Approaches aiming at sustainable agricultural production

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WAGENINGEN
UNIVERSITY & RESEARCH

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Contents

Preface **5**

1 Background **7**

1.1 Method 7

2 The approaches **8**

2.1 Agroecology 8
2.2 Sustainable intensification 8
2.3 Climate smart agriculture 9
2.4 Landscape approach 10
2.5 Conservation agriculture 10
2.6 Organic farming 11
2.7 Inclusive green growth 12

3 How different are the approaches? **13**

3.1 Goals 13
3.2 Discussion 14
3.3 Relative positioning of the approaches 14
3.4 Discussion 16

4 Wageningen UR expert opinions **17**

4.1 Results of expert survey 17
4.1.1 Contribution to the three policy goals 17
4.1.2 Contribution to specific topics 18
4.2 Discussion 18

5 Results of Twitter Network Search **20**

5.1 Method 20
5.2 Number of active parties and exchanges 21
5.3 Type of influential parties 22
5.4 Discussion and conclusions 23

6 Final remarks **24**

References **25**

Annex 1 Simplified timeline for the approaches **26**

Annex 2 Topics and goals in the questionnaire on approaches for sustainable agriculture **27**

Preface

There is more than one way to skin a cat. There are also various ways to improve agricultural production systems. Finding the most appropriate way is, however, difficult. Claims of methods and promoted technologies are seldom applicable over all systems or regions, evidence is not always clear, sometimes differences are minor or not clear for non-expert, often container concepts are used without clear definition.

Wageningen UR was asked to provide insight and guidance to policymakers working on agriculture and sustainable development with a focus on the objectives to Dutch policies: eradicate hunger and malnutrition, stimulate inclusive growth in the agricultural sector and achieve ecologically sustainable food systems.

This note does not provide an extensive review of the literature, it is a quickscan based on the input of researcher working on agriculture and food security at Wageningen UR. We looked at the different approaches from various angles but leave it to the reader to reflect on the outcomes.

Why bring out this note? We decided to release this document because it did serve its purpose to discuss and reflect on the different approaches. Other may benefit from the way we addressed the issue.

Any results presented reflect the opinion of the authors.

Jan Verhagen

1 Background

Various agricultural approaches aiming to rationalise and improve agricultural practises and to contribute to a better world emerged over the past decades (Conway & Pretty, 1991). Recently agro ecology, inclusive green growth and climate smart agriculture were added to the list. Most of the approaches focus on increasing agricultural production without depleting or over-exploiting the natural resource base on which it depends, some include on farmers' incomes or look at regional or global benefits.

How the approaches differ in foci is not always clear. Claims of success are not always well documented, reproducible or underpinned by science. Whether this diversity reflects different societal or scientific movements and whether policies should be redirected to link better to the initiatives is also not clear.

Current Dutch policies aim to link to the private sector to policy ambitions in order to find solutions for development challenges. Agricultural development is at the forefront of this policy. In November 2014 a joint letter by the ministries of Foreign Trade and Development Cooperation and Economic Affairs reemphasized the cooperation with the private sector (DME-2014.601068). Three key priorities were identified:

1. Eradicate hunger and malnutrition;
2. Stimulate sustainable inclusive growth in the agricultural sector;
3. Achieve ecologically sustainable food systems.

The approaches differ in the extent to how broad or narrow sustainability is defined affecting choices in practices ways to reach sustainable food production. For example, not all approaches include the social aspects related to sustainability ignoring the impacts of practices on farmers.

This study has two objectives:

1. Look at several approaches that aim to increase or promote sustainable agriculture, and to identify similarities and differences, while deriving implications for policy makers.
2. Provide insight in how the approaches to sustainable agriculture contribute to these priorities.

1.1 Method

We categorized the various approaches using simple indicators and used several methods to compare the approaches and to assess their contribution to the policy goals, especially to the three main goals of the Dutch policy agenda.

The report starts with a short introduction of the approaches, followed by an analysis to see how these relate to each other. The categorization and indicators analysis is done by the project team. In addition, a group of experts within Wageningen UR was approached to reflect on the selected approaches.

2 The approaches

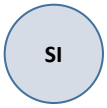
The study focusses on seven key approaches with different histories and entry points to sustainable agriculture. First we will shortly describe the approaches and present a tabular overview with the main characteristics.

2.1 Agroecology

Agroecology is the application of ecology to the design and management of sustainable production systems. It is a whole-systems approach to agriculture and food systems development based on traditional knowledge, alternative agriculture, and local food system experiences. The approach links ecology, culture, economics, and society to sustain agricultural production, healthy environments, and viable food and farming communities. (Source: agroecology.org)

Agroecology (AE) is a science, a practice and a movement. As a science, agroecology involves the holistic study of agro-ecosystems; as a practice, agroecology enhances the resilience and ecological, socio-economic and cultural sustainability of farming systems; and as a movement, it seeks a new way to link agriculture and with society Silici (2014). The concept has matured from a scientific discipline rooted in the ecological sciences starting in the early 20th century to a societal movement in the 1980s. AE is currently looking for a stronger link with agricultural policies, in this endeavour the historical roots in the ecological movement and the many interpretations could prove to be to an obstacle for agroecology to become an overarching concept.

2.2 Sustainable intensification



The goal of sustainable intensification is to increase food production from existing farmland while minimizing pressure on the environment. The approach is a response to the challenges of increasing demand for food from a growing global population, recognizing the overexploitation of land, water, energy and other inputs. (Source: www.futureoffood.ox.ac.uk)

The rational behind sustainable intensification is simple and straightforward. Key is the need to respond to the increasing and changing demand for food related to a growing and wealthier population without putting additional stress to the environment by claiming more land or via pollution (Pretty, 1997, Tilman et al, 2011). The leading community for SI consisting mainly of scientists and agronomists has a strong focus on primary production and resource efficiency of water and agrochemicals by using the best available technology and knowledge. The term sustainable is however not very well defined and seems mainly relate to environmental impacts.

This focus resonates well by farmers and industries as efficient use of inputs and increasing production levels have a positive effect on the performance and profitability of the farm (Baulcombe et al, 2009). It also links to science which has been looking at improving farm outputs for decades.

2.3 Climate smart agriculture

Climate smart agriculture (CSA) is an approach to developing the technical, policy and investment conditions to achieve sustainable agricultural development for food security under climate change. The aims of CSA are to sustainably increase agricultural productivity and incomes, adapt and build resilience to climate change and to reduce and/or remove greenhouse gases emissions, where possible. (Source: fao.org - Sourcebook on Climate-Smart Agriculture, Forestry and Fisheries)

Climate-smart agriculture (CSA) aims to transform and reorient agricultural production systems by developing the technical, policy and investment conditions to achieve sustainable agricultural development for food security under climate change (FAO, 2013). Three elements shape this approach i) increase productivity, ii) enhance resilience (adaptation) and iii) reduce GHG emissions and/or remove GHGs from the atmosphere (mitigation).

