems, be combined or weighted against each other for scaling or aggregation? Secondly, the workshop addressed the limits and constraints of comparing sustainability above the farm level. Can metrics adequately represent the sustainability and resilience of very different agricultural systems spread across the temperate and high altitude regions (e.g. mixed-cropping, animal grazing and confinement)? Can rapid, robust and real ‘sustainability’ metrics be reliably and usefully compared between sectors, countries and regions? What are useful benchmarking methods to assess relative performance of these very divergent systems? How can we best set targets for sustainable practices that inform where and when interventions are needed for transforming agricultural practices? Thirdly, the workshop confronted how measures of agricultural sustainability and resilience beyond the farm level might shape policy interventions at regional, national and international levels. How might up-scaled sustainability measures be used (or abused) by government and organisations like FAO, OECD and international food and fibre producers and distributors? What type of processes and cross-scale bridging organisation are needed to ensure the best use of up-scaled sustainability measures? The workshop concluded with a discussion of knowledge gaps and opportunities for research around these three themes. This was to help set an international and transdisciplinary collaborative research agenda for the coming 5 years amongst the TempAg researchers.

Climate vulnerability analysis facilitating transformation of watersheds in Kerala, India

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Abstract: Watershed Development Programmes (WDP) receive enormous attention due to their capacity to enhance production in rain-fed agriculture along with restoration of ecological balance and sustainability. Many of these programmes are questionable in terms of building climate change adaptation strategies among the rural poor in watershed areas. This paper analyses vulnerability towards climate change on watershed community level in Kerala, India. A case study was conducted in a watershed, which was implemented by a Non-Governmental Organisation (NGO). Primary data was collected using the Rapid Appraisal of Agricultural Knowledge System methodology with its main instruments household surveys, focus group discussions, key informant interviews and personal interviews with various stakeholders. Vulnerability due to climate variability is assessed by developing a Climate Vulnerability Index (CVI) which employs both qualitative and quantitative data. The composite index comprises of three dimensions of vulnerability - adaptive capacity, sensitivity, exposure - and its ten major components: socio-demographic profile, socio-economic assets, agricultural, livelihood, social networks, health, food, water, climate variability and natural disasters. As a main result, the vulnerability due to adaptive capacity indicators/subcomponents holds the highest value among the three dimensions of climate vulnerability. This implies an urgent need for location specific micro level planning of the watershed programmes with emphasis on activities to address water scarcity, soil and water conservation, farm diversification, production enhancement and livelihood alternatives for better coping strategies and resilience.

Keywords: Adaptive capacity, CVI, climate change, sensitivity, watershed development

Introduction

According to the Maplecroft (2015) Climate Change Vulnerability Index, which evaluates the sensitivity of populations, the physical exposure of countries, and the governmental capacity to adapt to climate change over the next 30 years, India stands second among the growth economies under the extreme risk category. The Centre for Climate Energy Solutions report (2015) states that India is the fourth largest greenhouse gas emitter, accounting for 5.8% of global emissions.

In India, 53% of the population depend on agriculture for their living. Among these, 55% of farmers rely on rain-fed systems in which ‘delayed, deficient or erratic rains’ lead to a severe reduction in production and productivity with resource misutilisation and degradation (Planning Commission, 2012). These rain-fed areas constitute 62% of the total geographic area of the country which produces 40% cereals and 85% pulses to support 40% human and 60% livestock population (Planning Commission, 2012).

The Indian Watershed Development (WSD) programme is one important strategy to adapt to climate variability and extreme climate events and thus to build adaptive capacity and resilience among the rural communities especially in rain-fed areas. According to Samuel et al. (2015), "*Watershed Development is a multi-sectoral intervention aimed at enhancing the potential of ecosystem resources and the socio-economic situation of the community in a specific landscape unit*". Various studies on watershed impact evaluation reveals WSD programmes have the capacity to reduce the risk associated with rain-fed agriculture and act as a tool for disaster management (Gandhi & Crase, 2012; Kerr, 2007).

Previous climate change studies conducted in India focus on: gender based adaptation to climate change (Bokhoree et al., 2012); climate variability and farmers' vulnerability in the flood prone district of Assam (Chaliha et al., 2012); climate vulnerability assessment in Himalayan communities (Pandey & Jha, 2012; Aryal et al., 2014); perception and knowledge level of climate issues (Nirmala & Aram, 2015); and climate change impacts on coastal ecosystems (Arul & Arul, 2015). However it is widely accepted that climate vulnerability studies should explore the socio-economic and institutional factors in depth (Gbetibouo et al., 2010) at local level (Vincent & Cull, 2010), integrate the sustainable livelihood approach and address the issue of sensitivity and adaptive capacity to climate change to a certain extent (Hahn et al., 2009). There is enormous heterogeneity within the districts with respect to resource access, poverty and coping strategies (Gbetibouo et al., 2010) so assessments at more disaggregated levels or at community level or to evaluate the potential programme/policy effectiveness must be done (Hahn et al., 2009). Moreover, Wisner (2010) suggests integration of climate change into ongoing efforts to give special attention to location specific knowledge for better adaptation strategies.

There is a large body of literature on climate vulnerability assessments which develop many indicators. Practical applications with an active involvement of community stakeholders are rarely undertaken. According to Smit and Wandel (2006) participatory vulnerability assessments enable recognition of multiple stimuli beyond climate and include political, cultural, economic, institutional and technological forces over time, scale and individuals.

The aim of this paper is to assess the climate vulnerability through a participatory bottom-up approach coupled with the development of a vulnerability index at watershed community level. This approach involves active participation of various stakeholders, integration of information from multiple sources (Smit & Wandel, 2006) and triangulation. The selected watershed programme has been implemented by one of the NGOs in Kerala state, India. This approach aims to bridge the gaps at microlevel planning and implementation by recognising the importance of governance, equity, priorities of the vulnerable sections, expected risks and benefits along with diverse perceptions to various climatic shocks and policy making.

Methodology

Description of the study area

Kerala, the south western state in India, is severely threatened by climate change. It is unique in social, economic, environmental and physical conditions such as high population density, integrated farming system, humid tropical monsoon with excessive rainfall and hot summers (Government of Kerala, 2014). Kerala is known as the "Gate way of the summer monsoon" to India and it is one of the wettest places in the world, where annual rainfall is of the order of 3000mm (Raj & Azeez, 2010). Homestead farming is a key feature of land use in this area, which includes a large number of species grown such as spices, medicinal plants, plantation trees, fruit plants, vegetables and tuber crops. In recent years there has been a major shift in rainfall pattern in Kerala, with significant decreases of the southwest monsoon (Guhathakartha & Rajeevan, 2008; Krishnakumar et al., 2009; Nikhil Raj & Azeez, 2012), and increases of the northeast monsoon in Kerala (Krishnakumar et al., 2009).

Palakkad is listed as one of the highly vulnerable districts to climate change in Kerala due to its specific geographic location, humid climate, high percentage of population relying on agriculture, a low ranking in the human development index, high social deprivation and a high degree of vulnerability to natural hazards like flood and drought with impacts on biodiversity and human life (Government of Kerala, 2014).The annual rainfall in this region is comparatively less than other parts of the state. Daytime temperatures often exceed 40°C in Palakkad with reports of severe sunburn in 2010 (Gopakumar, 2011).

The watershed selected for the study was Akkiyampadam watershed. It was implemented by The Peoples Service Society NGO in Kerala. The Akkiyampadam watershed lies between10° 58' 13" to 11° 00' 10" N and 76° 29' 27" to 76° 31' 06" E, located in Kanjirampuzha Grama Panchayat (bottom level self-government institution in Kerala). The treatable watershed area is 520 ha. The main soil types include Laterite and Red soil. Important water holding structures in the area are open wells, bore wells, tanks and ponds. Farmers cultivate coconut, cashew, arecanut, paddy rice, rubber, banana, pepper, vegetables and tapioca. Ninety-two percent of the farmers are marginal farmers with <1 ha of landholdings and depend on subsistence farming.

Vulnerability framework

This part of the paper develops the conceptual framework to analyse the components of vulnerability and their relations. Vulnerability assessment is a common tool for indicating the potential for harm to occur within human and ecological systems in response to global climate change (Fussel & Klein, 2006). Vulnerability thereby is "…*the degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate change, including climate variability and extremes"* (Fellmann, 2012). Moreover, vulnerability is an *"… integrated measure of the expected magnitude of adverse effects to a system caused by a given level of certain external stressors"* (Preston et al., 2011). This external dimension is represented as *exposure* which relates to "*the nature and degree to which a system is exposed to significant climatic variations".* The sensitivity of a system to climate change reflects the *"degree to which a system is affected, either adversely or beneficially, by climate variability or change*" (Fellmann, 2012). It shows the "*responsiveness of a system to climate change*" (IPCC, 2007). Sensitive systems are affected by even small climatic variations. Adaptive capacity is the ability of a system to adjust to climate change to moderate potential damage, to take advantage of opportunities, or to cope with the consequences (Fellmann, 2012). It is intrinsically linked with socio-economic factors of the system and with other determinants such as institutions, knowledge and technology (Adger et al., 2007). *Adaptation* is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

Measurement of vulnerability includes social processes as well as material outcomes within the system (Adger, 2006), which makes the quantification process difficult. The Climate Vulnerability Index (CVI) used here was developed based on the framework given in Figure 1. It implies that "*a system is vulnerable if it is exposed and sensitive to the effects of climate change and at the same time has only limited capacity to adapt*" (Mearns & Norton, 2010). On the contrary, a system is less vulnerable if it is less exposed, less sensitive or has a strong adaptive capacity (Smit & Wandel, 2006). Therefore, building adaptive capacity enables communities to mobilise resources needed to reduce vulnerability and adapt to climate change (Nelson et al., 2007).

The approach places importance on local community level knowledge and facilitates integrative, consultative and gender sensitive participation of all sectors of stakeholders in WSD programmes to express the impact and extent of climate variability. The Climate Vulnerability Index is based on three dimensions of vulnerability and its ten components as given in the Figure 1.

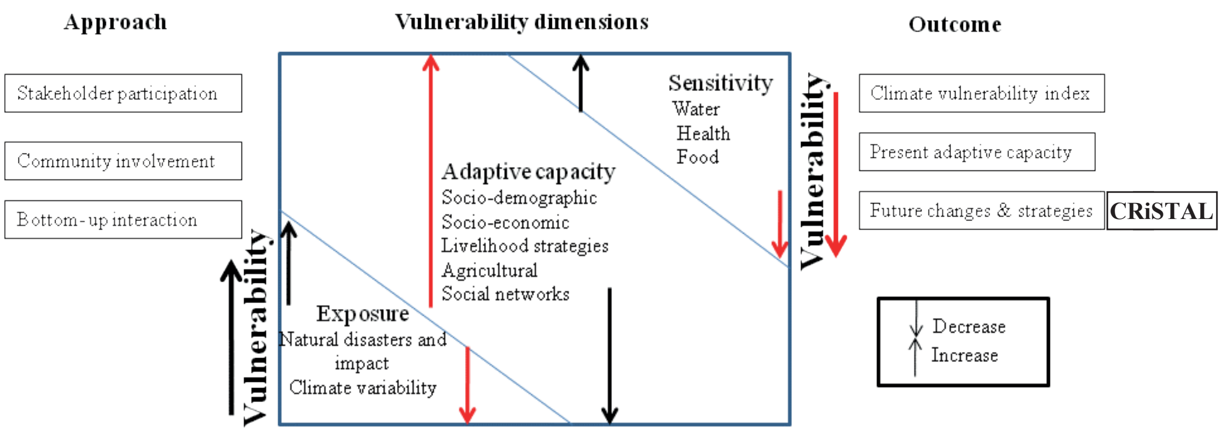

Figure 1. Framework for participatory climate vulnerability analysis

The CRiSTAL (Community based Risk Screening Tool-Adaptation and Livelihoods) allows analysis of existing activities and the extent to which the community resources are influenced by the climate hazards. The final analysis helps to propose actions and adaptation strategies for affected communities and resources. The CRiSTAL will be used in the later part of this research.

Vulnerability index

Climate vulnerability is multidimensional with complex interrelationships between multiple factors which are difficult to quantify. The proposed CVI includes three different dimensions: adaptive capacity, sensitivity and exposure. Each dimension is comprised of major components under which relevant indicators or subcomponents specific to the watershed area are included. The selection of subcomponents and indicators is very crucial in developing such an index with validity and reliability. The selected indicators were then pretested and checked within key informant interviews. Here, under the adaptive capacity dimension there are five major components namely socio-demographic profile, socioeconomic assets, livelihood strategies, agricultural and social networks. The major components and their subcomponents are depicted in Table 1. For calculating CVI, each major component contributes equally to the overall index (Hahn et al., 2009) while each major component is calculated based on a weighted average approach (Sullivan et al., 2002). The functional relationship of each subcomponent/indicator is considered whether it contributes positively or negatively to the overall vulnerability. For subcomponent/indicators with a negative relationship it has been hypothesised to decrease the vulnerability and calculate the hypothesised value by using (100-index value). The subcomponents/indicators are measured on different scales, and were therefore normalised between 0 and 1 so as to bring the values within a comparable range and thus form an index (Hahn et al., 2009).

Table 1. Climate vulnerability index: dimensions, major components and subcomponents

Dimensions of vulnerability	Major components	Subcomponents/indicators	Explanation of subcomponents
ADAPTIVE CAPACITY	Socio-demographic profile	Family dependency index	Ratio of population between 0-14 years and population of 60 years & above to the population between 15-59 years
		House type diversity index	Simpson's diversity index (1-D)#
		Family decision Index	Percentage of literate household head
		Poverty index	Percentage of families below poverty line
		Indebtedness index*	Percentage of families with debt
		Percent of high income households	Percentage of households with income of >2250 $/year
		Percent of male headed households	Percentage of households with male as head of the family
		Religious diversity index	Simpson's diversity index (1-D)#
	Socio-economic assets	House hold asset possession index	Inverse of (household asset+1)
		Farm asset possession index	Inverse of (farm asset +1)
		Average farm holding size	Average land holding size§
		Percentage of households with own water holding structures	Percentage of households with at least one water holding structure
	Livelihood strategies	Migration	Percentage of households in which at least one member migrated for better income
		Percent of households introduced new crop	Percentage of households introduced at least one new crop in farming
		Percent of households solely dependent on agriculture for income	Percentage of households with agriculture as the only source of income
		Farm diversification index	Inverse of (types of enterprises+1)
		New livelihood strategies adoption	Percentage of households which adopted new livelihood strategies in last five years
		Percent of households introduced livestock	Percentage of households which adopted livestock in farming in last five years

	Agricultural	Percent of rainfed farming	Percentage of households which are not following any irrigation methods
		Percent of net sown area	Percentage of cultivated land area
		Crop diversification index	Inverse of (types of crops+1)
		Percent of households adopting new varieties	Percentage of households which introduced new varieties in farming
		Decline in farm production	Percentage of households reporting decreasing trend in farm production
		Soil erosion perception index	Percentage of households who consider they have moderate to severe soil erosion on their land
		Non adoption of soil and water conservation works	Percentage of households where farmers not adopted any soil and water conservation works
		Households with <0.2 ha of land	Percentage of households with less than 0.2 ha of land
	Social networks	Percent of beneficiaries	Percentage of households which received benefits from the WSP
		Cooperation	Percentage of households which provided help to others during distress
		Percent of households with membership in co-operative institutions	Percentage of households which have membership in societies
		Percent of households receiving help from others	Percentage of households which received assistance
		Watershed committee membership	Percentage of households with members in WS committee
		No beneficiary contribution	Percentage of farmers who have not contributed any beneficiary share
		Percent of households lacking ICT access	Percentage of households with no access to ICT
		Participation in grass root planning	Percentage of farmers who participated in grass root planning
		Trainings	Percentage of farmers who received training on climate change
SENSITIVITY	Water	Water scarcity	Percentage of households with problems of drinking water during summer
		Dependency on water resources	Percentage of households dependent on other's water resources
		Public water sources	Percentage of households dependent on public tap for drinking water
		Groundwater decline	Percentage of households which reported decrease in ground water
		Gender inequality	Percentage of households where females fetch potable water
		Decreased availability of water	Percentage of households which reported decreased availability of water
	Health	Water resource depletion index	Percentage of households which reported severe depletion of water resources
		Waterborne diseases	Percentage of households which reported waterborne diseases in the family

		New disease incidence	Percentage of households which reported new disease(s)
		Poor quality drinking water	Percentage of households which reported decreased quality of drinking water
		Sunburn	Percentage of households with sun burn problems reported
	Food	Death due to climatic variabilities	Percentage of households with death due to climate variations
		Off-farm dependency	Percentage of households which depend only on off-farm for food
		Food insufficiency	Percentage of households which reported food insufficiency
EXPOSURE	Natural disaster & impact	Poor support from Govt.	Percentage of households which reported poor support from Govt. through PDS
		Death or injury due to natural disaster	Percentage of households with death or injury due to natural disaster
		Crop loss	Percentage of households which reported crop loss
		Housing or property damage	Percentage of households which reported housing or property damage
	Climate variability	Heavy wind	Percentage of households which reported heavy wind
		Temperature increase perception	Percentage of households which reported very high temperature increase
		Hot months increase perception	Percentage of households which reported hot months increase
		Erratic rainfall perception	Percentage of households which reported erratic rainfall
		Less rainy days perception	Percentage of households which reported less rainy days
		Extreme climate events	Percentage of households which reported at least one extreme climate event

Following, the values of each subcomponent/indicator are normalised using the equation.

$$Index_{sw} = \frac{S_w - S_{min}}{S_{max} - S_{min}} \quad \text{(Eq. 1)}$$

where,
S_w is the original subcomponent/indicator value for the watershed community,
S_{min} and S_{max} are the minimum and maximum values for the subcomponent/indicator.
After the standardisation, each subcomponent/indicator is averaged to calculate its value.

$$M_w = \frac{\sum_{i=1}^{n} Index_{swi}}{n} \quad \text{(Eq. 2)}$$

where,
M_w is one of the major components under the three dimensions of vulnerability,
$Index_{swi}$ is the subcomponent value of the watershed community and

n is the number of subcomponents under the major component.

After calculating the major component, the next step is assigning weights. The balanced weighted approach has been used in this study. The number of subcomponents under major components has been taken as the weight for calculating the index for major components. For example the index for Adaptive capacity (Ada. cap), Sensitivity (Sen) and Exposure (Exp), has been calculated according to Eqs. 3, 4 and 5:

$$Ada.cap=\frac{W_{a1}SD+W_{a2}SE+W_{a3}LS+W_{a4}A+W_{a}SN}{W_{a1}+W_{a2}+W_{a3}+W_{a4}+W_{a5}} \quad \textit{(Eq. 3)}$$

Where,
W_{a1}, W_{a2}, W_{a3}, W_{a4}, and W_{a5} are the weights for socio-demographic profile, socio-economic assets, livelihood strategies, agricultural and social network, respectively.

$$Sen = \frac{W_{s1}H+ W_{s2}F+ W_{s3}Wa}{W_{s1}+W_{s2}+W_{s3}} \quad \textit{(Eq. 4)}$$

where,
W_{s1}, W_{s2}, and W_{s3} are the weights for the components health, food and water, respectively.

$$Exp = \frac{W_{e1}ND+ W_{e2}CV}{W_{e1}+W_{e2}} \quad \textit{(Eq. 5)}$$

where,
W_{e1} and W_{e2} are the weights for natural disaster and climate variability respectively. The indicator values vary between 0 and 1 and may be interpreted as 0 for least vulnerable and 1 for the most vulnerable.

