

**Danish Agriculture
& Food Council**



SEGES



Sustainable Intensification of Agriculture in Developing Countries

Danish & Dutch Expertise and Technology

Presented by

**Danish Agriculture and
Food Council/SEGES
& Agriterra**

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INTRODUCTION

Agriterra and the Danish Agriculture and Food Council / SEGES, the collaborating organisations, share a joint vision on sustainable intensive agricultural production as a solution to the climate challenge. In Denmark and the Netherlands, farmers and their cooperatives have in recent decades succeeded producing more with less, limiting Greenhouse Gas (GHG) emissions while increasing agricultural production and as a result have produced some of the world's most climate efficient commodities.

The increasing demands on agricultural productivity due to the combination of rising income, population growth, objectives to meet nutritional requirements, biodiversity protection and climate change mitigation is fuelling the need for more efficient agricultural techniques. In developing countries, any movement away from traditional very low productive slash-and-burn agriculture is progress. In Europe, however, the nuances between intensive vs. extensive agricultural production, which requires a greater area of land required for the same amount of output, has resulted in fierce controversy.

The collaborating organisations have determined their focus will be on intensive agricultural production, which both increases output using the same area of land and gives room for forest protection and reforestation in developing countries where intensification will reduce forest felling. (see Figure 1).

Figure 1: Intensive vs. extensive agricultural production



Source: (Chalmers, 2019)

The collective expertise and experience of the collaborating organisations can be leveraged to support the agricultural sector in developing countries in Africa, Asia and Latin America make the transition to more sustainable agriculture. Current sustainable intensification and precision agriculture technologies and innovations as well as those yet to be developed offer great potential to support developing countries with climate change adaptation and mitigation.

Danish and Dutch farmers have carbon efficient technology solutions and knowhow to offer and are eager to co-create technological adaptations and innovations with farmers and cooperatives in developing countries. They are poised to engage in a decade-long process with the aspiration to work towards climate-neutral agriculture in Europe and contribute to adaptation, mitigation and rapid development in Africa, Asia and Latin America.

The collaborating organisations also aspire to facilitate accreditation of an agricultural entity, such as Agriterra, to the Green Climate Fund (GCF). This could contribute to enhancing the participation of agriculture in the implementation of the Paris Agreement, consistent with initiatives recently brought forth to the UNFCCC Standing Committee on Finance by stakeholders representing the farming constituency.

The World Farmers' Organisation (WFO) has expressed a desire for the Green Climate Fund to have an accredited entity from the agricultural community. "The inclusion of one or more accredited entities from for example, the world's agri-agencies and cooperatives, would enhance ownership of the implementation of the Paris Agreement amongst the global community of world farmers. Also, mobilizing GCF climate finance for peer to peer cooperation might be a valuable means to enhance transfer of technology and best practices for climate smart agriculture." (WFO, 2019)

Such an accreditation would facilitate knowledge transfer from world class agricultural advisory systems which underpin successful models of sustainable intensive production, such as the Danish and Dutch, to farmers and cooperatives in the developing countries. This endorsement would not only support the collaborating organisations to pilot new technological solutions and other visionary actions but could also lead to the discovery of new business models leveraging resources beyond traditional funding mechanisms to bring solutions to scale and make them replicable in other continents.

COLLABORATING ORGANISATIONS

The Danish Agriculture & Food Council (DAFC) /SEGES

The DAFC represents the farming and food industry of Denmark including companies, trade and farmers' associations, and owns SEGES (<https://agricultureandfood.dk/>). The DAFC is a member of the World Farmers Organisation (WFO), a farmer organisation, made by farmers for farmers. It is member-based and brings together national farmers' organizations and agricultural cooperatives, from all over the world. The WFO is represented as part of the Farmers Constituency at UNFCCC (<http://www.wfo-oma.org/>).

SEGES offers solutions for the agriculture and food sector of the future, with a primary objective to identify the commercial potential in agriculture to provide Danish farmers and horticulturalists with the best tools for running their businesses more profitably and in a way that takes account of the environment and animal welfare. SEGES covers all aspects of farming and farm management – from crop production, the environment, livestock farming and organic production to finance, tax legislation, IT, architecture, accounting, HR, training and conservation. This is carried out in close partnerships with universities, government departments, businesses, municipalities, regions and trade associations. As the research and innovation centre for agriculture and the food industry in Denmark, SEGES is part of the DAFC. (<https://www.seges.dk/en>).