CSA was coined by FAO in 2010 at the Hague Conference on Agriculture, Food Security and Climate Change. The concept was initially developed with a strong focus on mitigation and food security but evolved towards an adaptation and food security focus. In Europe, the concept is mainly driven by the need to meet the increasing demand for biomass in quantity and quality for various forms of industry (chemicals, pharmaceuticals, construction, packaging), and to provide alternative energy sources to replace fossil fuels for various other sectors in the economy (Wageningen UR et al, 2013). Also, agriculture is increasingly seen as a sector with potential to reduce greenhouse gas emissions.

Since its introduction, the term CSA was rapidly adopted by the international community, national governments and research institutions. The FAO and the Word Bank are the largest promoters, together with other UN agencies like IFAD, UNEP and the WFP, and with the CGIAR through its Research Program on Climate Change, Agriculture and Food Security (CCAFS). According to FAO, the CSA concept now has wide ownership. In July 2015, the Global Alliance on Climate Smart Agriculture (GACSA) which was launched during the UN Climate Summit in September 2014 in New York had 96 members, including 22 governments. Most members are from intergovernmental organizations and organizations for research, extension and education. Five members come from the private sector.

More than 100 civil society organisations rejected the GACSA, arguing that the CSA paradigm provides a platform for agribusiness and industrial agriculture to promote their practices as solutions to climate change. A quote from the letter: "Climate-smart agriculture will serve as a new promotional space for the planet's worst social and environmental offenders in agriculture." (Climate Smart Agriculture Concerns, 2014).

The Africa CSA alliance (ACSAA) was launched in June 2014 by The New Partnership for Africa's Development (NEPAD) with the aim to scale-up the adoption of CSA practices by smallholder farmers in Sub-Saharan Africa to improve their food and livelihood security and resilience to climate change.

The holistic nature of the CSA approach is at the same time its limitation. CSA covers different types of actions, spatial scales and domains. CSA relates to actions both on-farm and off farm, and incorporates technologies, policies, institutions and investment. Actions may include management of farms, crops livestock and fisheries to manage resources better, ecosystem and landscape management and services for farmers and land managers (FAO et al, 2015).

Due to the wide variety of actions in the form of management, organisation, policy and financing the CSA approach runs the risk to become a container term.

2.4 Landscape approach

Landscape approaches seek to provide tools and concepts for allocating and managing land to achieve social, economic, and environmental objectives in areas where agriculture, mining, and other productive land uses compete with environmental and biodiversity goals. (Source: Sayer et al., 2013)

The landscape approach (LA) was developed as a framework for landscape level conservation measures. The landscape approach looks across large, connected geographic areas to more fully recognize natural resource conditions and trends, natural and human influences, and opportunities for resource conservation, restoration, and development. It seeks to identify important ecological values and patterns of environmental change that may not be evident when managing smaller, local land areas. In short, the landscape approaches seek to address the increasingly complex and widespread environmental, social and political challenges that transcend traditional management boundaries (Reed et al., 2015).

Biodiversity conservation has been addressed in an explicitly "landscape context" since at least 1983 (Sayer et al., 2015). In 1997, a comprehensive account of ecosystem management used the term landscape only in the context of the visual impacts of forest management interventions. The approach is mainly promoted by conservationists, but increasingly used to link to industries and markets via the value chain.

LA combines conservation, food production and development efforts in the landscape context (Reed et al., 2015) and is adopted by mainly conservation oriented NGOs and to a lesser extent science groups and policymakers.

2.5 Conservation agriculture

Conservation agriculture aims to make better use of agricultural resources through the integrated management of available soil, water and biological resources, combined with limited external inputs. It contributes to environmental conservation and to sustainable agricultural production by maintaining a permanent or semi-permanent organic soil cover. Zero or minimum tillage, direct seeding and a varied crop rotation are important elements (Source: http://www.fao.org/docrep/004/y2781e/y2781e03.htm).

Conservation agriculture (CA) is defined in several ways but the key components are to keep soil disturbance by ploughing or other soil tillage practices at a minimum, leave crop residues in the field and use crop rotation to control diseases (Hobbs et al, 2008). The claimed benefits are a better soil quality resulting in higher and stable yields. In addition costs related to machine use for tillage and disease management are reduced. The idea of CA started in 1930s in the mid west of the USA during the dust bowl to fight land degradation. The approach is now widely adopted in the region. For similar reasons of soil degradation it has been adopted in parts of Brazil.

CA is widely promoted by global institutions such as the FAO, farmers in the US and Brazil who apply the approach. The scientific basis of CA and more specifically the transferability to other regions is recently debated in e.g. Hobbs et al (2008), Andersson & Giller (2012), Giller et al (2009, 2011). The positive effects on reducing soil erosion are recognised, but a key issues raised by Giller et al (2009) is that the proponents of CA focus mainly on the outcomes of a holistic CA approach and do not see the need to identify and understand the underlying causes and process that lead to the success. The diversity in definitions and a strong established community doesn't work in favor of the scientific underpinning of CA.

CA is limited in focus on management practices that impact short and long term soil quality. It was designed to combat soil erosion. Consequently, other benefits are not always clear or unintended, such as reduced costs related to lower fuel consumption. Recently mitigating climates change offered a new additional benefit via carbon sequestration, the potential of CA for climate change mitigation is however not clear.

2.6 Organic farming[1]

Organic farming is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. There are many explanations and definitions for this approach but all converge to state that it is a system that relies on ecosystem management rather than external agricultural inputs. It is a system that begins to consider potential environmental and social impacts by eliminating the use of synthetic inputs, such as synthetic fertilizers and pesticides, veterinary drugs, genetically modified seeds and breeds, preservatives, additives and irradiation. These are replaced with site-specific management practices that maintain and increase long-term soil fertility and prevent pest and diseases. (Source: http://www.fao.org/organicag/oa-faq/oa-faq1/en/)

Organic farming (OF) is an ecologically oriented type of farming that distinguishes itself from conventional farming by its emphasis on naturalness and environmental sustainability (IFOAM, 2010). The concept is rooted in the ideas developed by Rudolf Steiner in the early 1920's in response to the introduction of synthetic fertilizer. Initially, OF started by soil scientists who were looking for new ways on how advancements in biological science could be used in agriculture to remedy negative side effects. Up take of the approach is global including countries as Britain, Germany, Japan, and the US. The uptake is driven by idealistic, passionate and mainly prosperous followers of the anthroposophical ideas.

Currently OF is practiced in many countries and is promoted by NGOs but also by international agencies like the FAO. Research is well established in institutes and universities but not without debate. Perhaps the most debated issue is the land productivity of organic systems compared to other approaches. A recent review and metadata analysis of yield data by de Ponti et al (2012) comparing organic and conventional agriculture showed that currently organic yields of individual crops are on average 80% of conventional yields. The analysis of 362 datasets also showed a high variation of the yield gap of organic agriculture (standard deviation 21%). More recently Ponisio et al (2014) found that organic yields are only 19.2% (+3.7%) lower than conventional yields.

Methods used in OF are internationally regulated and based on standards set by the International Federation of Organic Agriculture Movements (IFOAM). This umbrella organization for organic farming organizations was established in 1972 and provides the standard for organic farming methods and which inputs can be used. Clear examples are the ban on certain agrochemicals such as inorganic fertilizer, pesticides and herbicides and genetically modified crops. This provides clarity to farmers and consumers but also restricts the approach in adopting new technologies and methods.