Then the overall index for vulnerability can be expressed as

$$CVI_w=\frac{\sum_{i=1}^{10} W_{mi}M_{wi}}{\sum_{1=1}^{10} W_{mi}} \quad \textit{(Eq. 6)}$$

where,
W_{mi} is the weight and
M_{wi} is the average value of each subcomponent.

Data collection

The selection criterion for the watershed was the one which completed the project activities before the year 2014 and for this we contacted the Western Ghat Development Cell, Palakkad. The Akkiyampadam watershed began in 2009 and completed the activities in 2013. The household interviews were conducted by us in August-September 2015 with the help of an assistant to survey within the watershed boundaries. Once in the village, the Community Development Society members, the Grama Panchayat Secretary and elected Grama Panchayat members were consulted to explain the purpose of the study and to obtain preliminary information regarding the implemented programme. The cluster sampling method was used in the selection of farm households i.e formed clusters of small, medium and large farmers (n=70) based on the primary and secondary data collected from the Agricultural Office of the watershed area. During data collection maximum care has taken to ensure participation from different levels of respondents: farmers, landless, labourers, self-help group members and women. A few key informant interviews were conducted namely with the Panchayat President, Agricultural Officer, elected members of Panchayat, the Community Development Society member of the women's self-help group, progressive farmers and the secretary of the watershed committee. The purpose of these was to learn about their role and to extend an offer of participation in and contribution to the planning and implementation of the programme. Two focus group discussions were conducted with men and women's groups to get an overview about existing problems, alternative solutions, future expectations on climate variability risk mitigation and adaptation strategies.

Results and Discussion

Table 2 shows the results of the subcomponents/indicator values, hypothesised values, normalised values and the average indicator values at the watershed community. Under socio-demographic components, there are eight subcomponents and among these, the religious diversity index holds the highest value (0.905) because there is heterogeneity in the belief system and people belong to three different religions i.e. Hindus, Christians and Muslims. This may create differences in opinion and disagreement among the community members on developmental issues. The family decision index (0.100) contributes least to the socio-demographic vulnerability indicator because 90% of the household heads are literate which shows the progressive nature of the community. The family dependency index (0.505) shows a high value with 33% of the household members dependent on others in the family for their means of living. Furthermore, 37.14% of the households are below the poverty line while rural poverty for the whole state is 7.3% (Government of Kerala, 2012). It clearly depicts the economic deprivation of the area, which has a positive functional relationship to the climate vulnerability.

The socio-economic vulnerability of the area contributes less to the overall vulnerability index. The farm asset possession index (0.468) is the highest contributing factor to the socio-economic vulnerability. The average farm holding size is 0.37 ha which is more than the per capita availability of land in the state of Kerala which is 0.23 ha (Government of Kerala, 2012). 90.00% of the households possess their own water holding structures for routine activities, which contributes positively to the adaptive capacity.

The Livelihood strategy component has a major share (0.579) in the vulnerability value because households are reluctant to adopt new crops and engage in farm diversification. Even in the midst of these negativities, only 5.7% of the farmers depend solely on agriculture for income.

Table 2. Normalised values of indicators with average indicator values of major components

Major components	Indicators/subcomponents	Akkiyampadam Value	Hypothesised	Normalised	Average indicator
Socio-demographic profile	Family dependency index	0.50	0.50	0.505	
	House type diversity index	0.58	0.58	0.580	
	Family decision Index	90.00	10.00	0.100	0.517
	Poverty index	37.14	37.14	0.371	
	Indebtedness index	65.71	65.71	0.657	
	Percent of high income households	11.40	88.60	0.886	
	Percent of male headed households	87.14	12.86	0.129	
	Religious diversity index	0.90	0.90	0.905	
Socio-economic assets	Household asset possession index	0.16	0.16	0.160	
	Farm asset possession index	0.47	0.47	0.468	0.156
	Average farm holding size	0.37	0.37	-0.105	
	Percent of households with own water resources	90	10	0.1	
Livelihood strategies	Migration	2.86	2.86	0.029	
	Percent of households introduced new crop	5.71	94.29	0.943	0.579
	Percent of households solely depending on agriculture for income	5.71	5.71	0.057	
	Farm diversification index	0.69	0.69	0.69	
	New livelihood strategies adoption	12.86	87.14	0.871	
	Percent of households introduced livestock	11.43	88.57	0.886	
Agricultural	Percent of rainfed farming	42.9	42.9	0.429	
	Percent of net sown area	90.16	9.84	0.098	
	Crop diversification index	0.42	0.42	0.420	
	Percent of households adopting new varieties	1.43	98.57	0.986	
	Decline in farm production	8.60	8.60	0.086	0.488
	Soil erosion perception index	44.29	44.29	0.443	
	Non adoption of soil and water conservation works	75.71	75.71	0.757	
	Households with <0.2 ha of land	68.57	68.57	0.686	
Social networks	Percent of beneficiaries	45.71	54.29	0.543	

	Cooperation	12.86	87.14	0.871	0.611
	Percent of households with membership in co-operative institutions	80.00	20.00	0.2	
	Percent of households received help from others	5.71	94.29	0.943	
	Watershed committee membership	5.71	94.29	0.943	
	No beneficiary contribution	0.00	0	0.000	
	Percent of households lacking ICT access	91.43	8.57	0.086	
	Participation in grass root planning	7.14	92.86	0.929	
	Trainings	1.43	98.57	0.986	
Water	Water scarcity	40.00	40.00	0.4	0.471
	Dependency on water resources	10.00	10.00	0.1	
	Public water sources	2.86	2.86	0.029	
	Groundwater decline	54.30	54.30	0.543	
	Gender inequality	100.00	100.00	1	
	Decreased availability of water	25.70	25.70	0.257	
	Water source depletion index	97.14	97.14	0.971	
Health	Waterborne diseases	0.00	0.00	0	0
	New disease incidence	0.00	0.00	0	
	Poor quality drinking water	0.00	0.00	0	
	Sunburn	0.00	0.00	0	
	Death due to climatic variabilities	0.00	0.00	0	
Food	Off-farm dependency	42.86	42.86	0.429	0.462
	Food insufficiency	1.43	1.43	0.014	
	Poor support from Government	94.30	94.30	0.943	
Natural disaster & impact	Death or injury due to natural disaster	0.00	0.00	0	0.011
	Crop loss	4.29	4.29	0.043	
	Housing or property damage	0.00	0.00	0	
	Heavy wind	0.00	0.00	0	
Climate variability	Temperature increase perception	94.30	94.30	0.943	0.749
	Hot months increase perception	92.90	92.90	0.929	
	Erratic rainfall perception	91.40	91.40	0.914	
	Less rainy days perception	91.40	91.40	0.914	
	Extreme climate events	4.29	4.29	0.043	

The agricultural vulnerability status also shows a higher value (0.488) with less adoption in new varieties and crop diversification. The soil erosion perception index (0.443) shows the awareness of the households about soil erosion in the watershed area. Many of them complained about medium-severe soil erosion despite only 75.71% of the households adopting soil and water conservation measures in their fields. One of the main objectives of the WSD programme is soil and water conservation and it shows the pitfalls in facilitating adoption of such activities in the farmer's field or common land.

Even though the social networking status (0.611) contributes a higher value towards overall climate vulnerability, 80% of the farms are members in cooperative societies. Nearly half of the households received benefits from the programmes and all of them paid beneficiary contributions either in terms of money or kind. Over the last two decades, decentralised planning has been institutionalised in Kerala with the 'Panchayati Raj' system of administration and implementation. Despite this only 7.14% of the households participated in the grass root level planning. The households expressed reluctance to opine that they received help from others. Only 5.7% admitted that they seek help from neighbours, family members or governmental institutions.

Among the sensitivity major components, water contributes the highest (0.471) to the average vulnerability. 40% of the households face scarcity of water during the drought season; the scarcity period varies between 2-6 months. These households depend on a neighbour's well or public tap for drinking water during this period and water fetching is the sole responsibility of the women in the house. 54.30% of the households reported a decline in groundwater compared to past years. Severe depletion of natural water sources (0.971) also plays a key role in contributing to the sensitivity dimension.

Health components show a positive trend to increase the resilience of watershed communities. There were no new disease incidences, waterborne diseases or complaints on poor quality drinking water.

Among food components, poor support from the government (0.943) contributes the highest to the average vulnerability (0.462). Only a very small percentage of households (1.43%) reported food insufficiency which also contributes positively to the resilience of the community. Natural disasters due to extreme events were not reported in the area over the last five years.

Climate variability perceptions was more pronounced in temperature (0.943) and hot months perception indices (0.929). The extreme climate events perception index (0.043) is very low while erratic rainfall perception is (0.929) and contributes to climate variability major component. The vulnerability due to adaptive capacity holds the highest value (0.504) while the sensitivity of the community is indexed as the least with a value 0.312 and is plotted in Figure 2.

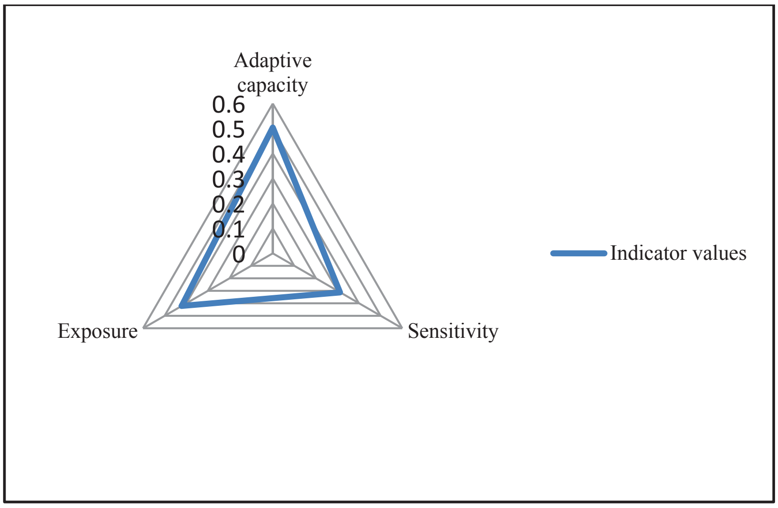

Figure 2. Vulnerability triangle diagram of the three dimensions of the Climate Vulnerability Index (CVI)

The vulnerability of Akkiyampadam watershed is 0.443 and it is hypothesised that the CVI value varies between 0 and 1 in the analysis. The CVI for a single watershed can be expanded to comparative CVI assessment of multiple watersheds to provide deeper insights into the three dimensions. This will be carried out in a future part of the research.

Conclusion

The study quantitatively evaluated the climate vulnerability at watershed community level in one of the highly vulnerable districts of Kerala state. First and foremost, despite the watershed programme aims for livelihood support systems, group mobilisation and production system improvement, vulnerability due to social networks and livelihood strategies contributes the most to the adaptive capacity vulnerability dimension. Policy makers should give priority to develop location specific policies and thus to address climate change and variability at the bottom level. Socio-demographic profile vulnerability reveals that priority should be given to incorporating more income generating activities to address rural poverty and indebtedness.

The farmers in the watershed area are very reluctant to adopt new crops, varieties and livestock into their farming. It may be solved by enacting measures to promote new crops suited to the agro-climatic conditions, drought resistant varieties and stimulate diversification of farm and livelihoods while formulating the action plans for implementation of the watershed programmes. Moreover, the programme aims at soil and water conservation measures while few farmers perceive the importance of soil erosion and adoption of such activities. This can be addressed through conducting more awareness programmes to convey the importance of protecting natural resources for present and future generations. Water scarcity and depletion of natural resources are major contributing components to the overall sensitivity of the watershed area. Kerala is the state which receives the highest average rainfall yet even in the midst of plenty of water many regions face extreme water scarcity. Indeed this should be considered as one of the main agenda items in future to include, for example, rainwater harvesting structures in the WSD programme.

Limitations of our study include the subjectivity in selection of subcomponents and the direction of relationship between the subcomponents and vulnerability. This will be addressed by applying Principal Component Analysis in future research. In this context, we could just conclude with the value of CVI, but comparison with other watersheds is also needed to place results in a larger context.

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Benchmarking sustainability farm performance at different levels and for different purposes: elucidating the state of the art

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Abstract: Multiple indicators for agroecosystems, sustainable land management, social development, rural livelihoods, biodiversity, etc. were already developed many years ago (Riley, 2001). Nowadays many of these indicators are used in a more holistic way, encompassing several or all of the aspects mentioned. However, this abundancy of frameworks, tools and metrics for agricultural sustainability assessment is still growing (Pope et al., 2013; Schindler, 2015). How does one navigate between benchmarking systems and sustainability assessment tools? What are the key characteristics to describe frameworks, metrics and tools that may facilitate the choice between them? How can one select the most appropriate for one's purpose? Our objective is to provide starting points to answer these questions. We performed a literature review regarding the characteristics proposed to discern metrics and tools. We used state of the art results from the OECD TempAg network, who inventoried integrated sustainability assessment tools and metrics designed for different purposes, to divide existing metrics and tools according to these characteristics focusing on the purpose, level and end-user. This paper first addresses conceptual aspects regarding sustainability assessment. It then describes the method used to define the characteristics, the characteristics themselves and finally shows the division of the tools. Our research resulted in a list of 25 characteristics, which were grouped into general assessment related information, information related to stakeholder participation and indicators related information. The division of tools and metrics according to these characteristics raises new questions and starting points for future research and helps us to refine our research questions.

Keywords: Integrated sustainability assessment, benchmarking, tool characteristics

Introduction

Increasing attention toward sustaining the environment in the early '90s led to the development of tools and metrics to assess sustainable development (Riley, 2001). These tools and metrics ranged from indicator lists, assessment models and indexes (Binder et al., 2010). They were developed for one or more specific themes or issues, had different aims and were related to different systems (Bockstaller & Guichard, 2009; Riley, 2001). At first, the focus was on environmental aspects (Rigby & Caceres, 1997 in Binder et al., 2010; Pope et al., 2004), but over time these tools were used in more holistic and integrated frameworks (Binder et al., 2010). Sustainability assessment has become an important aid in the process toward sustainability (Pope et al., 2004). It is defined by many authors and can be seen as a process which directs decision-making towards sustainability, integrates sustainability concepts into decision making or operationalises sustainable development as a guide for decision making by identifying the future consequences of current and planned actions (Bond et al., 2012; Hugé et al., 2013; Pope, 2006). Sustainability assessment tools and frameworks are developed to assess sustainability and facilitate sustainability assessment (Coteur et al., *in press*, derived from Gasparatos and Scolobig, 2012 and Ness et al., 2007). However, literature on sustainability assessment and sustainability assessment tools to support decision making is ever-expanding (Binder et al., 2010; Bockstaller & Guichard, 2009; Carof et al., 2013; Gasparatos & Scolobig, 2012; Marchand et al., 2014; Ness et al., 2007; Schindler et al., 2015). Many diverse processes are described as sustainability assessment due to its broad definition (Pope et al., 2004).

Questions arise as to how to navigate between these tools, what are their key characteristics and how can one select the most appropriate for one's purpose? However, literature is lacking regarding tool choice and effective use of tools and methodologies (De Ridder et al., 2007; Gasparatos & Scolobig, 2012). The objective of this research is to contribute to this gap in literature by providing a starting point to answer these questions. We performed a literature review regarding the characteristics proposed to discern metrics and tools. Furthermore, we used state of the art results from the OECD TempAg network, who inventoried integrated sustainability assessment tools and metrics designed for different purposes, to divide existing metrics and tools according to these characteristics focusing on the purpose, level and end-user. This paper first describes key issues regarding sustainability assessment, it continues by describing the characteristics of assessment tools and metrics and ends with a discussion on existing assessment tools and metrics analysed according to the described characteristics.

Key issues regarding sustainability assessment

Many authors have already discussed key-issues regarding the design and use of a sustainability assessment (e.g. Binder et al., 2010; Gasparatos & Scolobig, 2012; Gibson, 2006; Ness et al., 2007; Pope et al., 2004; Weaver & Rotmans, 2006). We will highlight some of the aspects of sustainability assessment, but like to stress that this list is not all-inclusive. One of the key issues is the contested meaning of sustainability and sustainable development (Bond et al., 2013; Hopwood et al., 2005; Pope et al., 2004; Waas et al, 2011). Bond and Morrison-Saunders (2013) (in Bond et al., 2013) describe five critical debates of issues related to sustainability assessment, two of them related to the concept of sustainability. They state that the meaning of sustainability should be formulated for every assessment, taking into account the context in which it occurs (Bond & Morrison-Saunders, 2013). The other critical debates are related to the indicator selection (holism versus reductionism), the contested time horizons and spatial boundaries, and the design of the assessment process itself as well as its outcomes (process versus outcome). Also Binder et al. (2010) highlight the need for a well-defined normative dimension of sustainability assessments, including the concept of sustainability (Binder et al., 2010). However, pluralism, a wide variety of views, should be seen as an opportunity and is an essential aspect of sustainability assessment (Pope & Morrison-Saunders, 2013). Therefore, Bond and Morrison-Saunders (2013) conclude, among other things, that communication to stakeholders about these debates or issues is crucial to create certainty and improve the credibility of the sustainability assessment.

Not only the assessment itself, but also the tools and frameworks used to facilitate these assessments are subject to variety. These assessment tools can have different purposes such as certification, communication (non-committal), reporting to policy makers (obligatory), firm development or research. Many assessment tools are designed to assess at a specific level of scale. Some will assess the farm level or field level, others the sector level, production system level, regional level or the land unit scale. Literature shows that these different levels also suggest different end-users (Van Passel & Meul, 2010). Tools assessing the farm level will be mostly used by farmers as results can be used to improve the sustainable performance of the individual farm. On the other hand, tools assessing sector and regional level are most interesting for policy makers as policy measures are drawn up at these levels. Other end users of tools can be extension workers, researchers, NGOs or actors of the supply chain. Assessment tools can also focus on different aspects of sustainability such as economic, social, cultural, environmental or governance aspects. This list of differences is not all-inclusive as many differences between tools occur. This variety of characteristics should however be taken into account when developing or selecting sustainability assessment tools and during the design of a sustainability assessment.

Furthermore, assessment tools are made up of indicators or metrics. Indicators are used to describe and determine the state or presence of a complex system (Steunpunt Duurzame Landbouw, 2006; UNAIDS, 2010). They measure performance or reflect changes related to activities, projects or programmes (UNAIDS, 2010), without necessarily measuring the state of the system itself (Steunpunt Duurzame Landbouw, 2006). These indicators can be quantitative or qualitative and their results can be visually or numerically integrated. Visual integration means that the indicator results are presented together within a table or diagram. Numerical integration combines the indicator results to present it as a single index or composite indicator (Gómez-Limón & Riesgo, 2009; Van Passel et al., 2007). Data source, the way of integration, weighing of the indicators and other factors are important aspects of integration and transparency is needed when dealing with composite indicators (Van Passel et al., 2007). A system can be represented in a holistic way by using many diverse indicators or in a reductionist way by using just a few indicators to assess a whole system.

When we want to gauge or compare the performance of a system, assessed with an assessment tool, we can use benchmarks. Benchmarking means comparing your own performance against a standard or with the performance of others. It involves continuous measuring, analysing and taking action to improve our performance (Poppe & van Asseldonk, 2015). There are different ways of setting a benchmark such as a predefined value from literature, regulatory standards or a benchmark based on the performance of other systems (Binder et al., 2010; Poppe & van Asseldonk, 2015).

Characteristics for assessment system description

As the previous section shows, the variety among tools is immense and there are numerous ways to categorise frameworks, metrics and tools for agricultural sustainability assessment. However, the question remains as to how to navigate and choose between these tools (de Ridder et al., 2007; Gasparatos & Scolobig, 2012). What are the key characteristics that may facilitate the choice between these tools?