Agriterra

Agriterra is an international specialist in cooperative development that offers high-quality, hands-on, peer-to-peer advice and training to cooperatives and farmer organisations to increase agricultural productivity, empowerment of farmers and off-farm rural employment. The agri-agency is founded and steered by the Dutch mainstream organisations of (young) farmers, cooperatives and rural women. Agriterra makes cooperatives bankable, creates farmer-led businesses, improves extension services to members and enhances dialogue between farmers and governments. Agriterra uses a unique pool of agricultural cooperative and farmer organisation experts from the Netherlands and other countries to perform assignments, engage in scoping or cooperative assessments in partnership models for governments, banks, investors and donors and act as a direct sourcing broker for agri-food businesses. Agriterra is unique in that it has a specific focus on agriculture and rural development and is embedded in the worldwide movement of farmers' organisations. (<https://www.agriterra.org/>). Agriterra is a member of Agricord – the global alliance of agri-agencies mandated by farmers organisations (<https://www.agricord.org/en>).

Synergy

It is a natural fit for the collaborating organisations to be working together as they are synergistic rather than overlapping. DAFC/SEGES offers world class agricultural advisory services in Denmark and Agriterra is a world class agri development agency. The organisations share a common vision of sustainable intensification and GHG emissions reductions in implementing the Paris Agreement and through this collaboration will offer their expertise to farmers and cooperatives in Africa, Asia and Latin America.

In this collaboration, Agriterra is the implementing agency and SEGES is the knowledge provider, who will support Agriterra by facilitating access to top-notch Danish knowledge on agricultural technology. Agriterra will source tacit knowledge for the field by recruiting and hiring experts from Danish cooperatives and farmer organisations, as it currently does from the Netherlands and elsewhere in the world. SEGES will provide IT tools for agriculture, such as those based on remote sensing, that could potentially be adapted to contribute to climate change mitigation in developing countries. SEGES will also monitor the progress in agricultural productivity, the metric identified as the best indicator for climate efficiency.



CONTEXT

Agriculture's impact on climate

A global climate emergency is taking place and is evidenced all over the world — melting glaciers, rising sea levels and extreme weather conditions. At the same time, the global population is projected to rise to 9.8 billion in 2050 with food demand projected to increase by more than 50% and demand for animal-based foods by nearly 70% (Searchinger, et al., 2018). Immediate climate action is required and if GHG emissions are not reduced, the planet will face major and irreversible changes, including food insecurity, which will disproportionately impact those in developing countries.

The global agricultural community and food industry face an important task to address climate change and at the same time have an opportunity to contribute to climate change adaptation and mitigation actions. The agriculture sector, responsible for critical functions such as food security and safety, has been the first economic sector to be impacted across the globe by a changing climate. Although the sector is a contributor to climate change, agriculture and farmers also have solutions for climate change, food safety, health and nutrition and rural development. For example, farming and forestry has an incredible potential role in climate action as is the only sector that can effectively sequester CO₂ from the atmosphere through photosynthesis, whereas other sectors can solely cut GHG emissions.

The Agriculture, Forestry and Other Land Use (AFOLU) sector is one of the main contributors to GHG emissions in the world, associated with approximately 20% of global GHG emissions. Agriculture uses almost half of the world's vegetated land (Searchinger, et al., 2018) and food production accounts for 24% of the world's CO₂ emissions (Smith & et al, 2014). In 2010, agricultural emissions were 12 GtCO₂e/Year, but emissions will triple by 2050 without productivity gains (Searchinger, et al., 2018). Resource constraints over water, soil, biodiversity and land will affect agricultural systems and unsustainable agroecosystems will further deplete these resources for the future (Pretty & Pervez Bharucha, 2014). Developing countries are most vulnerable to climate change and the family farmers in Africa, Asia and Latin America will suffer.