[1] In the questionnaire we used the term biological agriculture.

2.7 Inclusive green growth

Inclusive green growth is a term to describe a path of economic growth that uses natural resources in a sustainable manner. It is used globally to provide an alternative concept to typical industrial economic growth. Inclusive green growth adds the aspect of poverty alleviation. It aims to operationalize sustainable development by reconciling developing countries' urgent need for rapid growth and poverty alleviation with the need to avoid irreversible and costly environmental damage. (Sources: wikipedia.org and World Bank, 2012)

Inclusive green growth (IGG) is different from the previously discussed approaches because it encompasses all sectors of the economy. IGG was introduced linked to the Rio+20 conference to stress the importance of social welfare and short and long term environmental sustainability in economic growth. It builds on the sustainability paradigm introduced by the Brundtland Comission in 1987 and the three pillars of sustainable development: economic, environmental and social sustainability (later coined as people, planet, profit). IGG builds on the sustainability paradigm and aims to operationalize sustainable development by reconciling developing countries' urgent need for rapid growth and poverty alleviation with the need to avoid irreversible and costly environmental damage (Fay, 2012). The approach has become an important focus in Dutch foreign policy.

With IGG the development paradigm is shifting towards a balanced economic development in which the role of the natural resources base is acknowledged and benefits the welfare of current and future generations. So far the key players in IGG are national governments and international agencies, the approach is an overarching concept but not well defined and lacks a clear scientific community.

Both the strength and weakness of IGG is the fact that the approach focusses more on the governance process and not so much on goals and practices. Bouma & Berkhout (2015) indicate that "Inclusive Green Growth strategies require attention for resource efficiency and access, sustainable management of global public good resources and inter- and intra-generational equity" and "for Inclusive Green Growth strategies to be effective, these need to address the underlying market and governance failures that make current growth paths generally non-inclusive and non-green".

The position and strategies used for agriculture in an IGG process will strongly depend on the goals and aspirations of individual countries. Existing approaches and new technologies can be included but the main challenge will be to be clear about trade offs and synergies with

3 How different are the approaches?

In this chapter, we map the approaches according to their societal and economic goals. Next, we position the approaches along axes with end points representing extreme values of key characteristics relevant to policy makers and other actors with the capacity to influence agricultural production systems.

3.1 Goals

The aim of the indicator set is to map the main goals of the approach. We took the method developed by Vereijken (2002) who used six goals to describe the transition in agricultural visions and derived systems in Europe over the last 60 years.
The identified goals are:

- Production (P)
- Work & Income (W&I)
- Environment (E)
- Nature & Landscape (N&L)
- Health & Wellbeing (H&W)
- Climate (C)

Agriculture can serve a number of functions that link farming to society. Whether this actually will materialize will depend on the choices made at farm level and are the result of a combination of personal interests, skills, management style, the type of the farm and current agricultural and societal trends.

We will use the listed goals or functions to map the different foci of the approaches. Acknowledging that all goals can be served by most farming systems we focus on those goals that are explicit to the approach.

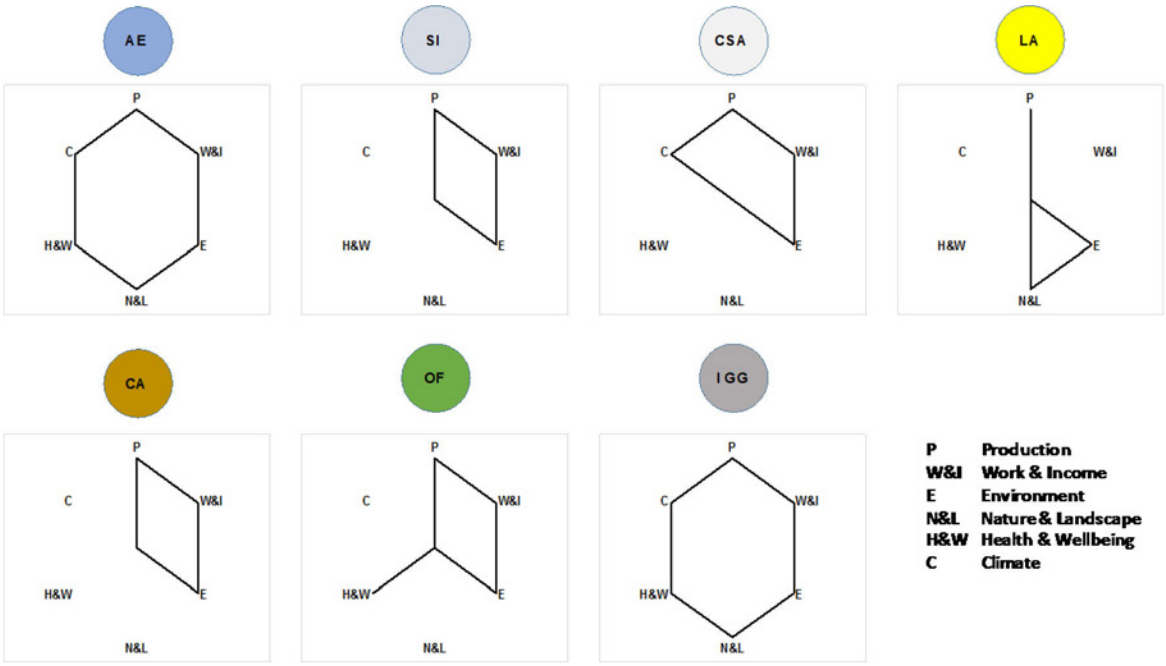


Figure 1 *Foci of the selected approaches.*

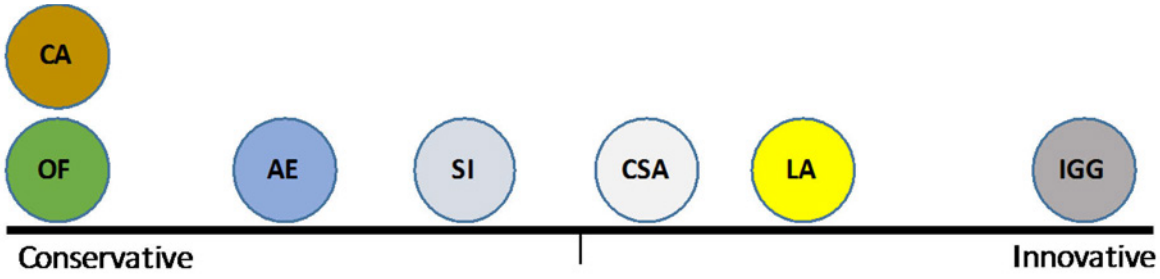
3.2 Discussion

From the mapping, presented in Figure 1, it is clear that almost all approaches focus on the traditional agricultural goals off production, work & income and environment. The landscape (LA) approach, with non-agricultural roots, does link to production but in relation to environment, nature & landscape. The "youngest" approaches AE and IGG are inclusive and link to all goals. It could be that these approaches are not developed enough to have a clear focus. Sustainable Intensification (SI) and Conservation Agriculture (CA) share similar goals.