In the context of the TempAg research collaboration on sustainable temperate agriculture an in-depth literature review was performed regarding the characteristics to discern metrics and tools. This specific research collaboration focuses on three themes and the literature review fits within the first theme “Delivering Resilient Agricultural Production Systems at Multiple Spatial and Temporal levels”. A first research question posed within this theme is “How can sustainability frameworks, metrics and tools and their implementation be enhanced to futureproof agricultural decision making at multiple levels on multiple scales?” To answer this question an inventory of existing frameworks and tools was developed and each tool was analysed on the basis of the list of characteristics. The frameworks, metrics and tools that were selected are specific to agriculture or applicable to agriculture, developed in and/or applicable in temperate climates and designed to assess sustainability in an integrated way (at least three dimensions – economic, environmental and social). Emphasis was somewhat put on farm level assessments.

The literature review resulted in a list of 70 characteristics. As the meaning and denomination of certain characteristics can vary between authors, characteristics with high similarity were clustered and working definitions were formulated. The list has been reduced to 25 essential characteristics, for which definitions were univocally formulated. These 25 characteristics, presented in Table 2, were grouped according to general assessment related information, information related to stakeholder participation and indicators related information.

Table 1. Characteristics for assessment system description

ASSESSMENT RELATED CHARACTERISTICS	
Characteristic	Definition
Origin	developed in which country or countries
Initiative	developed on the initiative of ?
Dating	year of development
Dimensions of sustainability considered (economic, environmental, scope of assessment - social, governance, cultural)	
Perspective on sustainability within scope (definition of sustainability, perspective on sustainability used)	
The intended function of the tool: reporting (obligatory), primary purpose of the communication (non-committal), firm development, research, assessment certification,…	
Spatial scale of the assessment: field, farm, industry, chain; level of assessment - national/regional, landscape, global, product,…	
The assessed farm type or production type: general (applicable to all sectors), scope (agricultural/food products or farm types); applicable to specific products or farm types (+ define which one)	
Is the system represented in a reductionist (few indicators are used in system representation to assess the sustainability of a whole system) *or holistic* (reflects the complexity of a system by using many diverse indicators) way?	
The one applying the assessment: individual farmers, extension applying user workers, policy makers, researchers,… or a combination: farmer and extension workers (Schindler et al., 2015)	
The end-user of the results: individual farmer, farmers in discussion groups, extension workers, policy makers, researchers,… or an end-user of results; combination: farmer + extension/farmers in discussion groups (Bockstaller et al., 2015; Schindler et al., 2015)	
Method of data collection: interview (individual farmer + extension worker); audit (control system); self-assessment (tools that can be used and interpreted individually); other	

Are the indicator scores aggregated? Yes/No; aggregation & weighting - if yes - is it a weighted aggregation and to what level?; if yes to weighting - method of weighting?
Are there reports/documents available for users regarding: content, transparency, purpose, method of assessment, indicator scores, interpretation of results, other?
Is the assessment being used, implemented? If yes; specify: only on level of implementation, a project basis, commercially used, used by farmers, used for certification, other.
STAKEHOLDER PARTICIPATION
Characteristic Definition
What was the type of stakeholder participation for every phase of the assessment?
Following the 6 stages defined by Binder et al. (2010): *(1)* *Preparatory phase:* defining context, goal and challenges; *(2)* Indicator *selection:* choosing the appropriate sustainability indicators, taking decisions on including interactions between indicators and how to weight indicators; *(3)* *Indicator measurement*: quantification of indicators and stakeholder participation processes (use of statistical data, surveys or categorised qualitative data); when? *(4)* *Aggregation of indicators:* taking decisions on whether or not to aggregate indicators, to which extent and how; *(5)* *Applicability* of the assessment results: the process of getting the generated knowledge ready for utilisation in practice; *(6)* *Follow-up:* reporting results, developing management advice, monitoring of indicators over time.
Who was involved? (farmers, extension workers (advisors), stakeholder participation - who? researchers, policy makers, civil society,…)
What type of stakeholder participation? stakeholder participation - how? (interviews, focus groups, workshops, other)
Time requirement for data collection: time for data collection (categories: < 2 h; 2-4 h; 1 day; 2 days; > 2 days)
INDICATOR RELATED CHARACTERISTICS - ACCURACY OF METHOD CALCULATION
Characteristic Definition
Primarily quantitative; primarily qualitative; equally quantitative and indicator type qualitative indicators
Are the data needed to complete the assessment at field level, farm level of data input level, product level, regional level or other?
Type of data used: accountancy, farmers' knowledge, expert data source information, field practices, site practices, other
What is the number of topics for this dimension? number of topics; number of themes; number of indicators

Are the data used for assessing correct and reliable? reliability of data input indicators within this dimension; yes for all; yes for most indicators of this dimension; no, data input for many indicators is doubtful	
Validation of method: are the calculation methods validated? If yes, what type of validation calculation was used?	
What kind of scoring system was used for scoring the indicators of this dimension? Benchmarks - which method is used?; expert based scoring - which method is used?; scoring from literature; other	

A list of initiatives divided by primary purpose, end-user and level of assessment

The preliminary results of the TempAg inventory show a large variation in development and content of the tools. Table 2 shows a variation of initiatives divided by the primary purpose of the tool (reporting, firm development, communication, research and certification), the end-user (farmer and policy) and the level of assessment (firm, sector and regional level). Farmer and policy were chosen as end-user because their aims (developing a farm or building/redirecting legislation) might be furthest apart.

As our original selection of initiatives focused somewhat on the farm level assessments, we see a larger amount of tools for the farmer as end-user. We said before that a specific level of scale suggests a different end-user. Results from Van Passel and Meul (2011) show significant differences between these levels as tools which assess at sector and regional level are only used by policy makers. This does however not show from our preliminary data results and many tools have multiple assessment levels, serving both the policy maker as well as the farmer (e.g. COSA indicators, NZSD, FAO-SAFA, SMART). These tools also have different purposes, ranging from firm development to research. These observations should be further investigated. Why do so many tools claim at serving both end-users and are these tools really used by both end-users? What does assessing at firm, sector or regional level mean for these tools? How do they fulfil these purposes and what methods do they use?

In any way, we need to gain more insight into the differences between these tools. If we do need different tools for farmers and policy makers, is it necessary or feasible to align data collection and therefore make the assessment more efficient? If there are tools the results of which can be used by both the farmer and policy maker, how are these results presented and used? Is interpretation of the results more difficult if it needs to serve both the farmer and the policy maker?

Conclusion

Questions arise on how to navigate between sustainability assessment tools. What are their key characteristics and how can one select the most appropriate for one's purpose? This research resulted in a list of 25 essential characteristics to discern tools and metrics. These characteristics were grouped according to general assessment related information, information related to stakeholder participation and indicators related information. It is a first starting point to guide tool selection as more insight is gained when analysing tools according to the characteristics. Furthermore, we divided a number of tools and metrics based on the purpose of the assessment, its level and the end-user. This preliminary result showed that a number of tools can be used by farmers and policy makers, used at different levels and for different purposes. However, these results pose new questions for future research. What is the difference between tools designed for a farmer or a policy maker? Do they use the same data source and how does data collection work? Are results presented in a different way and how do these end-users use the results in decision making?

Table 2. Initiatives divided by primary purpose, end-user and level of assessment

		FARMER	POLICY
REPORTING	**Firm Level**	COSA Indicators FAO-SAFA FLINT FtoM GRI INSPIA LEAF-SFR NZSD SAI-FSA2.0 SMART SPA	COSA Indicators FAO-SAFA FLINT GRI NZSD SMART
	Sector Level	COSA Indicators FAO-SAFA NZSD SMART	COSA Indicators FAO-SAFA FLINT NZSD SMART
	Regional Level	NZSD	FLINT NZSD
FIRM DEVELOPMENT	**Firm Level**	BJCD BRP COSA Indicators DEXiFruits DEXiPM EISA FAO-SAFA INSPIA KSNL LEAF-SFR MESMIS MOTIFS NZSD ORC-FAS RISE SAI-FSA2.0 SAN-SAS ScalA SMART Veldleeuwerik	BJCD COSA Indicators DEXiPM FAO-SAFA NZSD ScalA SMART
	Sector Level	COSA Indicators FAO-SAFA NZSD	COSA Indicators FAO-SAFA NZSD

		SMART	SMART
	Regional Level	MESMIS NZSD	NZSD
COMMUNICATION	**Firm Level**	FAO-SAFA INSPIA KSNL LEAF-SFR MOTIFS RISE SAI-FSA2.0 SMART	FAO-SAFA FLINT SMART
	Sector Level	FAO-SAFA SMART	FAO-SAFA SMART
	Regional Level	FoPIA	FoPIA
RESEARCH	**Firm Level**	COSA Indicators DEXiPM MESMIS SMART	COSA Indicators DEXiPM FLINT SEAMLESS SMART SVA
	Sector Level	COSA Indicators SMART	COSA Indicators FLINT SMART
	Regional Level	FoPIA MESMIS	FLINT FoPIA SEAMLESS TOA-MD 5.0 model
CERTIFICATION	**Farm Level**	GlobalGAP KSNL LEAF-Marque SAN-SAS	
	Sector Level		
	Regional Level		

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TempAg: an international research consortium for sustainable agriculture in temperate regions

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Abstract: TempAg is an international research network for national governments involved in agricultural research in temperate climates comprising ten countries. The aim of the network is to deliver resilient agricultural production systems at multiple levels. This includes specific focus on: i) optimising land management to produce food and other ecosystem services at the landscape level; and ii) sustainable food production at the farm/enterprise level. The consortium has launched three pilot activities to start its ambitious programme. These are: i) a survey of experts and the literature to identify concepts of sustainability, how it is currently measured and which indicators are important; ii) a stocktaking exercise to overview ecosystem services to and from different agricultural production systems and in different scales; and iii) a modelling exercise to identify the reasons for yield gaps (i.e. actual farmers' yields as opposed to potential yields under optimal management) and determine ways in which these might be closed. Initial assessments show that over the last two decades a multitude of frameworks, metrics and tools have been developed to characterise agricultural sustainability. The majority of frameworks were focused at farm scale, largely for use for farm development with indicator scores being aggregated in many to produce an integrated sustainability assessment. It was noteworthy that almost all of the ISAs implemented by farmers were associated with a specific commercial or certification context. A separate study showed that there was no consensus among individual experts about what constitutes reliable knowledge and useable datasets, and thus how agricultural sustainability might best be measured or expressed by indicators. Assessments of ecosystem services is at an early stage but work to date indicates few studies where multiple services have been quantified simultaneously in agroecosystems. An expert-based survey of yield gaps indicated that nutrient management was the overriding factor that largely explained crop yield and yield gaps. In some countries environmental legislation is putting up barriers to the amount of nutrients that can be used, causing some degree of yield gap, while in other countries it is more an issue of lack of resources.

Keywords: TempAg, agricultural sustainability, agricultural production systems, land management, indicators of sustainability

Introduction

TempAg is an international research network for national governments involved in agricultural research in temperate climates. Following preliminary support by the OECD, the network was launched in April 2015. Membership is by country, with each national government represented by a lead organisation for that country. The membership on 1 June 2016 was Belgium, Finland, France, Germany, Netherlands, New Zealand, Norway, Sweden, Switzerland and United Kingdom, with the OECD as an associate member.

The network seeks to increase the impact and return on the investments that members make in their national research programmes. TempAg's activities aim to enable communication between, and coordination of, existing and new research and technology as well as identify areas of research relevant to scientists and policymakers alike that are currently not addressed at an international level. The overarching goal of the network is to deliver resilient agricultural production systems at multiple levels. This includes specific focus on: i) optimising land management to produce food and other ecosystem services at the landscape level; and ii) sustainable food production at the farm/enterprise level.

Temperate agricultural systems include a number of characteristics that distinguish them from tropical systems including: 1) seasonality, leading to well-defined operations and growing periods and seasonally-dependent pest and disease incidence (although some tropical areas may also share some such seasonal characteristics); 2) less weathered soils, with different fertility characteristics and slower soil organic matter dynamics; 3) substantial inputs of fertilisers, agrochemicals or mechanisation in different combinations; 4) substantial investment by the private sector favouring investment in "high-value" crops such as wheat, soya, oil seed rape (canola), maize (corn) and potato, and in improved grasslands; and 5) globally the highest yields (mainly due to 2, 3 and 4).

The consortium has launched three pilot activities to start its ambitious programme. These are: i) a survey of experts and the literature to identify concepts of sustainability, how it is currently measured and which indicators are important; ii) a stocktaking exercise to overview ecosystem services to and from different agricultural production systems and in different scales (including livestock and orchards as well as cropping systems); and iii) a modelling exercise to identify the reasons for yield gaps (i.e. actual farmers yields as opposed to potential yields under optimal management) and determine ways in which these might be closed.

In this paper we focus on the highlights of the on-going study of indicators of sustainability (see Wustenberghs et al., 2015 and de Olde et al., 2016 for full details) and briefly outline progress of the other two activities.

Indicators of sustainability

The question underlying this activity is 'How can sustainability frameworks, metrics and tools and their implementation be enhanced to futureproof agricultural decision-making at multiple levels on multiples scales?' Over the last two decades a multitude of frameworks, metrics and tools have been developed to characterise agricultural sustainability aimed at a variety of potential end users. TempAg has promoted activity to determine what methodologies are currently being used, how they came into being and the relations between assessment method and purpose.

Wustenberghs et al. (2015) assessed 170 different frameworks and found that 53 of them were specific to temperate agriculture with all 53 having social, economic and environmental components; some also incorporated either cultural or governance elements or both. An email survey of those who had developed the frameworks produced 38 responses from which it was possible to ascertain some common features of content and users. The majority of the respondents had developed frameworks that were focused at farm scale (70%), largely for use for farm development (59%). Most had end users involved from the start and, for those that did, the type of indicators included tended to be quite broad and small in number.

Typically, indicator scores were aggregated to produce an integrated sustainability assessment (ISA) with 41% of the ISAs using weighting of indicator scores before aggregation.

The ISAs produced had been implemented in several ways. Only 10% had definitely not been implemented (with an additional 10% where the outcome was unknown) with about one-third of those that had been implemented used only within the project for which they were developed. It was noteworthy that almost all of the ISAs implemented by farmers were associated with a specific commercial or certification context.

TempAg has also encouraged work that examines the motives and criteria underpinning the selection of indicators of sustainability (de Olde et al., 2016). As shown in the study by Wustenberghs et al. (2015), a large number of indicators has been proposed in the many frameworks for assessing sustainability raising questions about their validity and usefulness, and the trust that can be placed in them. De Olde et al. (2016) asked two groups of experts, comprising 38 respondents, to rank the relative importance of eleven criteria for selecting individual sustainability indicators and of nine criteria for balancing a collective set of indicators; agreement on such matters is important if the selection, weighting and aggregation of criteria is to gain widespread acceptance. The survey found no consensus among the individual experts about what constitutes reliable knowledge and useable datasets, and thus how agricultural sustainability might best be measured or expressed by indicators.

A conclusion of this work is that the transparency, relevance and robustness of sustainability assessments could be substantially improved if the context of the assessment and the prioritization of the selection criteria for indicators were more openly accounted for in, for example, a collaborative design process (de Olde et al., 2016). Such a process could start by recognising how sustainability is operationalised in different contexts, and at different scales and levels. Participation in the process by which indicators and sustainability assessment tools are established may prove a more important determinant of their success than the final shape of the assessment tools. Such an emphasis on process would make assessments more transparent, transformative and enduring.

Progress with ecosystem services and yield gaps

TempAg's two other pilot activities have focused on the multifunctionality of land use as expressed through assessments of ecosystem services, and on the assessment of yield gaps.

Ecosystem services

The ecosystem activity is reviewing: i) which ecosystems have been most studied, both those obtained from agriculture and those delivering services to agriculture; ii) what combinations of services have been studied together to address multi-functionality and synergies or trade-offs; and iii) which agri-ecosystems (e.g. grasslands, cereals) have been studied with an ecosystem approach. The work to date has largely involved data mining of the scientific literature.

Text analysis and a web search found 2,800 papers which had mentioned ecosystem services. From these 10% were selected, abstracts read, and papers classified into studies relevant and non-relevant to agriculture. Further analysis distinguished between those that implicitly assess ecosystem services based on broad scale indicators/proxies and those that contain quantitative measures of ecosystem services in agricultural studies and examine production functions; only a few papers were found to contain studies of production functions.

Preliminary analysis of the surveys to date indicates that the research community is fragmented with little communication between groups. Moreover, very few projects have analysed multiple ecosystem services; most studies have examined only one service, some have explored two or three services, while the maximum was 34. Most studies have assessed ecosystem services employing proxies for broad scale indicators. A large number of these proxies mention the importance of landscape, but only by proxy, rather than using a clear measure. Finally, making assessments using production functions is a topic that could lead to policy advice, but this approach is rare.

Yield gaps

This activity has been advanced through two complementary work packages: the first uses local crop, weather and soil data to model crop growth and yield and then scales up to a national level; the second has used a semi-quantitative survey that has been responded to by 11 countries.

The modelling activity has mainly been with cereal crops. The initial selection of data is often from locations based on hotspots of crop production which are then modelled and results verified at various local points and then again at national level. Work has been completed for several European countries and is being extended to Uruguay, USA, Ukraine and Australia.

The purpose of the survey was to explain crop yields, crop yield gaps and, to a certain extent, resource use efficiency, examining factors that directly influence crop yields and crop management factors combined with physical conditions such as soil and climate. The semi-quantitative survey received assessments for 17 wheat, 13 barley and 8 maize crops. The detailed results can be found in López Porrero (2016), but crop management was regarded as the most important factor to explain yields that were less than the potential yield. Nutrient management was the overriding factor that largely explained crop yield and yield gaps. In some countries environmental legislation is putting up barriers to the amount of nutrients that can be used, causing some degree of yield gap, while in other countries it is more an issue of lack of resources.

Concluding remarks

The work of all three activities is ongoing and will be added to following a stakeholder workshop planned for October 2016 in London. Current plans include: 1) exploration of how the topic of integration and normalisation of sustainability indicators used by different stakeholders might fit with the other two activities; 2) tabulation of which ecosystem services have been studied together in agroecosystems followed by examination of trade-offs, synergies and clusters. There will be consideration of ecosystem disservices and how they should be treated together with how human inputs might best be related to ecosystem services in agriculture; and 3) continued refinement of yield gap analysis by expansion to considerations of efficiency of resource use and technology gaps, based on a recently developed method, plus expansion of work on trade-off analysis for food production, yield gaps, resource use efficiency and environmental impacts. The latter will involve estimating resource use efficiencies not just for land and water but also for nutrients, greenhouse gasses, energy and labour.

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Discerning the stars: characterising the myriad of sustainability assessment methods

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Abstract: A myriad of sustainability assessment (SA) frameworks, metrics and tools have been developed. As the TempAg network aims to deliver resilient agricultural production systems, *inter alia* by comparing their sustainability performance, the first step was to identify currently used SAs and discern their characteristics. Therefore, from an SA inventory, integrated sustainability assessment (ISA) methods (assessing multiple dimensions) for agriculture were selected for an in-depth survey with the ISA methods' developers or users. A large variation in ISAs was found. Strictly reductionist representations were rare, but holistic ones ranged from less than ten to hundreds of indicators. Next to farm development, other (combinations of) purposes were found: a wide range of end-users; a spectrum of data collection, processing and scoring methods; and variate methods to combine indicators into an ISA. Stakeholder involvement in ISA development was found to be common practice, especially in the early phases, defining the sustainability framework and selecting the indicators. This first pilot activity shed some light on the complexity of ISA methods and the variability in their characteristics. Further research may reveal how they can be sufficiently enhanced to futureproof agricultural decision making.