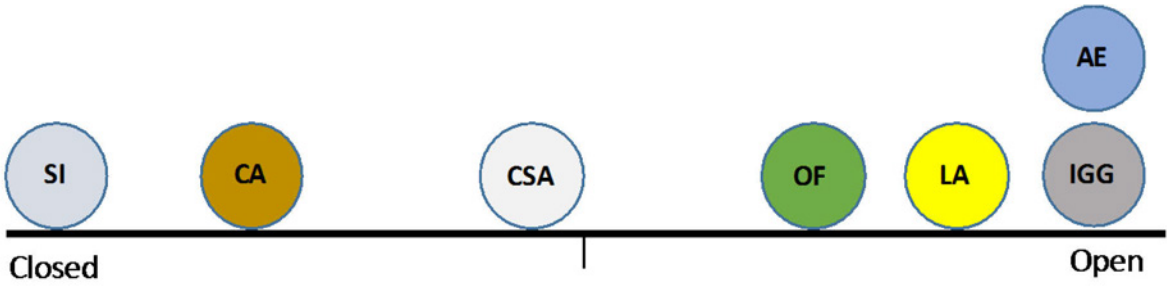
The mapping reflects the views of the project team. It also doesn't provide answers to the effectiveness of efficiency in achieving the identified goals.

3.3 Relative positioning of the approaches

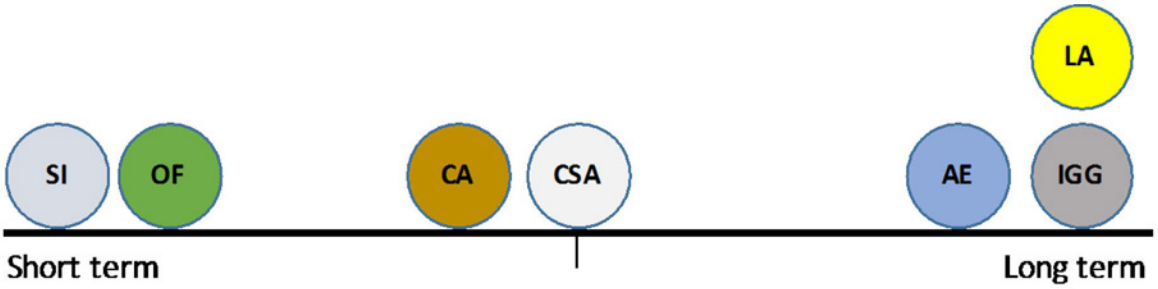
We selected extreme values of six relevant key characteristics and positioned the approaches on the axes in between based on the expert judgement of the project team.



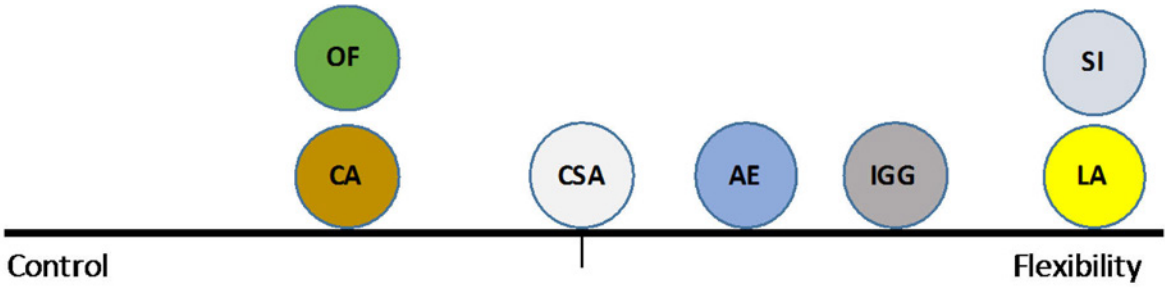
On this axis the approaches are positioned according to the willingness to adopt new technologies, methods and/or to include others functions or goals. More conservative approaches are those that are more reluctant to embrace or include new methods, functions and technologies, the more innovative approaches are those that are seeking to develop and include new technologies, methods and functions.



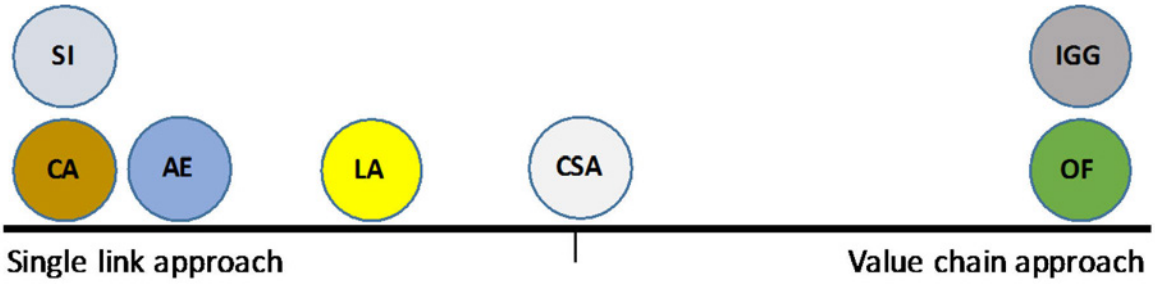
Closed approaches are those approaches that are focused on a limited set of goals related to (primary) agricultural production. Open approaches on the other hand are also looking for new opportunities both within and beyond primary production, like multifunctional or integrated approaches.



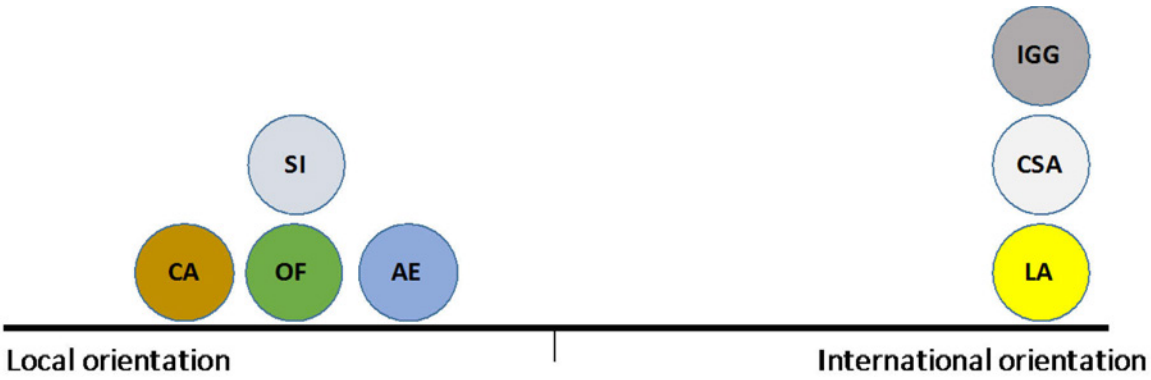
Short term approaches focus on more practical short term (<5 years) management approaches with quick visible effects whereas long-term approaches focus on more structural changes in food systems. A short term approach can be easily adopted by individual entrepreneurs, while long term approaches often need entering into partnerships.



This axis describes the differences between approaches that have a strong tendency to intervene in farm management versus the ones that allow self-regulation (flexibility/relaxation) and consider their system to be able to deal with variations and uncertainties.