Keywords: Integrated sustainability assessment, developers' survey, characteristics analysis

Introduction

What is "sustainable agriculture"? How is it perceived in different regions and contexts? How can agriculture's sustainability be assessed? In trying to answer these questions, a myriad of frameworks, metrics and tools have been developed. Assessments originated top-down or bottom-up; with or without stakeholder involvement; aiming at farm development, food certification, policy evaluation, global reporting, etc. For TempAg, an international research consortium for sustainable agriculture in temperate regions (Gregory & Kougioumoutzi, 2016), one of the aims is to deliver resilient agricultural production systems, *inter alia* by comparing their sustainability performance. Therefore, the first step was getting to grips with the currently used sustainability assessment frameworks, metrics and tools, how they originated and how different purposes resulted in different methods. This paper reports on TempAg's Pilot Activity 1.1.1, in which efforts for assessing sustainability in temperate (non-tropical) countries were surveyed.

Material and Methods

Inventory of sustainability frameworks, metrics & tools

In 2001 Riley noticed an "explosion" of indicators for agroecosystems, sustainable land management, biodiversity, social development, rural livelihoods, natural resources conservation, etc. Nowadays many of these indicators are used in more holistic frameworks, integrating several or all of the aspects mentioned. However, the universe of frameworks, metrics and tools for sustainability assessment is ever-expanding (Pope et al., 2013; Schindler, 2015). Any attempt at an assessment inventory can therefore at best be comprehensive, but not exhaustive.

For this pilot activity we could elaborate on earlier compilations of frameworks, metrics and tools, such as the ones made for the SAFA framework (FAO, 2013), by the TempAg network and by ILVO (Marchand et al., 2014). These inventories were complemented through study of peer reviewed, grey and internet literature. The inventory currently contains about 170 sustainability frameworks, metrics and tools.

From this inventory, a selection was made for further evaluation. Frameworks, metrics and tools were included, if they were: (1) specific to agriculture or applicable with minor modifications; (2) developed in and/or applicable in temperate climates; (3) designed to assess sustainability. As sustainability is commonly seen to encompass at least three dimensions - economic, environmental and social sustainability (Brundtland, 1987; Schindler et al., 2015) - *integrated* sustainability assessment (ISA) methods, assessing at least these three dimensions were preferred. ISA methods were not specifically selected on their scope, level or scale, although emphasis was put somewhat more on farm level assessments. The selection revealed 51 ISA methods, from all over the world, with broad ranges of scopes, assessment levels and data gathering scales, which were subsequently surveyed.

Survey of assessment system characteristics

How does one navigate between the myriad of sustainability assessments? How can one find the way to the right tool for one's purpose? Are there any dots and lines to make up a map? In other words: what are the key characteristics to describe frameworks, metrics and tools that may facilitate choice? The review of characteristics proposed to discern ISA methods is discussed by Coteur et al. (2016). They selected 25 essential characteristics, which provided the basis for a survey on: (1) the general ISA characteristics; (2) stakeholder participation in ISA development; and (3) the use of indicators in ISAs.

Qualtrics Research Suite was used to build a web-based questionnaire. E-mails were sent out to the ISA's developers or users, inviting them to take part and providing them with a questionnaire link. Information on 38 ISAs was retrieved, i.e. a 75% response rate. We feel confident that this sample is representative of the selected ISAs, that no specific ISA type or origin was left unsurveyed and that non-response was sufficiently random.

The survey responses were first analysed descriptively per characteristic. Second, relations between the characteristics were sought. For the continuous variables Pearson correlation coefficients were calculated. In the survey, however, most of the questions had multiple nominal categorical answering possibilities. These categories were converted to dichotomous variables (an option is used yes/no). Associations between these variables were determined by calculating tetrachoric correlation coefficients in SAS 9.4 software. The tetrachoric correlation - that rests on the assumption of underlying normally distributed variables (Bonnet & Price, 2005) - was preferred to the phi-coefficient - the linear correlation between underlying inherent dichotomous distributions (Chedzoy, 2006) - because of the calculation ease for many variables at once. Since Ekström (2011) ascertained a continuous bijection between both association measures, the underlying joint distribution should not have a substantial impact on the conclusions drawn from the analysis.

Results

Descriptive analysis of assessment characteristics

Of the 38 ISA methods for which the survey was filled out 20 were developed in western Europe and 14 at the international level. Only 3 originated from North and Central America and 1 from New Zealand. The distribution in the responses reflects the origins in the inventory, in which ISAs from Eastern Europe, Asia, Africa and South America are scarce or even lacking.

General assessment characteristics

The survey results are discussed below per ISA characteristic.

- ***Scope of the assessment***: 31 (80 %) of the surveyed frameworks, metrics and tools assess at least 3 sustainability dimension. Almost all methods assess the economic, environmental and social dimensions, 10 ISAs also assess the governance dimension. Other assessment dimensions mentioned include culture ("way of life"), plant cultural practices, animal welfare, entrepreneurship, innovations, multifunctionality and services.

- ***Perspective on sustainability***: only a minority of ISAs (7) look at sustainability from a societal point of view, 16 take the farm's perspective. Most respondents ticking "other", indicate that their ISA takes mixed points of view, e.g. "both societal and farm", "farm and regional", "societal and distributer and farmer". Also the "value chain" perspective is mentioned.

- ***Primary purpose of the assessment***: reflecting our ISA selection criteria, farm development is the primary purpose (intended function) of almost 2/3rd of the ISAs. Research, reporting and communication are each mentioned for almost 1/3rd of the ISAs. For over half of the ISA's multiple purposes were reported.

- ***Level of assessment***: even more than farm development is a main primary purpose, the farm is the main level of assessment (26 ISAs). Indeed, purposes such as identifying good practices, management optimisation or thinking and talking about sustainability are also supported by farm level methods. Field, chain, landscape and national/regional level are only mentioned for 8, 7, 5 and 5 ISAs respectively. For 27 ISAs (73%) only one assessment level is reported.

- ***Sector scope***: the majority of the ISAs are general, they can assess all farm types. Some are developed and/or mainly used in specific farm/production types, e.g. DEXiFruits, Ben & Jerry's Caring Dairy. Some ISAs consider more than farming, e.g. also forestry and fisheries (e.g. GlobalGAP, SAFA) or also processing of agricultural commodities (e.g. Field to Market).

- ***System representation***: only 2 respondents (5%) claim that their ISA represents the agricultural system in a reductionist way, i.e. *"few indicators are used to assess the sustainability of a whole system"* (MESMIS and Sustainable Value Added); half of the respondents (51%) state a holistic representation, "reflecting the complexity of a system by using many divers indicators"; and 43% state a combination of both, including the 3

ISAs that use only 8 indicators. As the economic dimension is handled in a more reductionist way than the environmental dimension, many ISA methods indeed use a "combination" of representations.

- ***Applying users***: people carrying out the assessments are quite diverse. In 18 ISAs researchers are still involved in the implementation. Almost as important are farmers and extension workers (advisors, consultants). 17 respondents report that the assessment is a joint effort by several people with different functions e.g. farmer + advisor. Other applying users mentioned are NGO's or supply chain actors.

- ***End-users***: individual farmers are the end-uses of the result of 3/4rs of the ISAs. The results of 1/2 of the ISAs can also be used in farmers' discussion groups. Only 3 respondents claim their ISA has a single type of user, for all other ISAs multiple end-users are foreseen (up to 8 types for the GRI G4 Sustainability Reporting Guidelines). Other end-users mentioned are students, policy makers, civil society, capital providers, operators in the supply chain, retailers, consumers, etc.

- ***Time needed for data collection***: for only 5 ISA methods it takes less than 2 hours to collect the necessary data. For 14 ISAs data collection takes 2 to 4 hours (half a day), but for 12 ISAs it takes 2 days or more.

- ***Data collection methods****:* interviews and self-assessments are both used in over half of the ISAs. Audits are used in 7 ISAs. Other methods include field measurements, animal welfare appraisal by vets, focus group discussions, surveys, public data, literature, etc. 17 ISAs use only one method, 20 use combinations of methods.

- ***Indicator aggregation and weighting***: 2/3rd of the respondents indicate that the indicator scores in their ISA are aggregated (Figure 1). Aggregation methods such as multi-criteria analysis, average scores per theme, simple sums and weighted sums are used. From the 22 ISAs that apply indicator aggregation, 15 weight the indicator scores before aggregation and again a variety of methods is described. A few methods leave the weights open, to be determined *ad hoc* by different users.

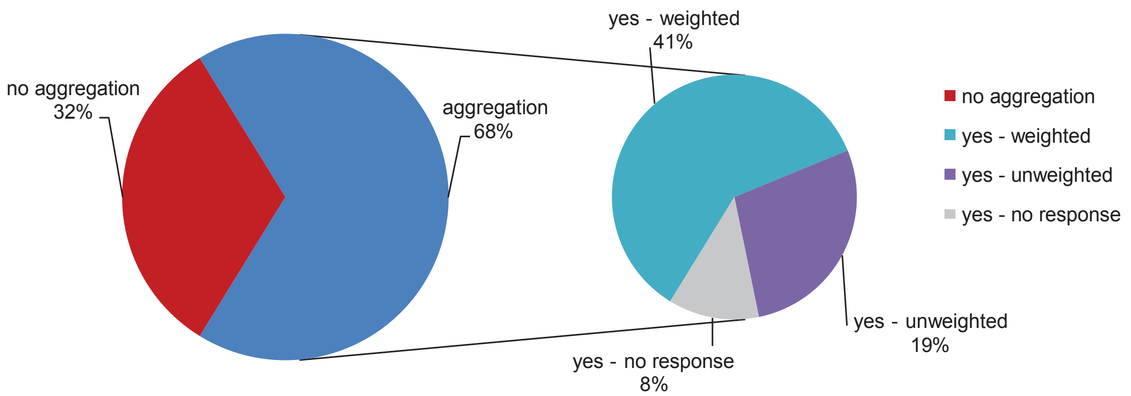

Figure 1. Aggregation of indicators scores and weighting in case of aggregation

- ***Transparency***: only 2 respondents state that no background documents are available about their ISA. Otherwise the ISA transparency seems quite well insured: for

10 ISAs documents are available on 5 topics, for 13 ISAs background documents are even available for all 6 topics mentioned in the survey.

- ***Implementation**:* "is the assessment being implemented?" was answered by 34 respondents, of which 30 said "yes". 23 ISA's were implemented, of which 10 were implemented only on the project basis, which might indicate that for 1/3rd of the ISAs implementation never went beyond the project where they were developed (yet). For the ISAs that are used by farmers, the respondents almost always indicate a combination with commercial use or certification use. Only 3 ISAs are implemented for farmers' private use only, outside a commercial/certification context. All 3 are linked to implementation on project basis.

Stakeholder involvement

Binder et al. (2010) defined 6 stages in ISA development and implementation:

1. *Preparatory phase:* defining context, goal and challenges (framework);
2. *Indicator selection:* choosing appropriate sustainability indicators, taking decisions on including interactions between indicators and weighting indicators;
3. *Indicator measurement*: quantifying indicators and processes (use of statistical data, surveys or categorised qualitative data);
4. *Aggregation of indicators:* deciding on whether or not to aggregate indicators, to what extent and how;
5. *Applicability* of the assessment results: getting the generated knowledge ready for utilisation in practice;
6. *Follow-up:* reporting results, developing management advice, monitoring over time.

We surveyed stakeholder involvement in each of these phases.

Stakeholder involvement was revealed to be common practice in the first two phases: in 94% of the ISAs, for which we received an answer, stakeholders played a part in defining the framework and in indicator selection. Stakeholder participation then falls back somewhat, but was in either phase still used in over 70% of the ISA methods. Focus groups are the most frequently employed methodology for stakeholder participation.

In all phases researchers are the most frequently involved stakeholders (Figure 2). In 2/3rd of the assessment methods, farmers were involved in the preparatory phase. Their involvement deceases as the development progresses, but reaches 2/3rd again in the last 2 phases. Extension workers (advisors) mainly intervene in the 3rd and 6th phase, i.e. in indicator quantification and in follow-up/implementation. If involved, civil society (including NGOs) and policy makers mainly intervene in the early phases. Other stakeholders consulted are food chain and retail representatives.

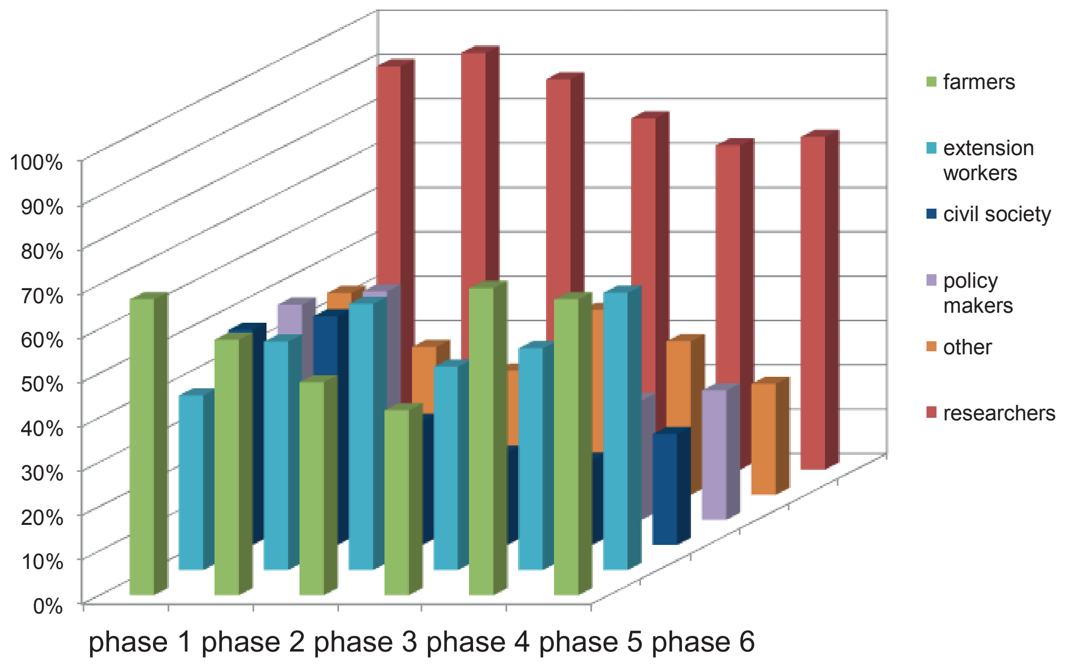

Figure 2. Percentage of ISAs in the survey in which different types of stakeholders are involved in each of the 6 phases of ISA development and implementation.

Indicator related information

33 out of 38 respondents answered "yes" to the question whether indicator related information is available (2 answered “no”, 3 did not respond). Only if this question was answered in the affirmative, and respondents had stated before that a particular sustainability dimension is assessed in their ISA, were they shown the subsequent questions on the indicators in each dimension. The following analysis is thus based on a variable amount of responses (Table 1 and Table 2).

- ***Numbers of themes and indicators per sustainability dimension:*** a large variation is reported in the numbers of themes used to describe each sustainability dimension, from only 1 to 25 (Table 1). The number of indicators shows even more variation, from only 1 economic indicator in the OCIS Public Goods Tool, up to 300 social indicators in OXFAM’s Behind the Brands Scorecard. The smallest total numbers of indicators are used in the Fieldprint Calculator, the SAI Sustainability Performance Assessment, the TOA-MD 5.0 model (8 indicators each) and the Farm Route Planner (10 indicators). At the other end of the spectrum, 700 indicators make up the Sustainability Monitoring and Assessment RouTine (150 economic, 200 environmental, 200 social and 150 governance indicators). The majority of ISAs use more themes and more indicators to describe the environmental dimension than to describe the economic and social dimensions. The numbers of themes per dimension are quite well correlated and the number of indicators are extremely well correlated (Table 4).

- ***Indicator types:*** for the economic and environmental dimensions mainly quantitative indicators are used, or a mix of quantitative and qualitative indicators. For the social dimension only few methods exclusively use quantitative indicators, for the governance dimension none do (Table 2).

Table 1. Numbers of themes and indicators per dimension in the ISAs in the survey

	Dimension	Economic	Environmental	Social	Governance	Total ISA
	N responses	25	28	25	7	29
Themes	median	**4**	**6**	**3**	**5**	**15**
	min	1	3	2	1	5
	max	19	18	25	14	198
Indicators	median	**9**	**22.5**	**18**	**19**	**64**
	min	1	5	2	1	8
	max	150	200	300	150	700

Table 2. Indicator types used per sustainability dimension in the ISAs in the survey

Dimension	Economic	Environmental	Social	Governance
N responses	28	31	28	8
Primarily quantitative	50%	52%	14%	0%
Primarily qualitative	21%	19%	36%	38%
Equally quantitative and qualitative	29%	29%	50%	63%

- ***Level of data input***: for all dimensions the farm and the farmer are the main levels of data input. The field, product or region levels are less prevalent in the surveyed ISAs. Other levels mentioned include the supply chain, community, a mix of levels for the environmental dimension and the farm family for the social dimension.

- ***Data sources***: farmers' knowledge is the data source most tapped into by ISAs: in 75% of the methods and for all sustainability dimensions. The accountancy is a source for economic data in 60% of the methods, but also for environmental, social and governance data it is still used quite frequently. About half of the methods also need expert information. Field and site practices obviously are mainly used for economic and environmental indicators. Other data sources mentioned for the economic dimension are literature and modelling; for the environmental dimension, expert systems; for the social dimension, the community, regional sources, household survey, survey with farm workers; and for the governance dimension, local policies.

- ***Indicator scoring***: for the economic and environmental indicators, scoring systems based on benchmarks are most used (75 and 85% respectively). Expert based monitoring becomes more important for the social and especially for the governance indicators. Several respondents report a mix of scoring systems within one dimension.

- ***Reliability of data input and indicator validation***: here non-response rates range from 18% for the economic dimension to 37% for governance. Do respondents feel this is sensitive information and thus are reluctant to answer? Or were "reliability" and "validation" insufficiently explained? The share of respondents stating that data input for all indicators is reliable is smallest for the social dimension. None of the respondents indicate that the data input for the economic indicators is doubtful. One does so for the environmental and 5 for the social indicators. Potential causes might be related to the data sources or the more qualitative nature of the social and governance indicators. If so, are these indicators less reliable *per se* or do the ISA developers/users feel less comfortable with qualitative indicators? About 2/3rd of the respondents state that the economic and environmental indicators in their ISA methods are validated. Only about 1/3rd does so for the social and governance indicators. Validation methods include resource data validated in previous studies, comparison with other methods, peer review, checking results with experts (e.g. accountants in the case of the economic indicators) and participative group validation.

Relations between assessment characteristics

Correlations between numeric assessment characteristics

In the questionnaire a number of options were given for most general ISA characteristics. Many respondents ticked several options, indicating e.g. multiple primary purpose. The numbers of attributes per general assessment characteristic proved to be quite well correlated (Table 3). The number of primary purposes (intended functions), number of dimensions considered, number of assessment levels (spatial scales), number of applying users (carrying out the assessment), number of end-users (using the assessment results), and number of ISA components for which background documents are available, all proved positively correlated. The correlations are not very strong, but many of them are statistically (very) significant. ISAs with more purposes thus usually also consider more dimensions, are assessed on more assessment levels, are applied by more users, can serve more end-users and have more types of background documents available.

Table 3. Correlations between the numbers of attributes of the general ISA characteristics

	N° primary purposes	N° assessment levels	N° applying users	N° end users	N° types of background documents	N° phases with stakeholder involvement	N° stakeholder groups (median from 6 phases)	Implementation
N° dimensions considered	0.407 0.012	0.475 0.003	0.366 0.026	0.480 0.003	0.257 0.125	0.148 0.384	-0.121 0.488	0.258 0.141
N° primary purposes	1	0.419 0.010	0.363 0.027	0.291 0.081	0.279 0.095	0.251 0.133	-0.020 0.911	0.355 0.040
N° assessment levels		1	0.303 0.068	0.442 0.006	0.303 0.068	0.115 0.498	0.168 0.335	-0.012 0.944
N° applying users			1	0.545 0.001	0.274 0.101	0.320 0.053	0.082 0.640	0.131 0.460
N° end users				1	0.427 0.008	0.465 0.004	0.137 0.433	-0.139 0.433

N° types background docs					1	0.248 0.139	0.373 0.027	0.300 0.085
N° phases with stakeholders						1	0.126 0.471	0.102 0.565

Pearson Correlation Coefficients and Probability > |r| under H_0: Rho=0. Statistically significant correlations are highlighted for probabilities ≤ 0.01, ≤ 0.05 and ≤ 0.10 respectively.

Table 4. Correlations between the numbers of themes (above the diagonal) and the numbers of indicators (below the diagonal) per sustainability dimension

Themes / Indicators	Economic	Environmental	Social	Governance
Economic		0.2737 0.2178	0.1851 0.4218	0.4409 0.3221
Environmental	0.6142 0.0018		0.9759 < 0.0001	0.7413 0.0566
Social	0.9014 <0.0001	0.8077 <0.0001		0.7750 0.0407
Governance	0.9889 <0.0001	0.9817 <0.0001	0.9962 <0.0001	

Pearson Correlation Coefficients and Probability > |r| under H_0: Rho=0. Statistically significant correlations are highlighted for probabilities ≤ 0.01, ≤ 0.05 and ≤ 0.10 respectively.

ISA complexity

The correlations above point to some kind of continuum among the ISAs with increasing complexity. Marchand et al. (2014) proposed characteristics to discern the complexity of indicator based sustainability assessments at farm level. They observed a continuum between two extremes: the full sustainability assessment and the rapid sustainability assessment. Full SA tools make use of detailed farm data and/or expert information, need trained advisers and/or expert visits to gather the data, and are rather long and expensive in duration. Rapid SA tools represent the other side of the spectrum. They use farmer's knowledge or readily available data, allow an audit by the farmer or an adviser, and are relatively short in duration. Based on these observations, one might for our sample of ISAs expect a relation between the number of indicators in a sustainability dimension and the numbers of data sources, methods for data collection and levels of assessment. However, this relation could not be confirmed: no significant correlations were found between these numeric values.

In addition, between the total number of indicators in the assessment systems and the time needed for data collection, no relation was found (Figure 3). Some combinations seem quite logical, e.g. > 2 days to collect the 300 indicators for OXFAM's Behind the Brands Scorecard. Some combinations seem counterintuitive, but can be explained by the method of data collection. For DEXiFruit, for example, < 2 hours suffice to collect the data to calculate 175 indicators using existing databases complemented with expert knowledge. By contrast data collection for the TOA-MD 5.0 model takes > 2 days for 8 indicators, but the indicators need to be modelled. It's not so much the number of different data collection methods that seems to determine the duration of data collection, as the type of method.

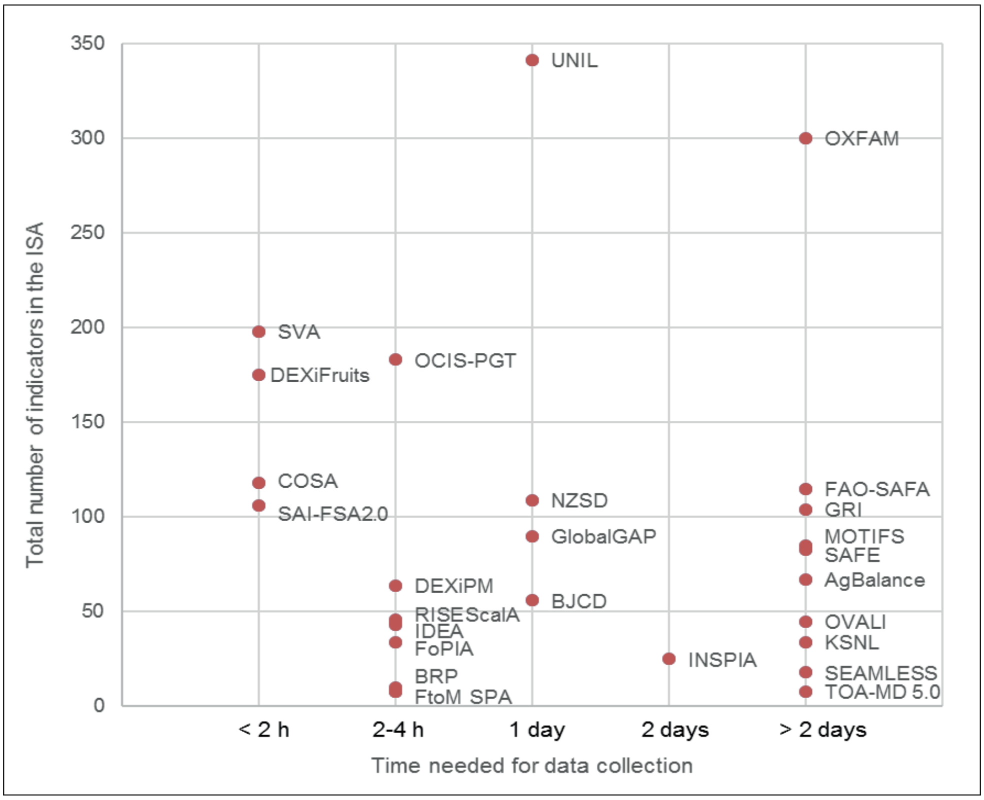

Figure 3. Time needed for data collection versus total number of indicators per ISA.

Associations with primary purpose and end-user

From the descriptive analysis it already became clear that not all ISAs cover all sustainability dimensions: some have a broader scope than others. The tetrachoric correlation analysis between the individual dichotomous ISA characteristics showed that the assessment scope is associated with both its primary purpose and its intended end-user. The primary purposes communication and farm development are strongly associated with the presence of an economic dimension (Table 5). On the contrary, the certification purpose is associated with the absence of an economic dimension. Farm development is also strongly associated with having an environmental dimension, while the other purposes are not. Regardless of the end-user of the ISAs the environmental dimension is most prevalent (tetrachoric correlation > 0.98 for all types of end-users) (Table 6). The economic dimension is most likely assessed if the end-users are policy makers, researchers or farmers in discussion groups. Individual farmers are not significantly associated with the economic dimension, probably because this dimension was significantly absent from certification systems and the individual farmer is an important end-user for those.

The social dimension is strongly associated with policy makers. The governance dimension is associated with research, policy makers and farmers in discussion groups.

Table 5. Associations of some general ISA characteristics with the primary purpose of the assessment

		Primary purpose									
		Reporting		Communication		Farm development		Research		Certification	
		Corre-lation	Pr > χ²	Corre-lation	Pr > χ²	Corre-lation	Pr > χ²	Corre-lation	Pr > χ²	Corre-lation	Pr > χ²
Assessment scope: dimensions	economic	-0,068	0,834	0,976	0,041	0,669	0,018	0,269	0,423	-0,576	0,090
	environm.	0,977	0,227	0,977	0,254	0,999	0,052	-0,262	0,537	0,920	0,492
	social	-0,310	0,367	0,971	0,101	0,491	0,138	0,082	0,824	0,973	0,324
	governance	0,352	0,252	0,121	0,709	0,431	0,172	0,068	0,834	-0,964	0,220
Assessment level: spatial scale	field	0,160	0,593	-0,981	0,016	0,058	0,843	0,394	0,169	-0,967	0,149
	farm	0,061	0,831	0,238	0,419	0,481	0,064	-0,548	0,036	0,973	0,082
	industry	0,999	0,001	0,357	0,298	0,982	0,034	0,310	0,367	-0,973	0,324
	chain	0,689	0,010	0,307	0,312	0,501	0,096	0,487	0,090	-0,965	0,181
	nat./regional	-0,185	0,597	-0,139	0,696	-0,592	0,052	0,475	0,128	-0,966	0,267
	landscape	-0,976	0,050	-0,139	0,696	-0,592	0,052	0,727	0,011	-0,966	0,267
	other	0,352	0,252	-0,976	0,041	-0,158	0,609	0,068	0,834	-0,964	0,220

Tetrachoric Correlation Coefficients and Probability > Chi Square under H_0: Rho=0. Statistically significant correlations are highlighted for probabilities ≤ 0.01, ≤ 0.05 and ≤ 0.10 respectively.

The associations of primary purpose with assessment level point to different spatial scales being assessed for different purposes (Table 5). The reporting purpose is strongly associated with industry-wide and chain level assessment, but the landscape level is absent. ISAs with a communication purpose do not use field level assessment (negative association). If the purpose is farm development, assessment can be performed at farm, industry or chain level, but not at landscape, regional or national level. The ISAs with a research purpose focus on landscape or chain level assessment, but not on the farm level. ISAs with a certification purpose, by contrast, are strongly associated with farm level assessment.

Concerning the end-users, the assessment level associated with individual farmers is the farm (Table 6). This is probably linked with the certification tools in the survey that have the farm as assessment level. The larger spatial levels - landscape, or national/regional - are not used for individual farmer's assessments. These level are rather associated with policy makers, who are also strongly associated with the industry wide level and with the chain level. They are not concerned with the farm or field assessment levels. Rather surprisingly, the extension worker (advisor) as end-user is strongly associated with the field and the whole industry assessment levels, not with the farm level.

Another interesting association is found between the individual farmer as end-user of the ISA results and the system representation. The association is negative for holistic ISAs (-0.507), but positive for combinations between holistic and reductionist representations (0.646, both significant). This indicates that reductionism is important when farmers use ISAs. This is consistent with Schindler et al. (2015), who argue that reductionist methods might facilitate the communication of complex and complicated information, but also risk losing sight of the complex and often characteristic picture of reality and of what is important at the local level. Sustainability assessment should thus allow some complexity, but above all provide sufficient stakeholder interaction to understand the local context and to elaborate indicators that fully represent the analysed system, while remaining useful.

Table 6. Associations of some general survey characteristics with the end-user of the assessment

		End user: who is using the results of the assessment?									
		Individual farmer		Farmer in discussion groups		Extension workers		Policy makers		Research	
		Corre-lation	Pr > χ^2	Corre-lation	Pr > χ^2	Corre-lation	Pr > χ^2	Corre-lation	Pr > χ^2	Corre-lation	Pr > χ^2
Assessment scope: dimensions	**economic**	0,179	0,585	0,571	0,055	0,125	0,692	0,987	0,008	0,604	0,039
	environm.	0,999	0,014	0,992	0,083	0,982	0,142	0,982	0,142	0,995	0,072
	social	0,012	0,974	0,020	0,954	-0,491	0,138	0,982	0,034	0,422	0,211
	governance	0,172	0,621	0,538	0,075	0,422	0,158	0,669	0,018	0,991	0,004
Assessment level: spatial scale	**field**	0,304	0,353	0,435	0,123	0,601	0,025	0,398	0,156	0,629	0,024
	farm	0,687	0,007	0,127	0,641	0,093	0,736	-0,108	0,693	-0,011	0,969
	industry	0,969	0,123	0,352	0,306	0,999	0,005	0,999	0,005	0,986	0,021
	chain	-0,092	0,774	0,102	0,733	0,289	0,325	0,520	0,065	0,571	0,050
	nat./regional	-0,570	0,064	-0,177	0,584	0,301	0,345	0,999	0,001	0,989	0,009
	landscape	-0,570	0,064	0,135	0,676	-0,009	0,979	0,592	0,052	0,421	0,194

Tetrachoric Correlation Coefficients and Probability > Chi Square under H_0: Rho=0. Statistically significant correlations are highlighted for probabilities ≤ 0.01, ≤ 0.05 and ≤ 0.10 respectively.

Stakeholder participation

Schindler et al. (2015) emphasise the importance of stakeholder involvement in ISA development. They recommend participation throughout all phases, from planning to final evaluation (see Stakeholder involvement section above). For the ISAs in our analysis, the number of phases with stakeholder involvement shows a significant positive correlation with the numbers of applying users and end-users (Table 3). Stakeholder participation throughout the development process is thus linked with more types of users. The correlation evidently does not show the causality of this relation. Developing an ISA method that envisages multiple users, might require more stakeholder involvement or inversely, if stakeholders are involved in more phases, they might be more willing to implement the ISA, as suggested by Binder et al. (2010), Triste et al. (2014) and others.

A negative correlation was found between the number of phases involving stakeholders and the number of environmental and social themes (- 0.573 and - 0.559 respectively). This could indicate that more frequent stakeholder involvement might help to restrain the number of themes being assessed or maybe just to cluster indicators in a smaller numbers of themes. The number of indicators was not significantly correlated.

Moreover, one could imagine that stakeholders with different backgrounds involved in the early phases of ISA development, might result in more diverse purposes or themes taken into consideration. This assumption, however, is not confirmed: no significant correlations were found between the the numbers of stakeholder categories and either of the general ISA characteristics, nor with the numbers of themes/indicators. The only exception is a 0.60 (very significant) correlation between the number of stakeholder categories in phase 5 and the number of applying users. Also, the number of end-users, the number of assessment levels and the number of background documents were all correlated with stakeholder involvement in phase 5 (0.49, 0.35 and 0.43 respectively). This emphasises the importance of diverse stakeholder participation in getting the ISA ready-for-use in practice.

The lack of association with stakeholder involvement was confirmed by the tetrachoric correlations with the individual ISA characteristic. This for instance showed that the intended end-users are not necessarily involved in the development. For ISA's used by individual farmers, farmer participation is only significantly positive in phase 5 (applicability). In phase 3 (indicator quantification) the association between the farmer as end-user and farmer participation is even more strongly and significantly negative. By contrast, extension workers and policy makers are involved in most development phases of ISAs for which they are the end-users.

Finally, we checked whether stakeholder involvement improved transparency in the sense of the number of background documents available. No correlation was found with the number of phases involving stakeholders, but the number of stakeholder groups was correlated significantly (although not very strongly) with documentation (Table 3). The aspects content, purpose, methodology, indicator scoring, indicator aggregation and interpretation of the results for which we asked about background documents roughly correspond with the 6 phases in ISA development. The associations between the individual types of documentation and the stakeholder types involved in the corresponding phase were rather disappointing though. Particularly farmers' participation and documentation availability show negative associations in all phases.

Implementation

ISAs seem to have a better chance of being implemented if they have multiple purposes and if more background documents are available: both show a rather weak, but significant correlation with implementation yes/no (Table 3). The total number of indicators and the time needed for data collection in contrast do not seem to influence implementation, as no correlation was found.

Detailed association analysis shows:

- Implementation on project basis is associated with "other" purposes than the ones listed in the survey (consultancy, teaching, impact assessment and policy support were mentioned); various applying users (extension worker, researcher, civil servant, others except auditors); researchers or policy makers as end-users; and a wide availability of background documents;
- Commercial implementation is associated with the reporting purpose (+ 0.68), not with research (- 0.66); assessment at farm or industry-wide level, not landscape level (- 0,98);

  "other" end-users, such as "businesses, investors and banks" or "supply chain operators: food companies, retail, … up to consumers";
- Certification obviously is associated with the certification purpose, but not research (the opposite of implementation on project basis); the farm as assessment level; auditors and sometimes farmers as applying users; farmers as end-users, as well as others (buyers);
- Use by farmers is associated with farm-level assessment; civil servants as applying users; "other" users, as for most of the commercial or certification ISAs also "used by farmers" was ticked as implementation type. Surprisingly, it is NOT associated

with farm development as a primary purpose; nor with the farmer as end-user of the ISA.

Participation by few stakeholder groups showed significant association with implementation as such. However, farmer participation was rather positively associated with most types of implementation, particularly with certification and use by farmers.

Preliminary conclusion

The survey of integrated sustainability assessment methods reached a 75% response rate and resulted in an abundance of data on the ISA methods' characteristics, revealing a large variation between the ISAs in the survey. Strictly reductionist representations were rare, but holistic ones ranged from less than ten to hundreds of indicators. Next to farm development, other (combinations of) purposes were found: a wide range of end-users; a spectrum of data collection, processing and scoring methods; and variate methods to combine indicators into an ISA. Stakeholder involvement in ISA development was found to be common practice, especially in the early phases, defining the sustainability framework and selecting the indicators.

Correlation analysis revealed many associations between the ISA characteristics. However, the amount of detail explored by the tetrachoric correlations also resulted in an explosion of association measures, which hinders detection of the interesting ones. These associations cannot thus suffice to discern between the myriad of ISA methods. Further research is needed, starting with cluster analysis of ISA methods and their characteristics. It may also be interesting to expand the quantitative research with qualitative research, e.g. in-depth interviews with ISA developers, to grasp the full extent of reasoning behind ISA methods and the difficulties in their implementation. Thus decisive conclusions may be reached on *how sustainability frameworks, metrics and tools and their implementation can be enhanced to futureproof agricultural decision making at multiple levels and multiple scales*. For now, this first pilot activity managed to shed some light on the complexity of ISA methods and the variability in their characteristics.

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Defining and assessing the sustainability of Swedish agriculture by public agencies

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Abstract: The purpose of this paper is to present an analysis of how ‘sustainable agriculture’ is defined and assessed by Swedish public agencies. Through a content analysis of key policy documents and web communications addressing farm sustainability in Sweden and interviews with agency officials, the use of the concept of sustainable agriculture is analysed. The analysis shows that Swedish public agencies deal with many aspects of what can be considered part of the concept of ‘sustainable agriculture’. However, the term is not explicitly defined by the agencies but rather filled with meaning according to relevance in different situations on an ad hoc basis. The economic pillar is often given priority by the agency with the main responsibility for agricultural sustainability, the Swedish Board of Agriculture. No integrated sustainability assessment frameworks (SAF) including all sustainability pillars are used by Swedish authorities. Environmental issues are structured into a cross-sector system of environmental quality objectives of which different agencies have responsibility. More ways to measure sustainability at the national level was not deemed necessary by agency officials. Potentially SAFs could be useful for more structured discussions on which sustainability themes to include in different situations and for assessing the sustainability of individual Swedish farms for marketing purposes.

Keywords: Sustainability assessment, national agricultural policy, Sweden, public agencies

Introduction

Background

The need to make agricultural production more sustainable has increased in importance in agricultural policy as well as in the public discourse in Europe during the past decades. This can be seen in increasing consumer interest in organic and locally produced food, in the recent ‘greening of the CAP’, and in the numerous tools that have been developed aiming to facilitate the assessment of farm-level sustainability with the ultimate goal of influencing farmers to more sustainable farming practices (Carof et al., 2013; Marchand et al., 2014; Schader et al., 2014). In Sweden in particular, this interest has been manifested in many ways, including a boom in sales of organic foods and the initiation of the development of a national food strategy by the Minister of Rural Affairs which will to be presented during the spring of 2016. Sweden in general has high ambitions when it comes to environmental sustainability, for example it is one of few countries that has introduced a carbon tax on energy. This tax, together with other policies and access to both bioenergy from forests, nuclear and hydro power, has led to the decarbonisation of the energy system. Focus has then turned to food systems with a recent increased interest in more sustainable eating habits and farming practices. Some actors, including some farmers and farmers’ organisations, fear that this attention and the stronger environmental policy actions that it might lead to might negatively affect farmers’ profitability which is already under stress.