This axis describes the relative position of approaches that include the value chain as part of their strategy to reach their goals and those that focus on a part in the value chain. The approaches focusing on a part of the value chain are strongly related to primary production. Taking a value chain approach implies understanding at which stages in the value chain economic and natural resources are consumed and under which market dynamics, and acting upon this to design solutions which are cost-efficient and welfare-optimising. These solutions could include creating incentives, increasing cooperation, or adopting technology.



Local orientated entrepreneurs focus on primary agricultural production, sustainability and resilience within their farming system and marketing to local or regional consumers. The approaches with an international orientation also include goals such as reduction of Greenhouse Gas emissions or development of ecological networks and look for a strong connection to the global political agenda.

3.4 Discussion

The selected axes are useful in the relative positioning of the approaches. This is particularly clear for the local – international and the single link - value chain axes where the groupings are most prominent.

IGG is an open, flexible, broad and inclusive approach which embraces innovation and focuses on the long term in an international setting. Whereas CA is a closed, conservative approach with a strong control over the tools and methods and has a strong focus on the short term in a local setting.

Moreover, the positioning of the approaches differs between the key characteristics. As such, the key characteristics and positioning of the approaches can be of use to policy makers to consider which approaches could be suitable for reaching policy goals. The approaches SI, IGG and CA figure most frequently on the end points of the axes, indicating that these approaches have a clear profile.

The positioning reflects the views of the project team.

4 Wageningen UR expert opinions

Because this study covers a broad range of approaches and to get a broader perspective to what the differences are we opted to include a small survey calling on expertise available in Wageningen UR. In this survey we specifically looked at the three key goals of Dutch foreign policy on food security and indicative topics as formulated in a statement from the Dutch Government to the parliament creating a direct link to a policy brief and including besides agronomic researchers we also included the social sciences in the survey.

The experts were asked to indicate the degree to which the approaches contribute to a list of topics and goals.

Key goals of Dutch foreign policy in relation to agriculture:
- Eradicating hunger and malnutrition
- Improving inclusive and sustainable growth in the agricultural sector
- Realising sustainable food production systems

The topics are listed in Appendix I and include a range of options from primary production, gender, market access and value chain. The Wageningen UR experts were asked to rate the goals and options for each approach they were comfortable with to share their opinion. We used a scale of 0 to 5, with 0 indicating no contribution, and 5 a very strong contribution, a blank indicates that the expert was not comfortable answering the question. The questionnaire was sent to 24 experts of these 11 responses were received, of which 2 from the project team.

4.1 Results of expert survey

Although the intention was to have a short survey, several experts indicated that the time needed to fill in the questionnaire was long, others did point to recent publications.

The experts appeared to be most comfortable in responding to questions related to agroecology, sustainable intensification, climate smart agriculture and organic farming. for which responses were received from on average 8-10 persons (Table 1).

Table 1 *Number of respondents per approach.*

Approach	CSA	SI	AE	OF	LA	CA	IGG
Respondents	11	10	9	9	8	7	7

4.1.1 Contribution to the three policy goals

All approaches score high on the goal to 'realising sustainable food production systems' with an average score of 3 (Figure 2). AE stands out with (score 3.3) and CA and OF are rated lower with 2.7. For the goal 'eradicating hunger and malnutrition' the range is significantly larger with IGG rated at 3 and CA with 1.3. Please note that the results are based on 11 responses.

None of the approaches stands out only IGG and SI score high for all three goals. For IGG consensus is higher than for SI.

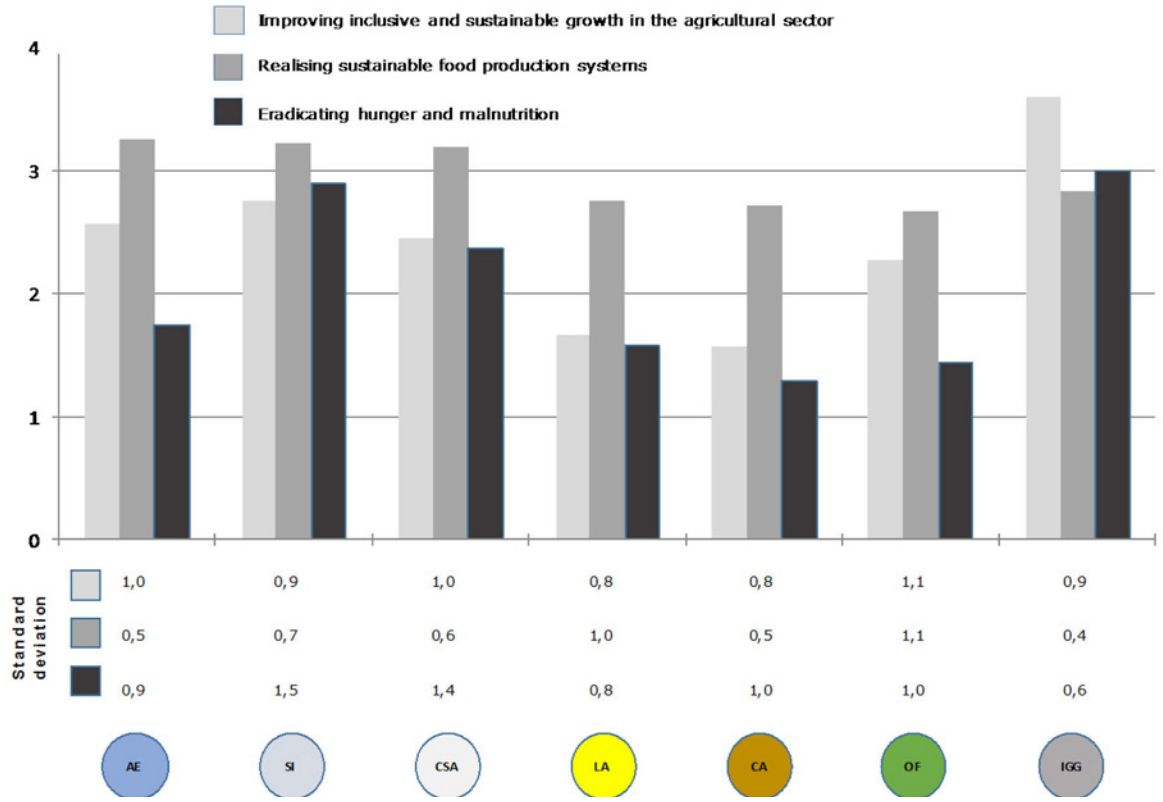


Figure 2 *Scoring.*

4.1.2 Contribution to specific topics

Overall, scores given to the contributions of the approaches to specific topics (see Figure 2) were below 3. Specific topics such as 'contribute to the requirement of 50-70% increase of agricultural yields until 2050' SI is rated as highest with a rating of 3.8 OF, with a score of 1.6, is closing the ranks. Not surprisingly for climate change mitigation and adaptation CSA scores high with 3.8 and 3.7 respectively, the other approaches are in the same range around 2.5. Increasing agrobiodiversity is, according the respondents, best served via AE and OF, and to a lesser extent LA. IGG is ranked as the approach least contributing to agro biodiversity.