Despite this rising interest in farming and food systems at many levels and from many angles, there is clearly no consensus about what sustainable agriculture means or how it should be reached. However, as in the case of EU farming, farmers' decisions and actions towards sustainability are to a large extent governed by regulations and subsidies emanating from the comprehensive Common Agricultural Policy (CAP) (Serra & Duncan, 2016). Such subsidy systems and regulations following from CAP are implemented by government agencies in each member state, in Sweden by the Swedish Board of Agriculture. Although Swedish agriculture is governed by CAP on an over-arching level, several national policies and regulations also influence the agricultural sector and food production in Sweden, including environmental policies.

In the shifting emphasis of the CAP towards further 'greening' of agriculture, national government agencies such as the Swedish Board of Agriculture will have to take up the challenge to, in practice, steer farmers towards this increased greening while at the same time ensuring farm economic and social viability. We think that the sustainability assessments for agriculture that have emerged from the research community in recent years might be used for facilitating the work of agencies like the Swedish Board of Agriculture. The assessments could potentially be helpful in suggesting which themes should be enhanced for a more sustainable agricultural production, provide methods and tools facilitating the assessment of agricultural sustainability and provide support in handling goal conflicts between different sustainability impacts. To be able to take on this role, a framework developed without a specific national context in mind might however have to be developed, and to be able to do this better knowledge about how sustainability issues are currently framed and addressed by relevant national agencies is helpful. Thus as a first step towards facilitating such a process we aim in this paper to provide a better understanding of how the Swedish agencies currently frame and work with sustainability.

Aim

The purpose of this paper is to present an analysis of how 'sustainable agriculture' is defined and assessed by Swedish public agencies. Through a content analysis of key policy documents and web communications addressing farm sustainability in Sweden and interviews with agency officials, the framing and use of the concept of sustainable agriculture is analysed.

Swedish agriculture and its governance

Swedish agriculture

Arable land (2.7 million ha) occupies 6.5% of total land in Sweden, while the rest is dominated by forest (approximately 50%), marsh and moorland, mountains and lakes (approximately 33%) (SBA, 2009). Semi-natural pastures and meadows occupy 1% of the land, but the area is steadily decreasing due to a decline in grazing animals and production intensification (SBA, 2013a). Many of Sweden's red-listed species can be found in its semi-natural pastures and therefore preserving these pastures is one of Sweden's most important environmental goals (SEPA, 2015).

The geographical location of Sweden makes agriculture challenging in the north of the country, where grass/clover leys and barley are the most common crops. Southern Sweden is characterised by plains and cereal production and is also where most pig and poultry production takes place, whereas most cattle farms are located in plains and forest districts in central and southern Sweden (SBA, 2015b). The number of farms has decreased rapidly during the last 50 years and farms have become larger and more specialised in e.g. cereals, dairy or broiler production. This is due to increasing difficulties to ensure profit as a result of for instance increased competition with farmers in other EU-member states, a relatively short growing season and relatively strict regulations for environmental protection, animal welfare and labour costs, Out of total employment, approximately 1.5% of the Swedish labour force is employed in agriculture in Sweden (SBA, 2015b). Most farms are family businesses and one third of farms combine farming with other activities such as contracting, forestry or tourism.

The reliance on domestic food supply in Sweden is approximately 50% for beef, 65% for pork and poultry, 90% for dairy, 100% for cereals and 20% for fruit and vegetables (NFA, 2011; SBA, 2013b, 2013c). Sweden's main agricultural export products are cereals, beverages and processed foods; the export value is approximately half of the value of imported products. EU is the main market for both imports and exports (SBA, 2009).

The value of production was 51 billion Swedish Crowns (5.7 billion Euros) in 2014 which corresponds to approximately 0.5% of Swedish GDP (SS, 2016). Approximately half came from crop production, most importantly cereals, and half from livestock production, of which approximately half was associated with dairy production (SS, 2016). Livestock production, in recent years most predominately dairy production, is struggling with profitability due to fierce competition on the European and global market, while cereal production on the plains has shown more stable economic results.

Governance of Swedish agriculture

Like many other countries in Western Europe, Sweden implemented price support and import taxes to protect domestic agriculture after the economic crises of the 1930s. In 1947 three overall targets were established by the Swedish parliament. The first, the production target, aimed at total self-sufficiency of food. The second goal, the efficiency target, aimed at increasing efficiency in agriculture in order to produce competitive food. The third target, the income objective, meant that farmers' incomes would be on a par with the wages of industry workers. These objectives were to be achieved through price controls and a state-led rationalisation of the agricultural sector i.e. merging of small farms into larger and more rational units (Slätmo, 2014).

During the 1980s, however, concerns were raised as regards the support systems' effect on the Swedish economy and in 1983 all subsidies for agricultural products except for milk were abandoned. In 1989 it was decided that the agricultural sector should be completely deregulated and prices of products should instead be governed by consumer demand. The new agricultural policy also drew attention to the environmental problems caused by intensive use of fertilisers and pesticides and monoculture farming. This was a reason why payments for more extensive production systems were introduced in 1986 and 1990 (Slätmo, 2014).

However, Swedish agriculture experienced a very short period of deregulation and never had time to change as a consequence of this, as Sweden joined the EU in 1995 (Rabinowicz, 2003). As a EU member Swedish agriculture is governed by the EU CAP mainly through the Single Farm Payment (support based on area cultivated and not considering what is produced) and Rural Development Policy (sustainable development in the countryside) (SBA, 2011).

CAP, through its translation into various subsidy systems and regulations has the overall focus of balancing reasonable consumer prices of food with farmers working standard and environmental sustainability, while at the same time avoiding having a distorting impact on trade with countries outside EU. Like the Swedish turn in the 1980s described above, since the 1980s CAP has also shifted towards more emphasis on supporting aspects of environmental sustainability. This has been re-emphasised with the recent 2015 CAP reform in which the emphasis on environmental sustainability of farming has increased further (EU, 2016).

In its application of the CAP, the Swedish Government further specifies that its goal within the area is to:

"…promote sustainable fisheries, animal welfare, good animal health, a market-oriented, competitive agriculture as well as availability of safe and wholesome food." (GOS, 2016b). Further, the Swedish Government has the following goal for the green sector: *"the green industry to be viable, drive innovation and contribute to climate adaptation and that natural resources are used sustainably."* (GOS, 2016c).

The Swedish Board of Agriculture (SBA) is the agency assigned to implement the CAP in Sweden and any additional policy that the government decides to introduce in agriculture. Instructions for this work are issued yearly in a directive from the government to the agency (ESV, 2016).

Turning to environmental policy, Sweden has organised this into a set of environmental quality objectives (EQO) (SEPA, 2015). The overarching goal, the 'generational goal', is to hand over to the next generation a society in which the major environmental problems in Sweden have been solved, without increasing environmental and health problems outside Sweden's borders. Sixteen EQOs (Table 1), which describe the desired state of the Swedish environment, have been adopted by the Swedish parliament. These objectives are to be met within one generation, *i.e.* by 2020 (2050 in the case of the climate objective). Different government agencies are responsible for following up and evaluating specific EQO and reporting on progress towards the objectives on an annual basis.

Table 1. Swedish environmental quality objectives.

Environmental quality objective	**Responsible agency**	**Covered in the report 'Sustainability in Swedish Agriculture 2012' as:**
1. Reduced Climate Impact	SEPA	Covered under the heading *Greenhouse gases*
2. Clean Air	SEPA	Not covered
3. Natural Acidification Only	SEPA	Included under the heading *Nutrients and eutrophication*
4. A Non-Toxic Environment	Swedish Chemicals Agency	Covered under the heading *Plant protection*
5. A Protective Ozone Layer	SEPA	Not covered
6. A Safe Radiation Environment	Swedish Radiation Safety Authority	Not covered

7. Zero Eutrophication	Swedish Agency for Marine and Water Management	Included under the heading *Nutrients and eutrophication*
8. Flourishing Lakes and Streams	Swedish Agency for Marine and Water Management	Included under the heading *Nutrients and eutrophication*
9. Good-Quality Groundwater	The Geological Survey of Sweden	Included under the heading *Nutrients and eutrophication*
10. A Balanced Marine Environment, Flourishing Coastal Areas and Archipelagos	Swedish Agency for Marine and Water Management	Not covered
11. Thriving Wetlands	SEPA	Covered under the heading *Cultural landscape and biodiversity*
12. Sustainable Forests	Swedish Forest Agency	Not covered
13. A Varied Agricultural Landscape	SBA	Covered under the headings *Soil fertility, Genetic engineering, Cultural landscape and biodiversity, Renewable energy, Organic production*
14. A Magnificent Mountain Landscape	SEPA	Not covered
15. A Good Built Environment	National Board of Housing, Building and Planning	Covered under the heading *Waste* and *Organic waste from society*
16. A Rich Diversity of Plant and Animal Life	SEPA	Covered under the headings *Genetic engineering, Cultural landscape and biodiversity, Organic production*

The concept of 'sustainability' and sustainability assessments for agriculture

There is a long tradition of research on the politics and implementation of sustainability. Much of this literature takes the Brundtland report from 1987 as its starting point. The report defines sustainable development as: "*development that meets the needs of current generations without compromising the ability of future generations to meet their needs"* (UNWCED, 1987: p. 9) and it highlights the equal importance of the three pillars of social, environmental and economic sustainability (UNWCED, 1987). One conclusion from this large body of work is that as sustainability is a contested and highly political concept, without a fixed meaning, its overarching and general definition enables many different interpretations which leads to power struggles over meaning and negotiations between interests (Binder et al., 2010; Kambites, 2014). Since the mid1990s the academic and policy interest in sustainability assessments has risen exponentially (Bond et al., 2012). This includes sustainability assessments for agriculture (Schader et al., 2014). Indeed, a significant number of frameworks for assessing sustainability in agriculture through indicators have emerged in academic publications in recent years (Carof et al., 2013; Marchand et al., 2014; Schader et al., 2014).

Sustainability assessment frameworks (SAF) for agriculture are often indicator based assessment tools structured into three or four hierarchical levels (de Olde et al., 2016). The tools differ somewhat in structure and scope and have somewhat different purposes and objectives. Common for most tools is that a comprehensive set of indicators measuring detailed aspects (e.g. water use and water quality), are aggregated into different sub-themes/themes/components (e.g. water) associated in turn with the different sustainability dimensions or pillars (environmental, economic or social). The indicators are measured through scientific literature, financial statistics, investigations at location and surveying farmers. Based on this empirical material 'experts' (e.g. researchers, advisors or a third party assessor) decide/measure the score for each indicator and aggregate the indicators to a 'sustainability score'. The results are aggregated into different themes/components and presented as spider diagrams. Through the chosen indicators and how they are measured, these frameworks 'decide' what it means 'to improve the situation' towards sustainability.

So far the use of these tools in practice has been limited due to limitations in data availability and high time and budget requirements for performing the assessments, as well as a lack of perceived relevance of these assessments among farmers (de Olde et al., 2016).

Method

A content analysis (Krippendorff, 2004) was performed with the aim of surveying how the concept of 'sustainable agriculture' is defined and used by Swedish public agencies dealing with agriculture and environment. The web pages of the following agencies were searched for the term 'sustainable agriculture' ('hållbart jordbruk' in Swedish) by using the search field of the web pages and by manually looking through the main menus: the Swedish Board of Agriculture (SBA); the Swedish Environmental Protection Agency (SEPA); the Swedish Chemicals Agency (SCA); and the Swedish Agency for Marine and Water Management (SAMW). These agencies were selected as they are responsible for EQO related to agriculture (Table 1).

In all places in the text where the term 'sustainable agriculture' or related terms such as e.g. 'sustainable development of agriculture' was found, the context in which the term was used was read with the purpose of understanding how the term was being defined. However, only SBA and SEPA web pages contained any hits for this search term. To enrich our understanding of how 'sustainable agriculture' was considered by these agencies, we therefore complemented the initial search with reading a selected number of texts (listed below) in full, and through direct questions via email and telephone to selected key informants. The following texts were read in full:

- The report *Sustainability in Swedish Agriculture* (SBA et al., 2012) issued jointly by the SBA, SEPA, Statistics Sweden and the Federation of Swedish Farmers (LRF).
- The stated vision of the SBA and the associated roadmap were analysed in order to understand whether sustainable agriculture is included as an explicit goal in the strategic plan of the SBA (SBA, undated)
- The directive from the government to the SBA (ESV, 2016)

Emails were sent to the main official email address of the SBA and SEPA agencies to explicitly ask for their official view on ‘sustainable agriculture’.

Telephone interviews were performed with two officials at the SBA to ask for further guidance on definitions of or tools to measure agricultural sustainability used by the agencies that were not searchable on the webpage.

Results

Definition of sustainable agriculture

A clear reference to the concept of ‘sustainable agriculture’, including a definition, was not found in any of the documents from any of the agencies or the government. Neither was the concept of ‘sustainable agriculture’ explicitly or extensively used by Swedish authorities as a concept to integrate economic, environmental and social issues related to agriculture. Some reports use the term ‘sustainable’ but in very different ways and without providing further definition. For example, one report from SEPA mentions the term sustainability only in relation to ‘economic sustainability’ (SEPA, 2013), while the SBA roadmap states: *“we now clarify the need for a holistic approach by emphasising competitiveness and sustainability.”* (SBA, undated).

Here, on the contrary, the issue of competitiveness (which might otherwise be seen as part of the economic pillar of sustainable development (c.f Brundtland, 1988)) is separated out from the concept of sustainability. This phrase is illustrative of many of the policy texts regarding agriculture and sustainability; competiveness is mentioned first and other sustainability issues (e.g. climate, environment in general and animal welfare issues), later as ‘add-ons’. Also, social impacts of agriculture are not mentioned at all, and are perhaps indirectly seen as only a part of the economic sustainability. Another example comes from the goal description of the Swedish Food Strategy that is under development where again environmental aspects come after economic aspects, and social aspects of farming remain unmentioned:

“Objectives of the project are to increase employment, production, exports, innovation and profitability in the food chain, while relevant national environmental targets are met.” (GOS, 2016a)

The argumentation builds on the notion that ‘if companies are not competitive there will be no companies that can be sustainable’ which is also used in the EU CAP:

“In short, EU agriculture needs to attain higher levels of production of safe and quality food, while preserving the natural resources that agricultural productivity depends upon. This can only be achieved by a competitive and viable agricultural sector operating within a properly functioning supply chain and which contributes to the maintenance of a thriving rural economy.” (EC, 2013)

While it is difficult to argue against this line of reasoning, an alternative starting point could be that ‘without healthy eco-systems, agriculture is not possible’. A recurring theme is also that if Swedish agricultural activities are reduced, this will move impacts from food production to other countries hence exporting the environmental impact from Swedish food consumption abroad. It is also argued that this would increase the pressures of agricultural practices on the environment globally as production abroad is often viewed in Sweden as more environmentally and socially damaging.

Swedish policy communication takes this one step further as agriculture is often assumed to be a prerequisite for reaching environmental targets; an assumption found frequently in the texts analysed. One example is the SBA roadmap that states:

"Without agriculture there is no one who can deliver environmental benefits." (SBA, undated).

What this refers to is probably the EQO of "*A Varied Agricultural Landscape*" that the SBA has responsibility for monitoring. This EQO is about the preservation of the farmed landscape and of agricultural land for food production while biological diversity and cultural heritage assets are preserved and strengthened. This goal is monitored and evaluated based on indicators such as the amount of cropland cultivated and pastures grazed. Much emphasis again is placed on the preservation of semi-natural pastures, judged to be one of the most threatened ecosystems in Sweden (Eide, 2014). As these are slowly diminishing, meeting this target is seen as improbable, and much emphasis is put on preserving these systems.

In addition, according to the Swedish Food Strategy, Swedish agriculture and Swedish food production contributes to sustainable development by the export of Swedish products which have been produced with low environmental impact and good animal welfare compared to other countries. This line of reasoning builds on the assumption that these products will replace other more impacting products on the market. It can however be questioned whether it is realistic to assume that Swedish agricultural products will be able to compete on a global market, even including potential added values.

The only explicit reference to 'sustainable agriculture' that we could find was in the report S*ustainability in Swedish Agriculture* (SBA et al., 2012). This report, which was published jointly by the SBA, SEPA, Statistics Sweden and the Federation of Swedish Farmers, provides a brief discussion of the concept of 'sustainable agriculture' in the introduction. Here the starting point is environmental, stating that agriculture affects the environment both positively (by keeping the farm landscape open, grazing animals maintaining pasture land with high biodiversity and through the preservation of cultural heritage environments) and negatively (by emissions and resource use). Here environment is understood both as the physical landscapes in Sweden and the wider global eco-systems. The English summary defines 'sustainable agriculture' as:

"Sustainable agriculture integrates three different aspects; environmental health, economic profitability and social and economic equity. Sustainability rests on the principle that we must meet the needs of the present without compromising the ability of future generations to meet their own needs. A sustainable agriculture conserves our natural resources, is adapted to the environment and is environmentally ethical. An economically and socially sustainable development in the countryside requires for instance that agriculture produces high quality food at reasonable prices to the consumer and provides the producers a reasonable income." (SBA et al., 2012)

However, the text in Swedish does not provide a clear reference to the concept of 'sustainable agriculture', instead it concludes that in order for agriculture to be sustainable it must minimise environmental impacts to an acceptable level while the economic return is satisfactory and the social terms acceptable.

Finally, although it is stated in the vision and roadmap of the SBA (SBA, undated) that agriculture should contribute to a sustainable society, in these strategic documents the emphasis is on competitiveness and lessening the administrative burden on farmers i.e. contributing to economic sustainability of farmers above all.

Assessment of sustainable agriculture

Neither the SBA nor the SEPA use an integrated framework for assessing the sustainability of agriculture. For environmental sustainability much emphasis is placed on the national EQO. However, the EQOs measure impacts from all sectors, agriculture being one, so there are no explicit targets or benchmarks for agricultural impacts. For example, the climate target includes a reduction of total emission of greenhouse gases in Sweden by 40% from 1990 until 2020. However, the sector wise responsibility to contribute to this reduction is unclear i.e. whether all sectors should reduce emissions by 40% or if this number should differ considering different factors such as technical feasibility and cost.

The SBA explicitly states in mail conversations and interviews that they work with parts of the total sustainability in different projects and initiatives; addressing food waste, meat consumption, agricultural policy, organic production and ecosystem services etc*.,* all aimed at reaching more sustainable food production. Different indicators and measurements of sustainability issues are used in different projects according to the relevance of the specific project. These indicators are not further harmonised. There are also established indicators used to follow up initiatives within the CAP Rural Development Policy, however, these are mostly focused on whether payments within the programme have been paid although they also measure some other issues more related to sustainability e.g. the number of farm workers that have had their working conditions improved (SBA, 2015a).

The report *Sustainability in Swedish Agriculture* (SBA et al., 2012) presents a summary of how agriculture affects different sustainability themes and is the most comprehensive and integrated summary of the sustainability in Swedish agriculture issued from Swedish authorities. It is unclear how the included themes were selected but for the environmental themes several relate to the national EQO (Table 1). The report also includes a section on the social situation in agriculture which revolves around the social situation of the farmer. Social issues on a societal level i.e. agriculture's contribution to society, is dealt with in several chapters including the preservation of agricultural landscapes and the species dependent on that, the potential of agriculture to deliver renewable energy to other sectors, to recycle organic waste, to contribute to rural development and to deliver safe foods.

Discussion

This analysis showed that although Swedish authorities deal with many aspects that might be framed as components of 'sustainable agriculture' this is not done explicitly, and how different aspects of sustainability might relate to each other is seemingly not discussed, and not dealt with in an integrated approach.