4.2 Discussion

The questionnaire was designed to capture in a fast manner how Wageningen UR experts position the contribution of the approaches to the goals and topics that underpin Dutch policies on food security. The questions were based on the statement from the Dutch Government to the parliament.

The results provide insight in how, a limited group, Wageningen UR experts rank the approached. They suggest that IGG is seen as the approach that will best serve the policy goals followed by SI, CSA and AE, whereas OF, LA and CA are least likely to contribute to the three policy goals.

At the more detailed topic level the picture is somewhat different. Topics are linked to certain goals the higher scoring approaches for 'Eradicating hunger and malnutrition' are the production oriented ones such as CSA, SI, and AE followed by OF and IGG. For the sustainable development oriented goal 'Improving inclusive and sustainable growth in the agricultural sector' IGG and CSA are ranked as contributing the most. Also for topics related to 'Realising sustainable food production systems' AE, CSA are the highest ranking approaches followed not far by the other approaches.

Please note that the results related to the topics lists are based on 11 responses and standard deviations ranges from 0 to 1.6.

The statement to parliament was not designed to capture the details of the various approaches, and the questionnaire is limited in its range and depth. Several topics such as nutrition outcomes, institutional quality, reducing post-harvest losses, breeding programs, breeders' rights are not directly addressed by most approaches. Issue not well captured are organisation strengthening via e.g. cooperation's and the role of markets. All approaches except IGG are poorly connected to economic development outside the agricultural sector which are crucial in combating hunger and malnutrition

5 Results of Twitter Network Search

Social media are increasingly being used to create awareness and exchange information. To explore the network of people and organisations communicating about the selected approaches and the main topics addressed by these actors we used information from social media. This information is helpful in identifying influential actors.

5.1 Method

We analysed social media networks on the selected concepts in Twitter using NodeXL, an add-in for MS Excel (Smith, M. et al., 2010) which supports the exploration of social media by extracting network data.

We used the NodeXL Twitter Data Import feature to extract networks for the selected concepts on sustainable agriculture.

Searches were performed using the terms for the concepts as written, e.g. "climate smart agriculture". NodeXL collects from Twitter recent tweets on the topics, and creates a 'vertex' for each unique user who either tweeted one of those tweets, was replied to in one of those tweets, or was mentioned in one of those tweets. Next, NodeXL connects the vertices with 'edges'. Edges indicate the type of relationship that can be created through Twitter: follows, replies, mentions and tweets (Smith, M. et al., 2010). Ref438460468.

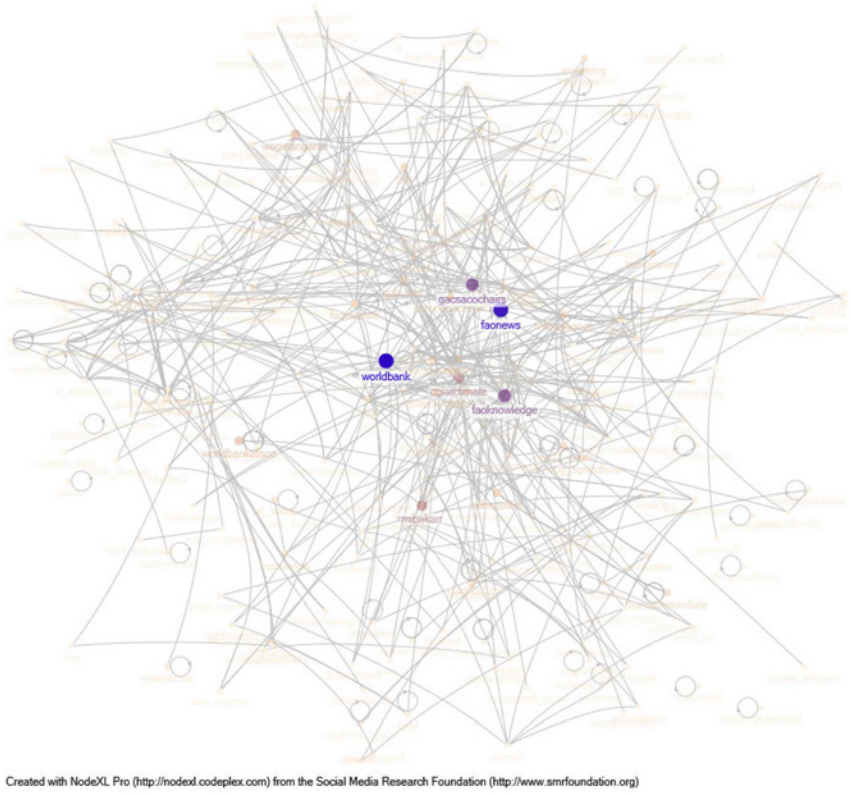


Figure 3 *Social Media Network on Twitter, reflecting activities between 8 and 15 December 2015 on the subject 'climate smart agriculture'.*

Figure 3 shows an example of a social media network mapped by NodeXL. Vertices are indicated by circle symbols, with more influential parties in larger, coloured circles. The grey lines indicate the relationships created in Twitter (edges).

With NodeXL properties of the network can be derived through network metrics. These metrics can be used to derive information on the importance of a vertex representing a Twitter user. The 'betweenness centrality' metric is a measure of "a node's centrality in the network equal to the number of shortest paths from all other vertices to all others that pass through that node" (Grimes, 2012). More simply it is a measure of a node's ability to bridge different subnetworks (Grimes, 2012). The individuals or organisations behind nodes with a high value for the betweenness centrality could be interpreted as influential in the network. The type of organisation was examined for each approach for the ten nodes with the highest betweenness centrality. The following types were recorded: network, NGO, individual, media, R&D institute, farmers' organization, financial sector, private sector (including industrial platforms), international organization. Individuals may include civilians but also representatives of industry, governments, R&D or NGOs expressing views through their personal Twitter accounts.

An important limitation from the NodeXL search is that Twitter results not older than one week are provided; it is not possible to obtain results older than a week with NodeXL (Smith, et al. 2010). Therefore the network search was performed four times during the project period: on August 16, September 17, December 1 and December 15 2015. This limitation implies that the results from the Twitter search must be interpreted with care; the global political and economic situation in the period of the search may strongly influence the types of Twitter users recorded, and the subjects addressed by them.

5.2 Number of active parties and exchanges

The number of Twitter users and 'edges' captured in the search on each concept are shown in Figure 4. The figure shows that 'organic farming' is by far addressed most on Twitter, with more than 2000 twitter users using the term in three of the four periods examined, and between 3000 and 8000 activities of either following, replying, mentioning or tweeting. Averaged over the four periods, the terms 'agroecology', 'climate smart agriculture' and 'organic farming' have the highest number of Twitter users and activities on Twitter. The terms 'sustainable intensification', 'landscape approach', 'conservation agriculture' and 'inclusive green growth' are hardly addressed.