Our analysis indicates that the SBA sets economic profitability above other sustainability goals as a result of their explicit mission to support the agricultural sector (ESV, 2016). This line of reasoning is aligned with a view on sustainability that Hopwood et al. (2005) classified as the

‘Ecological Modernisers’. This view relies on the prevailing neoliberal growth paradigm and considers progress towards greater environmental sustainability only possible if businesses can profit from such initiatives (Mol & Sonnenfeld, 2000). Nevertheless, the SBA spends and has spent considerable resources on different initiatives for increased environmental sustainability. This is in line with the ambition to market Swedish agriculture as environmentally and animal friendly. Sweden has a long tradition in this area, having been in the forefront of animal welfare regulations and environmental policy for many years.

The analysis also shows how the social dimension of sustainability is given much less emphasis in the work by these Swedish agencies. This is usefully viewed in the light of research that shows how it will not be possible to steer towards more environmentally sustainable agricultural practices if proposed changes undermine the social dimensions of farming e.g. that farmers feel that they get appreciation for their work and that they have a decent quality of life (Burton & Paragahawewa, 2011; Burton & Schwarz, 2013; McGuire et al., 2013). It is only in recent years that agricultural sustainability has been introduced at all as a concept, previously concepts such as environmentally-friendly agriculture was used more in isolation from economic aspects. Some authors argue that keeping environmental sustainability separate is advantageous as integrated approaches risk making the environmental aspects drown in the broad range of sustainability issues and that *“…integrated forms of impact assessment may simply serve to promote dominant economic perspectives over broader sustainability and environmental concerns”* (Morrison-Saunders & Fischer, 2006). It is too early to say whether a potential broadened and more integrated approach towards agricultural sustainability will face this challenge, but it is clearly one aspect to keep a watch on.

As mentioned above, the Swedish EQO cover all sectors in society *i.e*. in Swedish environmental policy there are no specific targets for agriculture. However, the SBA is the agency with main responsibility for the EQO ”A Varied Agricultural Landscape” which is clearly linked to agriculture and affected only indirectly by other sectors. This responsibility is apparent in many texts that talk about agriculture as indispensable for this target. For other EQOs e.g. ”Reduced climate impact” and ”Zero eutrophication” the SBA works in cooperation with the SEPA to reduce these impacts. However, the division of responsibilities is not clear, and as the SBA also has an explicit mission from the government to strengthen the agricultural sector, its role in this cooperation is also to make sure that policy suggestions in this e.g. the climate area are “*realistic and not threatening for farm profitability*” (quote). Hence, SBA has two, in some ways contradicting roles here: reducing greenhouse gases from agriculture; and making sure climate policy does not negatively affect farmers’ profitability. Our analysis indicates that currently the later seems to get the priority

Another relevant on-going discussion regards the way policy in society is organised on a higher level. Some argue that to reach sustainable development it would be preferable to organise national and EU policy on a food system level e.g. jointly considering agricultural policy and health policy in order to reduce policy incoherence (Alarcon, 2015). For example, while agricultural policy supports the production of sugar and livestock production, health policy struggles to reduce the consumption of such products. For such an organisation, indicators on food system level rather than agricultural level would be needed.

So, to return to our initial assumption: could integrated SAFs be useful for governmental agencies responsible for agricultural sustainability? Potentially they could be useful for highlighting when and how it is possible to meet various goals jointly, when there are trade-offs between different goals, and for opening up for discussion how to deal with such trade-offs. One advantage of using integrated sustainability assessment tools or frameworks is that these (at least in theory) present different sustainability perspectives or themes on the same scale. Whether it would be an advantage to do so on a national scale is unclear. Using a sustainability assessment framework on the national level e.g. assessing the sustainability of Swedish agriculture as a whole, would require either grouping existing indicators e.g. the EQO, the economic and social indicators (and normalising them to a common scale), or introducing or developing new indicators that are not currently used in Sweden but maybe in another country. Both of these approaches are clearly a challenge. Officials interviewed in this study do not regard that as very meaningful or realistic as they will still have to report sustainability issues under the EQO umbrella as well as for the indicators demanded by EU. It also needs to be considered whether an assessment on different agricultural sectors e.g. cereal production, dairy, pig production etc. would be more useful than an assessment on the agricultural sector as a whole as this generalisation risks masking important factors. In summary, additional indicators or tools at the national level would be redundant according to these officials and add little additional value to what is already assessed. As one of them expressed himself:

“We do not need more ways to measure, we need more action.”

Potentially, SAFs could lead to more action as they can be a way to facilitate structured discussions around which sustainability themes are in need of further actions including identifying who has the possibilities to act. In addition, both officials independently mentioned that a broad application of SAF at the farm level would be very valuable if results from these could be gathered at a national level. Results from such assessments could be used by authorities to: 1) help market Swedish agriculture by making the added value of Swedish agriculture (e.g. low use of antibiotics, good animal health) more explicit; and 2) to help the authority to prioritise between different sustainability areas to invest in.

Conclusions

Swedish public agencies deal with many aspects of what can be considered part of the concept of ‘sustainable agriculture’. However, the term is not further defined by the agencies but rather filled with meaning according to relevance in different situations on an, what seems to be, ad hoc basis. The economic pillar is often given priority by the agency with the main responsibility of agricultural sustainability. No integrated SAFs including all sustainability pillars are used by Swedish authorities, but environmental issues are structured into a cross-sector system of environmental quality objectives of which different agencies have responsibility. More ways to measure at the national level were not deemed necessary, but potentially SAFs could be useful for more structured discussions on which sustainability themes to include in different situations and for assessing the sustainability of Swedish farms on a farm level for marketing purposes.

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Target setting and burden sharing in sustainability assessment beyond the farm level

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Abstract: While great progress has been made towards monitoring agricultural sustainability through the use of indicators, setting sustainability indicator targets that motivate the transformation of farming systems for sustainability and resilience is often overlooked. This paper examines the role of target setting and benchmarking comparisons in sustainability assessment. A review of 186 indicator metrics and their targets from 12 sustainability assessment frameworks showed a preponderance of practice-based rather than performance-based measures. Many targets were implicit and embedded within the way ratings or standards were measured rather than explicitly derived from external information or processes. Ratio scales were rarely used for indicator measurement. Given these limitations, most assessment frameworks are weak tools for the comparison of agricultural sustainability between sectors, regions or nations. We then considered the equity implications of sustainability burden and benefit sharing and drew lessons from recent international climate change negotiations to recommend guidelines when erecting production level sustainability targets and benchmark comparisons between farms, regions, sectors and countries in the way being considered by the TempAg network. Equitable participation by multiple stakeholders in the process of erecting targets is important to achieve fair outcomes that underpin lasting commitment to sustainability. Scrupulous application of equity and fairness is more likely to change values of the farming families, food processors and distributors and consumers for collective action. Adjusting targets to match local social, economic and ecological constraints on farming performance may be fairer, but this local tuning also challenges the design of and use of targets and benchmarks that have been upscaled to regional and national levels for informing sustainability policies across temperate agriculture as a whole. So will TempAg targets and benchmarking help or hinder transformation for sustainability and resilience?

Keywords: Target setting and benchmarking, fairness, responsibility, TempAg

Introduction

Food production is required to grow substantially if it is to meet global demand of nine billion people by 2050 (OECD-FAO, 2010). Achieving this increase in food production to supply global markets, while meeting consumer and citizen expectations, and maintaining biodiversity and ecosystem services is an important challenge. Agricultural systems will need to improve in all parts of the world in order to ensure the long term sustainability of food, fibre and biofuel production (Pretty et al., 2008). The search for practical solutions to enhancing sustainability requires both a farm-level focus complemented with a view towards developing appropriate social and economic policies at regional, national and international levels. The 'Collaborative Research Network on Sustainable Temperate Agriculture' (TempAg), is one recent and potentially effective initiative to help co-ordinate sustainability interventions at multiple spatial and temporal scales (Gregory, 2016). It is a coalition of agricultural researchers and policy makers from across temperate and high altitude production areas of the OECD that amongst much else, aims to *identify and critically evaluate the available tools and guidelines to assess sustainability and transform agricultural production systems across multiple scales.* The TempAg team therefore proposed elements of the workshops on "farm level" and "beyond-farm level" sustainability assessment tools as a valuable part of the IFSA 2016 symposium.

Agricultural performance improvements will be accelerated by erecting sustainability 'reference values' such as performance targets, critical thresholds, minimum standards and benchmarks. Without targets or benchmarks, measures of sustainability indicators provide little opportunity for risk management by decision makers like farmers, processors and distributors, marketers, policy analysts and government. Indeed, without reference values, sustainability assessment is in danger of being seen as measurement for measurement's own sake, and farmers are less likely to see the exercise as relevant and an opportunity for themselves, rather than a cost and threat imposed by 'outsiders'. This paper is the first of a series from the New Zealand Sustainability Dashboard project (Benge et al., 2016) to focus on how reference values are currently designed and used. We first briefly present an overview of reference value definitions and structure as deployed across 12 sustainability frameworks that currently operate in very different contexts around the world. We then go on to consider how reference values may actually be used for encouraging change and apportioning responsibilities at two levels: first we present a review of the international climate change mitigation agreements as a potential example of the way the tools being tested by TempAg might be used by an international organisation such as OECD or FAO to meet a collective target for agricultural sustainability; and second, a hypothetical example of how those principles from climate change mitigation might be applied at a local collective industry for both benchmarking and target setting for transforming production.

Reference setting and benchmarking in sustainability assessment

Types of reference values

We reviewed the wider sustainability assessment literature and then selected a stratified random selection of up to 20 indicators across four pillars (economic, social, environment, governance) for each of 12 sustainability frameworks currently in operation around the world: Sustainability Assessment of Food and Agriculture systems (SAFA); The Sustainability Consortium (TSC); GLOBAL.G.A.P.; LEAF Marque Standard (Linking Environment and Farming); International Federation of Organic Agriculture Movements (IFOAM) Standard; BioGro Organic Standards; Response-Inducing Sustainability Evaluation (RISE) 3.0; BioBio (Farmland biodiversity indicators); OECD Agri-environmental indicators; Mauri Model; The Sustainable Agriculture Network - Sustainable Agriculture Standard (SAS); Sustainability Monitoring and Assessment RouTine (SMART). Altogether we reviewed 186 indicators, scored them for the presence or absence of reference values, and devised a typology of how indicators and reference values were constructed.

Our extensive literature search identified only a few papers that attempted a critical overview of agricultural sustainability reference setting structure ((van der Heide et al., 2007; Van Cauwenbergh et al., 2007; Bastian et al., 2007; Acosta-Alba & van der Werf, 2011). Considerable confusion arises from conflicting definitions of targets and benchmarking, so our first plea is for sustainability assessors to converge on a standardised set of definitions.

Out of the 186 indicators randomly selected from the 12 sustainability frameworks, the majority (96%) had a 'target', either in the form of a standard (a minimum standard required; 47%), or rating (a measure or evaluation of performance; 49%). The proportion of indicators with targets (96%) was higher than previously anticipated because 'embedded' targets, or implicit expectations, were categorised as a 'target' rather than the absence of a reference value. For example, a rating of farm management on a 5-point/category ordinal scale ranging from 'poor to 'excellent' implicitly suggests that an 'excellent' rating could be achieved by all farmers. The 'excellent' rating is the implicit or embedded target. Most targets (93%) were implicit, while only 7% of targets were independent of the way the rating scale was measured and instead derived from external information on acceptable or optimal performance. Our second plea is for sustainability assessors to motivate improvement by making targets more explicit and direct.

The majority (65%) of the targets were "practice-based" (assessing adherence to specific best farming practices), whereas 31% were "performance-based" (monitoring farming outputs). The remaining 4% of targets were a mixture of practice and performance-based. We found that most practice-based ratings were loosely defined and deployed statistically weak metrics for trend analysis. More fundamentally, they make an overarching assumption that improved sustainability (of some unstated amount) will emerge if a given practice is in place (e.g. soil health is monitored in some way). Our third plea is that more performance-based rating systems are deployed for improved assessment and learning.

The majority (58%) of targets were simple binaries (usually the presence or absence of a desired practice). Some (24%) used semi-quantitative ordinal scales, and only 18% deployed a measurable target using a ratio scale for measurement. Many of the latter were "secondarily derived" i.e. aggregations at an industry or product level to calculate the percentage of producers or suppliers that achieved some binary performance or practice criterion at the individual farm level. Binary and ordinal scales have several well-recognised limitations of scale depression; low sensitivity for measuring change and limitations of how they can be combined for upscaling and aggregation of indicators and targets. There were several examples where the subsequent manipulations and interpretations of binary and ordinal scales violated fundamental properties of measurement scales and statistics. Our fourth plea is that true ratio scales of measurement are used for indicators and targets at the farm level and not just in secondary aggregations of the data beyond the farm scale.

T***argets are not always needed: internal benchmarking for encouraging improvement***

Many of the applications of sustainability measures appear to be designed for internal comparison of relative performance between farms now (spatial comparison), or changes in their own performance with past years (temporal comparisons). Provided that the metric has been scored in a relatively consistent manner, continuous improvement can result by the comparison a farmer sees with their neighbours or at least other producers facing the same or similar constraints. In this way, those signalled to be in the bottom quartile of performers may be motivated to improve and climb past their colleagues next season or as they develop their systems. This in turn will potentially trigger renewed efforts of the previous leaders. The underlying model is one of an "improvement escalator" where the overall average performance will climb when farmers compete with each other and become aware that it is indeed possible to improve. In this model, benchmarking is a type of passive incentivisation tool that requires no particular target or plan. It has the advantage of local relevance and naturally fits with the way farmers often monitor their own performance by comparing with their neighbours.

Benchmarking oneself against earlier performance is a temporal version of the same internal benchmarking tool. It would be possible to set targets for rates of improvement, but we found these to be relatively rare.

Equity when setting targets: lessons from climate change negotiations
Specific, quantitative, time-bound targets can be linked to indicators so that performance can be interpreted clearly on a 'distance-to-target' basis (Moldan et al., 2012). Target setting for sustainability assessment requires two distinct, yet closely interconnected steps. The first is to define the target either quantitatively or qualitatively, while the second is to assign responsibility for meeting the target. Figge (2005) argues that society defines in political processes the 'goalposts' of sustainable development, and suggests that it is these targets that parties need to meet. Voluntary sustainability assessment initiatives are becoming an increasingly common way to address sustainability concerns. Regardless of what targets are set, participants to a voluntary sustainability initiative are unlikely to willingly adopt a sustainability performance target unless they perceive it to be fair. A balance is required between the overall target that is expected to be met, and the fairness of each party's obligations for meeting the target. Equity concerns play an important role in the establishment of sustainability performance targets because acceptability of collective responsibility will be enhanced if the target is perceived as fair amongst those participants expected to enact it.

International climate change negotiations and the associated literature have devoted significant attention to both the setting of a performance target, and the assigning of responsibilities for achieving that target amongst nations. A common determination that global warming should be limited to 2°C is a clear performance target that has been developed largely through scientific research. The division of obligations amongst multiple disparate nations for meeting this target however, involves ongoing ethical and political debates around equity and distributive justice ideals, as each nation expresses its own vision of fairness (Lange et al., 2010). The concepts of equity, justice, or fairness, here used interchangeably, have been central to discussions on sustainability since its inception (Pearce, 1987). The normative foundations for equity concerns are based on philosophical and moral theories of distributive justice (Pearce, 1987). Distributive justice is concerned with fairness in outcomes.

Providing equal opportunities and need satisfaction for people is a central feature of the concept of sustainable development (Langhelle, 2000). Multiple international treaties and agreements intended to confront complex and interconnected issues, like those presented by sustainability, address equity through the concept of 'Common but Differentiated Responsibility' and 'Respective Capabilities' (CBDR & RC) (UN, 2015).

The Rio Declaration provides one of the clearest enunciations of CBDR & RC in an international agreement:

> *In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command* (UN, 1992 Principle 7).

Interconnected ecological networks and economic interdependence between countries mean that each country can be subject to the environmental and consumption choices of others. Yet, each country alone does not have the capability to address these issues which require co-operation, thereby promoting the idea of 'common' responsibility (Rajamani, 2000). At the same time as global issues require global co-operation, it has been recognised that the differences in country's capabilities, technology, historic responsibility and needs (amongst other factors) mean that all countries do not have an equal opportunity to address global issues, and therefore their responsibilities to act should be 'differentiated'. Both the United Nations Framework Convention on Climate Change, and the Kyoto Protocol were explicitly based on the concept of CBDR, which continues to play a key role in the post-2012 climate change negotiations.

Perceptions of fairness in the allocation of the burdens associated with sustainable development can influence the viability of a sustainability proposal both at an international level, and at an individual level (Carlsson et al., 2011). At the centre of climate change negotiations is a debate on the equity and fairness implications of the burdens imposed by emissions mitigation (Dannenberg et al., 2010). While climate change mitigation is a direct concern of agricultural sustainability, the broader framework of international climate change negotiations can also provide guidance on the likely challenges that could occur in setting agricultural sustainability performance targets for a wide and diverse group of participants.

Lange (2010) demonstrates that equity considerations underpin many of the differences between country's interpretations of which path to climate change mitigation is optimal. Countries are likely to only accept treaties with international obligations if they are perceived as fair (Stalley, 2013). This same fairness requirement underlies the acceptance of other, lower level, sustainability initiatives. What is deemed to be fair rests upon the weight each entity puts on different distributive justice principles.

Constructing burden sharing criteria

Distributive justice principles that provide grounds for a departure from absolute equality have been discussed extensively in both philosophy and welfare economics (Yaari & Bar-Hillel, 1984). The search for appropriate equity principles on which departures from equality can be justified has experienced a resurgence of interest in recent years due to the global challenge of climate change, and the associated international negotiations (Carlsson et al., 2011; Lange et al., 2010). Despite a vast array of fairness principles being described by the literature, there is a considerable convergence on three basic principles of distributive justice (Underdal & Wei, 2015). They are: *need*, which refers to a minimum required threshold for goods or benefits; *capacity*, which refers to the ability to contribute to problem solving; and *responsibility*, which refers to culpability for contributing to an issue.

Need principle

The principle of need provides an absolute standard that must be achieved through any distribution. Multiple studies have found evidence of support for meeting basic needs as a central requirement of distributive fairness (Carlsson et al., 2011). The principle of need implies a threshold below which an entity would not be obliged to accept any burden for addressing an issue. This is clearly evident in the Kyoto Protocol, where Non-Annex 1 countries were excluded from emission mitigation targets (UN, 1998). The selection of a need threshold should be undertaken within the context of the issue being addressed. In the research literature, one of the most common approaches has been to create a threshold, and grant exemptions, at the point where average income falls below an official poverty line (Baer, 2013; Underdal & Wei, 2015). For example, the United Nations classifies countries into three broad categories, based primarily on their Gross National Income (GNI). In 2013, countries with less than $1,035 GNI were classified as low income countries (UN, 2014), under the Kyoto Protocol these countries generally fell into the Non-Annex 1 category and were excluded from any requirements to reduce GHG emissions due to their more urgent development needs (UN, 1998).

> Countries with per capita CO_2 emissions above the world average … have proportional responsibility for all their own emissions. Countries emitting between 50% and 100% of the world average … are proportionally responsible for emissions within that interval only. Countries emitting <50% of the world average … are granted full exemption.

Box 1. Responsibility assignment mechanism for CO_2 emissions

Responsibility

Distributive justice theory distinguishes between an agent's role in causing damage and that agent's moral responsibility for the damage it has caused (Underdal & Wei, 2015). Konow (2001) emphasises that responsibility should only be considered in respect to variables which can be influenced by an agent. However the 'Brazilian Proposal' in climate negotiations argues that countries should be considered culpable for historic emissions, despite present day governments having no control over the actions of past governments, and past governments having had no understanding of the adverse effects of GHG emissions (Klinsky & Dowlatabadi, 2009). Climate change negotiations coalesced around the year 1990, in which the first IPCC report was published to develop a mechanism to assign responsibility for historical damage to the world's atmosphere. It has been argued in climate change research that, as the responsibilities of individuals within a country vary widely due to power and income inequalities, the best level of analysis for determining responsibility should be individuals, or small entities rather than countries (Newell et al., 2015). However, Underdal & Wei (2015, p. 38) developed a responsibility assignment mechanism that assigns proportional responsibility for CO_2 emissions amongst whole countries as shown in Box 1.

This approach eliminates responsibility for those who have contributed little to the issue, it gives partial responsibility to those who have contributed at a level below average, and full responsibility to those above average. In doing so, it protects the development of low emitters and assigns them no moral responsibility for the issue. The latest round of climate negotiations, COP 21 in Paris however, moved away from the Kyoto Protocol approach of completely exempting developing countries from responsibility, towards a more bottom-up approach, whereby countries now determine their own emission targets (UN, 2015). Under the new 'Paris agreement', while developing countries are still expected to make smaller mitigation commitments than developed countries, they can no longer be said to be 'exempt'. Assigning these countries a 'low responsibility' for their emissions is a more accurate interpretation of the latest climate change agreement.

Capability principle

Capability refers to an entities capacity to contribute, and can only be properly assessed with reference to a specific task or function. Capability in climate change negotiations, has related largely to a country's material wealth often measured by GDP (Füssel, 2010) which is seen to be a determinant of its ability to contribute to climate change mitigation and adaption. A wide range of interpretations of capability have been put forward by researchers and policymakers. At one end of the spectrum is the capability approach, which focuses upon people's capability to achieve outcomes that they "value and have reason to value" (Sen, 1999, p.18). Due to the substantial cultural and socio-economic variation at all levels of societies on what 'a life that people value and have reason to value' means, the capabilities approach presents a significant challenge to apply in an international, or even a nationwide context. The Human Development Index (HDI), which is based on some of the key concepts of the capabilities approach, and developed in part by Sen himself, does however provide a measure of capability (Winkler et al., 2013) which has been applied to multiple countries. The HDI comprises a composite measure of health, education and standard of living (gross national income per capita), which combined are considered to measure human development, but can be reframed as a measure of capability (Winkler et al., 2013).

Confronted with complexity and data limitations however, capability in international climate change has largely been limited to simply 'capacity to pay' for mitigation, measured by GDP per capita (Underdal & Wei, 2015). In a similar vein, a relatively prominent approach to equitable burden sharing in climate change negotiations known as the Greenhouse Development Rights (GDR) framework, defines capability as *"income above a threshold, below which individuals are presumed to have 'development' as their appropriate priority and thus be exempted from climate-policy burdens"* (Baer et al., 2009, p. 270). What makes the GDH framework unique amongst other methods for determining capability in climate change negotiations is that its site of focus is at the individual household level, rather than a national level, making it particularly relevant for agricultural sustainability assessment.

Burden sharing of targets and equitable benchmarking: a hypothetical example for New Zealand agriculture

The three principles of CBDR & RC and criteria for measuring and categorising entities against them might be used at a much more local scale to erect fair targets and to determine which other entities to benchmark their performance against. In order to identify potential problems and opportunities, we have conducted a thought experiment in which we apply them to three measures of environmental sustainability measured on New Zealand orchards, vineyards and farms by the ARGOS and NZ Sustainability Dashboard project (Merfield et al. 2015): efficient use of energy; appropriate application of artificial fertilisers; and minimal yet sufficient application of chemical sprays to achieve Integrated Production goals.

Following the United Nations approach to basing a *needs* threshold on a monetary criterion (UN, 2014), a *need* threshold within an agricultural sustainability assessment context could also be set based on a financial measure. In accordance with the long-term requirements of sustainability, solvency (understood as a ratio between liabilities and equity) can provide an indicator of a farms ability to meet its basic needs and continue operations (see Table 1).

Table 1. A hypothetical application of three primary principles of distributive justice applied to target setting and benchmarking for individual orchards, vineyards and farms

Equity Principle	Example Criteria	Categorisation
Need	Solvency e.g. • Solvency Ratio = $$ potentially earned - $$ owed for production and land	• **Low Need** – Solvency ratio greater than zero • **High Need** – Solvency ratio less than zero
Responsibility	Historic performance against a sustainability issue relative to the group average, measured as distance below or above some optimum level (or band of levels) e.g. • Difference in fruit/spray/ha from IPM target. • Decreased fruit/J energy invested/ha from the maximum predicted from yield curve.	• **Low Responsibility** – Performance above the group average • **Medium Responsibility** – Performance between 50 percent and 100 percent of the group average • **High Responsibility** – Performance below 50 percent of the group average
Capability	Solvency beyond the need threshold e.g. • Solvency Ratio = $$ potentially earned - $$ owed for production and land (only applicable where solvency>0)	• **Low Capability** – Solvency ratio below 50 percent of the group average • **Medium Capability** – Solvency ratio between 50 percent and 100 percent of the group average • **High Capability** – Solvency ratio above the group average

While there is no formal ranking of the importance of the three primary distributive justice principles by the UNFCCC, it appears to be widely accepted that insofar as needs refer to basic goods or fundamental human rights, the needs principle is the most important, and provides a gateway test for entry into assessment against the other principles (Underdal & Wei, 2015). We therefore suggest a need threshold could be set at a solvency ratio of zero, under which entities are no longer able to meet their debt obligations (Figure 1). Any farm that is insolvent is unlikely to be in a position to take on significant additional sustainability burdens in a voluntary sustainability initiative and therefore be exempt from additional sustainability burdens.

The approach to categorising *responsibility* provided by Underdal & Wei (2015) shown in Box 1 can also be adapted to apply in an agricultural sustainability assessment scenario. For the purpose of this paper, the point is not to quantify a required standard of performance improvement, such as a certain percent reduction in emissions, but rather to categorise farms based on their level of responsibility into groups of high, medium, or low for issues like application of fertiliser, chemical sprays or energy consumption (see Table 1 and Figure 1). However several complications must be considered, rather than simply assuming risk from sprays or fertiliser is linearly related to application rates. Sprays are applied to New Zealand kiwifruit and vineyards within strict Integrated Pest Management guidelines based on pest insect counts and trigger thresholds to protect market access requirements – applying too few sprays can build resistance amongst the pests, and would fail to protect the crop and exports; applying too many sprays creates unnecessary toxic risks for the wider environment and human health risks amongst consumers. If we assumed the consequences of over-spraying were the same as those from under-spraying, the absolute (+ or -) deviation from optimum could measure responsibility for change as well as 'distance to target'. Similar approaches could apply to fertiliser use where the optimum application is set at sufficient inputs to maintain soil health and production. On the other hand, responsibility measured by energy use is more likely to be linearly and directly related to environmental harm, especially where the energy subsidies for food production are based on fossil fuel inputs. However, even in the energy case, ethical consideration of providing food security could be included by scaling all energy inputs against the amount and quality of food produced per hectare: adding successively more energy subsidies into production eventually will produce little extra fruit, so we expect (fruit/J/ha; Table 1) to level and then inflect downward when too much energy is used. Responsibility for adjusting energy inputs might therefore be best measured as the relative inputs above the point on a yield curve where fruit/J/ha first begins to flatten as energy inputs climb.

There are many objections that can be raised to adopting a simple GDP per capita, or other monetary approach to defining *capability* alone, particularly from the more rigorous perspective provided by the capabilities approach (Sen, 1999). Levels of development or capability cannot be entirely understood by an increase in individual consumption or GDP. However, like the GDH framework (Baer, 2013) and other approaches (see Winkler et al., 2013), a first approximation might be to adopt a simple monetary measure of *capability* based on the previous definition of *need* to assign high, medium, or low capability for in the same manner as proposed for the responsibility categorisation (Box 1,Table 1, Figure 1).

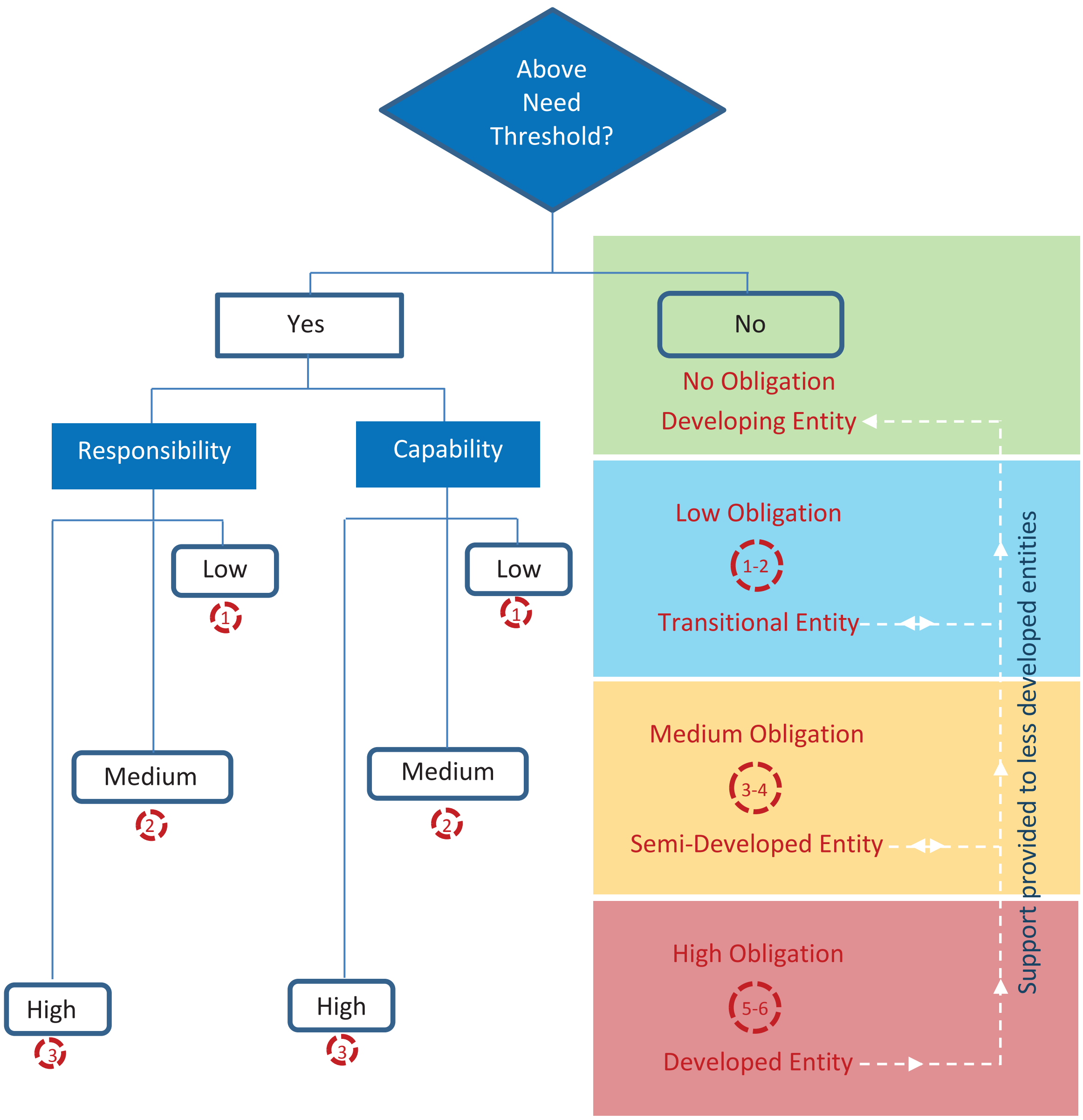

Figure 1. A potential burden sharing framework for sustainability targets for individual farms, orchards, vineyards or forests within an industry-wide sustainability programme. The underlying principles are based on the climate change mitigation negotiations between nations. Although applied to burden sharing, the same principles can be applied to fair benchmarking, in which the farm's current performance is only scaled against other farms that face the same (low, medium, high) levels of capability.

Elements of this same approach might also form the basis of equitable benchmarking when comparing performance against other farms i.e. once the need threshold has been met, is it more fair and acceptable to compare current performance of only those farms that share the same *capability* to do something about the problem?. If a proxy measure was available for *responsibility* (such as historical discharge of an accumulating pollutant), then it might be feasible to define benchmark panels based on some combination of both *responsibility* and *capability*.

General Discussion and Conclusions

The framework presented by this paper is intended to provide a starting point for discussions around burden-sharing when setting targets for agricultural sustainability assessments. Our review of 12 sustainability frameworks showed that most included targets, but in general they lacked an explicit rationale for how they are derived. This lack of transparency is likely to undermine their usefulness for encouraging collective action amongst all the participants in food and fibre production, distribution, marketing and consumption. Most of the indicators were practice-based i.e. a measure of the presence or absence of a best practice (farming input) and simply assume that they will lead to sustainability (a farm output). Performance-based indicators could test this fundamental and widespread assumption that we can adequately steer sustainability by monitoring farm inputs, but the necessary performance-based scoring systems were relatively uncommon. Frequently, the quantitative measures presented are secondary calculations on aggregated scores above the farm level (e.g. what proportion of farms in a given agricultural sector or product line followed best practice). We expect such general primary scores of inputs at the farm level to be relatively crude tools for learning and incentivising change, because the scale of measurement is binary or ordinal, and the definitions are necessarily generalised, making them hard to evaluate and potentially not trusted by decision makers working further along the food supply chain.

Outsiders beyond the farm will potentially be interested in a much “bigger picture” formed by large-grained and aggregated metrics, whereas producers must make decisions on fine-grained and locally tuned information to guide their own investments and land care. “No one size fits all” when designing sustainability metrics or indicator sets (de Olde et al. 2016) and the TempAg research team has rightly identified that the scale at which comparisons are to be attempted has a crucial influence on what is measured, how, by whom and for what purpose. We found it difficult to propose limits for how sustainability performance could be compared by TempAg or OECD between nations which farm temperate agroecosystems, because it is not yet clear how such comparisons would ever be used in a policy context. Is the intent to create league tables like those commonly used by OECD to compare social and economic wellbeing across its member states? We presumed yes, or at least that such broad scale comparisons would be wanted if they could be robust enough. Our review of existing sustainability frameworks suggested that the measures at farm scales are far too crude to yet allow this aggregated comparison of absolute measures. We conclude that individual farms, local communities or industries, and even national agricultural sectors, should instead best use the existing sustainability assessments for learning and improvement by ‘internal *benchmarking’*. In this use, sustainability metrics are only used as relative and proxy measures of change and improvement in their own local contexts rather than looking across to compare performance in very different ecologies and socio-economic constraints and opportunities. This may be a slower way of incentivising change, but it is practical and the local comparison ensures equity and local relevance in ways that farmers looking over at their immediate neighbours can quickly accept as valid and fairer.

When setting out to review the design criteria for setting targets and making benchmark comparisons, we quickly encountered the more general question of how targets and benchmarking comparisons can be made fair and thereby enduring and collaborative in effect. Although our hypothetical application of CBDR & RC proxy measures suggests that some proxy measures can conceivably measure responsibility and capability to shift local farm inputs and management, two further overarching complications are likely to arise when applying the CBDR & RC framework to target setting and equitable benchmarking: (a) are all dimensions of sustainability performance to be considered equally important; and (b) are responsibility and capability to be treated as equally important after first meeting need thresholds? It seems inevitable that a farm may fall into the low performance bracket for say energy, yet medium for fertiliser, and also fertiliser is a very important component of energy use on the farm. So overall targets for whole farming systems adjustment must weight these different components in some agreed way. Similarly, a solvent farm may score low on responsibility yet high on capability for the same environmental input issue. Figure 1 has an embedded assumption that CBDR has the same driving importance as RC, in which case a target response or benchmark comparison would be scaled as the average of the two fairness criteria. A valid moral argument can be made that entities with a low responsibility should have low obligations (Konow, 2001). However, collective challenges like sustainability rely heavily of group participation in a social contract (Rawls, 1971). So some will argue that all those with the capability to act have a moral obligation to do so, even if they played a relatively little role in creating the problem, or are currently performing better than many of their counterparts to minimise future impacts.

Clearly our thought experiment and Table 1 & Figure 1 work best as heuristic devices to illustrate several potential complications in applying the CBDR & RC approach at farm, national or international levels. Much work is left to be done in devising fair bases for comparisons of agricultural sustainability performance by TempAg. Nevertheless, the international experience in dealing with a shared common problem like climate change mitigation illustrates that failure to take proper account of need, responsibility and capability when setting targets or making benchmark comparisons would undermine collective action across temperate agriculture systems. Feeding a growing human population using global markets and distribution systems, avoiding land degradation and loss of biodiversity, and global biosecurity are just some of the ways that show finding shared solutions to agricultural sustainability is no less complicated or urgent than combatting climate change. Extreme care is needed in ensuring and negotiating fairness and ethical concerns when erecting targets and comparing farming performance across multiple scales and jurisdictions within temperate agricultural systems.

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Workshop 2.5: Beyond participatory methods-approaches for facilitating transformation of agriculture and agri-food systems

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Rarely in the history of agricultural research and practice has a concept spread as quickly as participatory methods. In less than 30 years, they have changed the rhetoric of research organisations, extension service providers and aid agencies. They have aided research in communicating more effectively with farmers, agricultural input suppliers, traders, consumer groups and policymakers. They have made research more democratic, responsive and effective. Today most actors underline the utility of participatory methods in their daily work. Participatory methods have transformed our understanding of agricultural research and development – eventually, they have transformed farming systems. In the course of their application, however, participatory methods have been transformed too. Few researchers pay attention to the silent erosion of values and quality standards participatory methods once implied. They rarely realise or articulate that participatory methods meant more than active involvement of people in agricultural projects and programmes that affect them. Few remember that participatory methods initially aimed at reallocating power to marginalised members of society. Today, we often ignore that standard use (or misuse) of participatory methods in research and development programmes has silenced poor people, leaving social relations and political exclusion unaddressed. The starting point for this workshop was the disparity between the original ideas that drove participatory methods and the practices of today. Much of this disparity does not originate from stakeholders, such as farmers, or the participatory methods themselves. The problems are caused by the way researchers and agricultural development experts apply the methods. Therefore, this workshop addressed the patterns driving what we call 'conventionalisation' of participatory methods. If we understand how and why this conventionalisation occurs, we will be in a better position to steer the re-transformation of participatory methods, and eventually regain some of their original strengths. Any research or organisation engaging in transformative action, remains ineffective if it does not address application challenges of participatory methods.

As convenors of this workshop, we believed that regaining what has been lost is a valid justification for discussing conceptual, empirical and experiential ideas around the topic. We also proposed that existing participatory methods will not be sufficient for solving current sustainability challenges and wicked problems. We feel that to promote change, facilitation methods have to enable deep, radical transformations of agri-food systems. We see a need for fresh ideas on how to facilitate the transformation of values, beliefs and self-perceptions of people engaging in multi-actor processes, as well as structures and operational procedures without prescribing outcomes. This workshop, therefore, explored methods in support of individuals and groups who pursue such transformation. From participants, we sought methodological propositions for what IFSA 2016 called enabling *'purposeful social and technological transformation of farming systems in different parts of the world'*. The possible entry points for the discussion included theories and concepts around resilience, adaptive governance, and translational leadership. Propositions needed to be applicable to action research, work for change agents and coaches, as well as community leaders. Although they are relevant all around the world, we focused on societies experiencing precarious livelihoods, socio-ecological fragility, and power asymmetries.