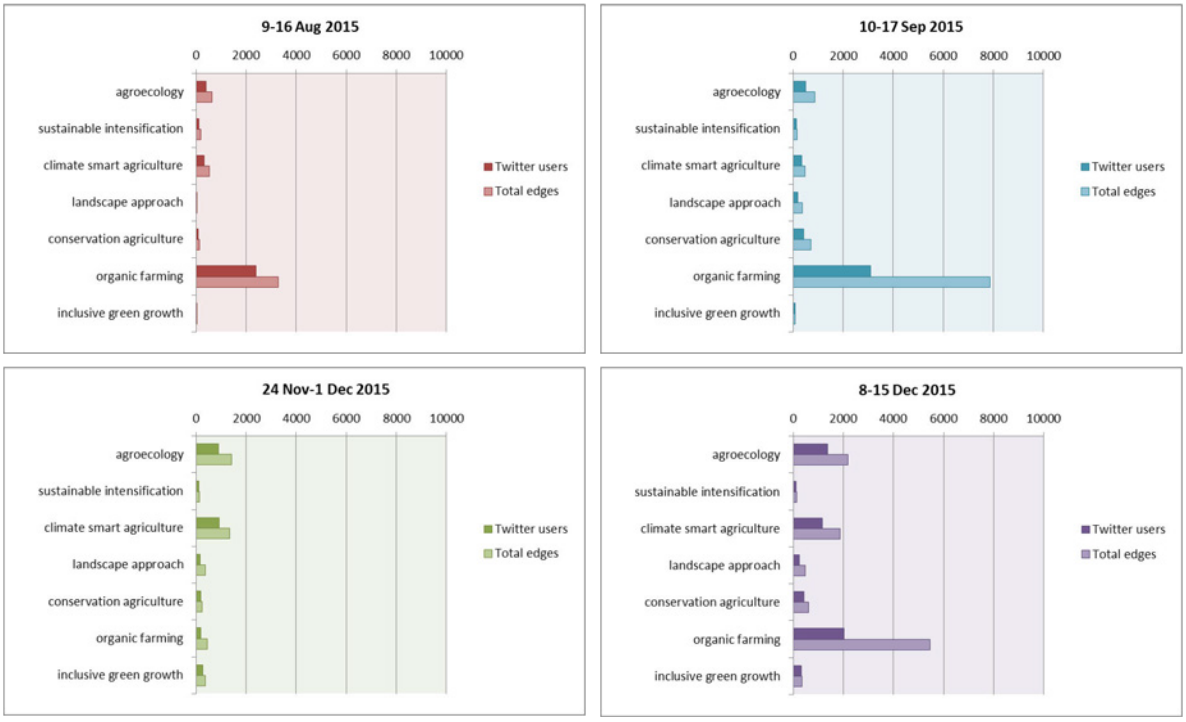


Figure 4 *Number of Twitter users and 'edges' in search on concepts of sustainable agriculture in 4 periods in 2015.*

5.3 Type of influential parties

AE, CSA and OF are addressed on Twitter by the most influential parties (Figure 5). For AE the farmers' organizations are the most influential. OF is addressed by a broader range of parties, including individuals, international organizations, media, networks, NGOs and the private sector. Considering all approaches media, networks and NGOs use Twitter most as a communication tool.

Remarkably, farmers' organizations were found to strongly address AE, where they were highly influential, and conservation agriculture. The financial sector was most active on CSA, the private sector on organic farming. Clearly governments, political parties, R&D institutes were not influential via Twitter.

Average of Betweenness Centrality	Concept							
User type	agroecology	climate smart agriculture	conservation agriculture	inclusive green growth	landscape approach	organic farming	sustainable intensification	Average
farmers' organization	121827		172					40724
financial sector		75090		4187	12			35236
government		1026	946	2186				1586
individual	43753	16812	1198	5602	87	135527	328	28177
international organization		76684		1242	71	109104		38375
media	49797	22928	1976		19	202283	6	66580
network	42559	156507	88	575	102	191426	51	54201
NGO	45282	18170	626	1	99	222124	756	58092
political party				177				177
private sector	40864	26784	705		46	147971	14	36910
R&D institute	8477	27601	1723		138	36	509	9594
Average	**45675**	**40713**	**1147**	**3489**	**84**	**169096**	**419**	**37859**

Figure 5 *Level of influence of parties addressing the concepts of sustainable agriculture on Twitter, expressed in the Betweenness Centrality.*

The dynamics changes over time for AE and CSA the level of influence increased, where OF received a peak of attention in September. The low level of influence for all approaches in August is perhaps explained by the period of summer leave in countries on the northern hemisphere. The upward movement in December can partly be attributed to the COP21.

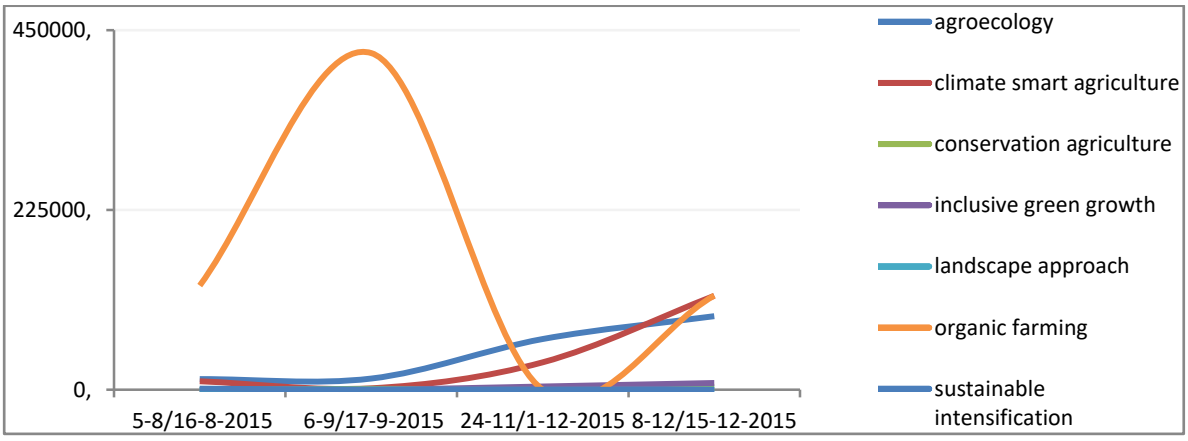


Figure 6 *Change in time of average level of influence of parties.*

5.4 Discussion and conclusions

The Twitter network search analysis showed that the approaches 'agroecology', 'climate smart agriculture' and 'organic farming' receive attention on Twitter, whereas 'sustainable intensification', 'landscape approach', 'conservation agriculture' and 'inclusive green growth' are hardly mentioned. This indicates that during the survey period the first three concepts receive attention from society.

The most influential parties addressing the most recognised concepts - AE, CSA and OF - are farmers' organizations and networks for respectively AE and CSA. OF is mostly addressed by individuals, international organizations, media, networks, NGOs and the private sector. This is an indication that these types of organizations are interested in these approaches. The interest could be positive, by promoting or implementing the concepts, but also negative, by criticising the approach. The proportion of positive to negative wording in the top words mentioned in the tweets indicates that positive expressions largely outweigh the negative wordings (10:1 on average), even for much debated approaches of sustainable agriculture like CA, CSA and OF.

Governments, political parties and R&D institutes were not influential at all in addressing the approaches of sustainable agriculture on Twitter. This most likely indicates that these groups are more focussed on other communicate channels to get their messages across.

Farmers' organizations and the private sector are important in implementing sustainable agriculture, both are highly influential in AE. In addition, the private sector was also highly influential in CSA and OF. This may guide policy makers in the subjects of dialogue with these parties and the selection of policy instruments.

The results apply to the period from August to December 2015, and have to be seen in the societal, political and economic context of this period. Results can change suddenly, as is demonstrated by the change in activity on OF.

6 Final remarks

To compare and evaluate different approaches was not a straightforward exercise. This is maybe because the different approaches have grown or matured over the years or because priorities in society changed. In this report the approaches were looked at to get insights in whether and how the approaches contribute to three priorities in Dutch food security policy agenda:

1. Eradicate hunger and malnutrition;
2. Stimulate sustainable inclusive growth in the agricultural sector;
3. Achieve ecologically sustainable food systems.

We started with a short introduction of the approaches and categorized the approaches using different sets of indicators. In addition, we tapped into the expert pool of Wageningen UR to reflect and provide input. This study provides insight in how the team views the different approaches and is meant to help policy makers with placing these approaches in a wider context. And although drawing firm conclusions is difficult we want to share the following observations:

Most of the approaches focus on production and environmental impacts following either a path to reduce inputs or increase efficiencies. Also work and income is often part of the equation but how this is achieved is not made explicit, in most cases the assumption is the increased production will result in higher revenues.

Flexible approaches provide a clear opportunity to allow for learning may provide a good option to reach the set policy goals. The more prescriptive approaches are more restrictive but provide clear guidance to user groups.

Unfortunately, all approaches lack a clear monitoring and evaluating system. If any monitoring is done the key focus is mainly on the inputs and activities used and not on the actual outcomes or results. A more systematic way to monitor and evaluate the various approaches could help in assisting farmers and policy makers to shape sustainable agriculture and achieve policy goals related to agriculture.

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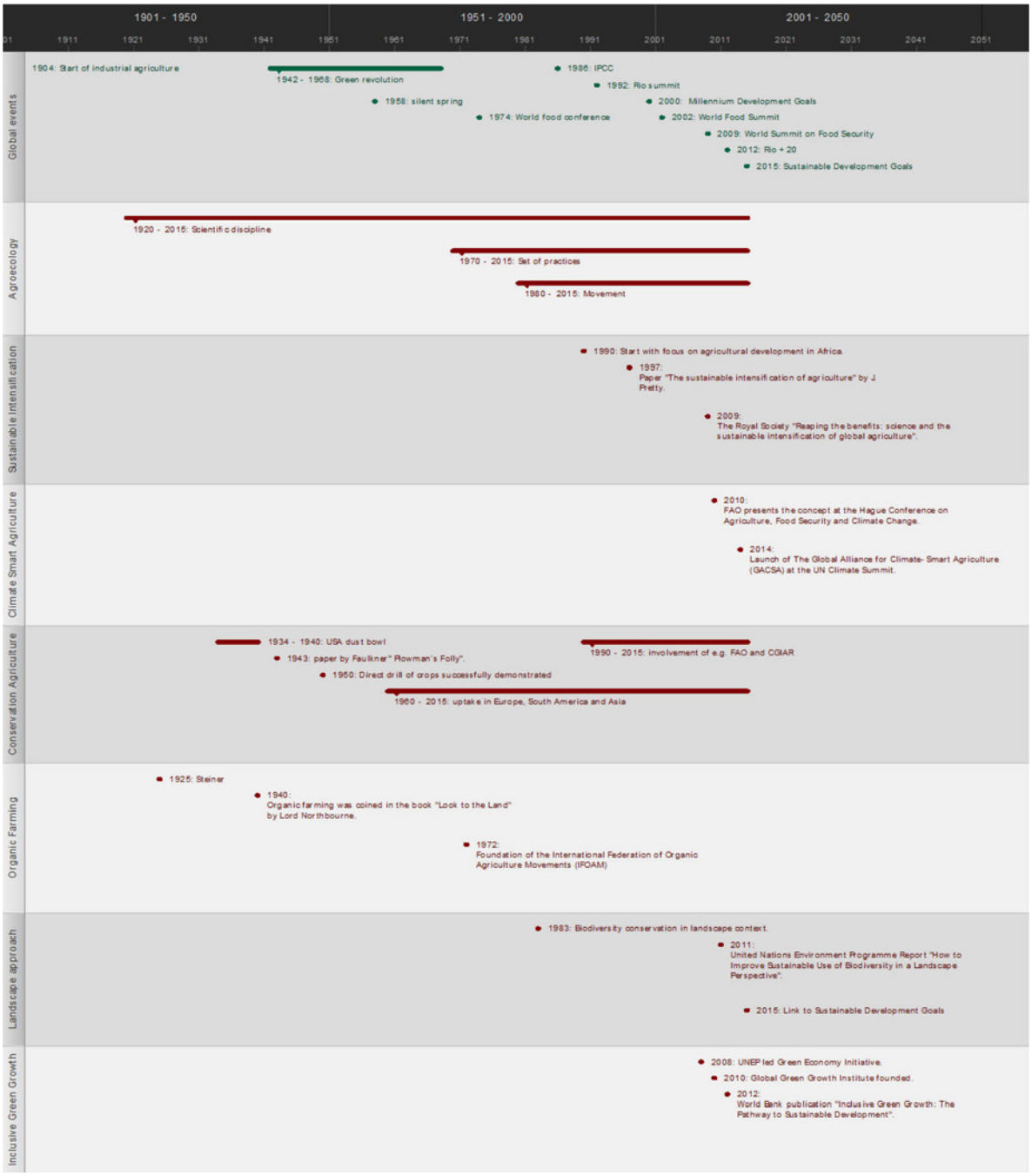
Annex 1 Simplified timeline for the approaches



Annex 2 Topics and goals in the questionnaire on approaches for sustainable agriculture

Goals
Eradicating hunger and malnutrition
Improving inclusive and sustainable growth in the agricultural sector
Realising sustainable food production system
Topic
increasing health-improving substances in food products
crop & livestock breeding programs
reducing post-harvest losses
combating pests and diseases
building resilience against shocks (e.g. from drought or price fluctuations)
contribute to the required 50-70% increase of agricultural yields until 2050
incentivizing young farmers and female farmers to agricultural entrepreneurship
contribute to the improvement of income for smallholder farmers
stimulating cooperative activities and membership
improved access to seeds by strengthening local seed production
support plant breeders' rights
improve food chain efficiency (logistics, reduce losses and energy use)
challenge private sector to provide smart solutions and inclusive business models for food chains
decreasing food waste/loss and increasing food quality
strengthen international corporate societal entrepreneurship (OESO guidelines, Principles of Committee on World Food Security)
stimulate water reuse & recycling
maintain/improve soil health
rehabilitate marginal land
energy saving, using renewable energy
valorising residue and waste streams from agriculture
increasing agro-biodiversity (by e.g. crop rotations, cover crops, herbs, field borders) and biodiversity in natural land (e.g. corridors, habitats)
climate change mitigation through reducing GHG emissions or capturing and storage of CO2
Contribute to adaptation to climate change
sustainable development of livestock sector

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Report WPR-677

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