Smallholder farmers are responsible for a relatively small but substantial share of AFOLU emissions, accounting for 5% of all emissions globally (Vermeulen & Wollenberg, 2017). Although in many cases, smallholders are users of natural resources and ecosystems, there is potential to reduce their emissions through the adoption of low emissions strategies or carbon fixation practices, such as optimization of nitrogen fertiliser use, reduced tillage, improved productivity, reduced slash-and-burn agriculture through agroforestry and avoided conversion of forest to farm land.

Agriculture is the most significant driver of deforestation. In Africa and South East Asia in particular, forest degradation and deforestation are a result of activities undertaken by subsistence farmers. For example, about 60% of new agricultural land in Africa came from intact forests in the 1980s and 1990s and was mainly used for small-scale and subsistence agriculture and farming (European Union, 2018). However, and the dynamics vary per region and with the geographic distribution of the importance of commercial vs. subsistence agriculture (Kissinger, et al., 2012), such as expanding cattle herding in Latin America in both commercial and subsistence agriculture. The use of wood through savannah burning and cooking/heating is also a major contributor of deforestation. Although it is not an efficient way of treating plant residues and seasonally results in black carbon emissions, when used carefully it can serve as an important way to reduce forest fire risk. For smallholder agriculture and its dynamics, which vary immensely and impact net emissions, it is important to invest in agroforestry,

conservation agriculture and the use of carbon fixating plants depending on soil, water availability and use of natural resources.



Slash-and-burn agriculture – photo: Agriterra

Africa contributes 8% to global GHG emissions (European Union, 2018), of which 36% consists of wood burning. Deforestation due to slash-and-burn agriculture is unaccounted for in this percentage. Every year 1 billion hectares is destroyed in Africa by slash and burn agriculture and carbon emissions for each hectare equals 6000 cars (Savory, 2013). Africa has the highest per capita levels of the world for black carbon emissions, the most damaging air pollutant, contributing almost 17% to overall black carbon emissions. In Asia particularly in Indonesia and Malaysia, another large source of emissions is generated from burning peatland. The growing demand for fuel wood for cooking and heating increases the need for planted forests. About 2.4 billion people rely on wood or charcoal for their domestic energy needs (FAO, 2018). Unless the remaining forest areas in Africa are protected by investing in planted forests, agroforestry and agricultural productivity, competing land use methods and the need for wood will gradually consume forests.

Although smallholder farmers have considerable experience in dealing with climate variability, the unprecedented levels of variability associated with long-term climate change are outside the realm of their traditional coping strategies. They are disproportionately vulnerable to the impacts of climate change as a result of poverty, marginalization and reliance on natural resources and their livelihoods are frequently threatened by weather extremes (Sietz, et al., 2012). Agricultural productivity in African rural areas, for example, is severely affected by climate variability which elevates the vulnerability of rural households to food insecurity (Mohammed et al., 2018). Projections indicate that aggregate yields of maize in smallholder rain-fed systems in Africa and Latin America are likely to show a decrease of $\approx 10\%$ by 2055 (Morton, 2007).

The contribution of poor rural dwellers to environmental damage and climate change, makes action particularly urgent in developing countries due to the expected doubling of population in Africa, for example. For nearly 10 billion people globally to have enough to eat, it will necessary to produce more food (e.g., cereals, maize, vegetables and potatoes) more efficiently.

In addition, consumption of animal-based foods is projected to rise 68% between 2010 – 2050, with an 88% increase in consumption of ruminant meat (meat from cattle, sheep, and goats), partly due to income growth as more people are lifted out of poverty in developing countries and able to afford to supplement their diets with meat (Searchinger, et al., 2018). This increased demand for a more animal-based diet is major contributor to the food, land and GHG mitigation gaps as it will require many times more feed and land inputs and emit far more GHG emissions per food calorie generated than plant-based foods (Searchinger, et al., 2018).

In December 2015 at the Paris Climate Conference (COP21), 195 countries adopted the first-ever universal, legally binding global climate deal, The Paris Agreement (European Commission, n.d.). Its central aim is to strengthen the global response to climate change by keeping a global temperature rise this century well below 2°C above pre-industrial levels, pursue limiting temperature increase to 1.5°C and strengthen the ability of countries to deal with the impacts of climate change (UNFCCC, 2019). The EC's strategic long-term vision is for a prosperous, modern, competitive and climate-neutral economy by 2050 (European Commission, 2018).

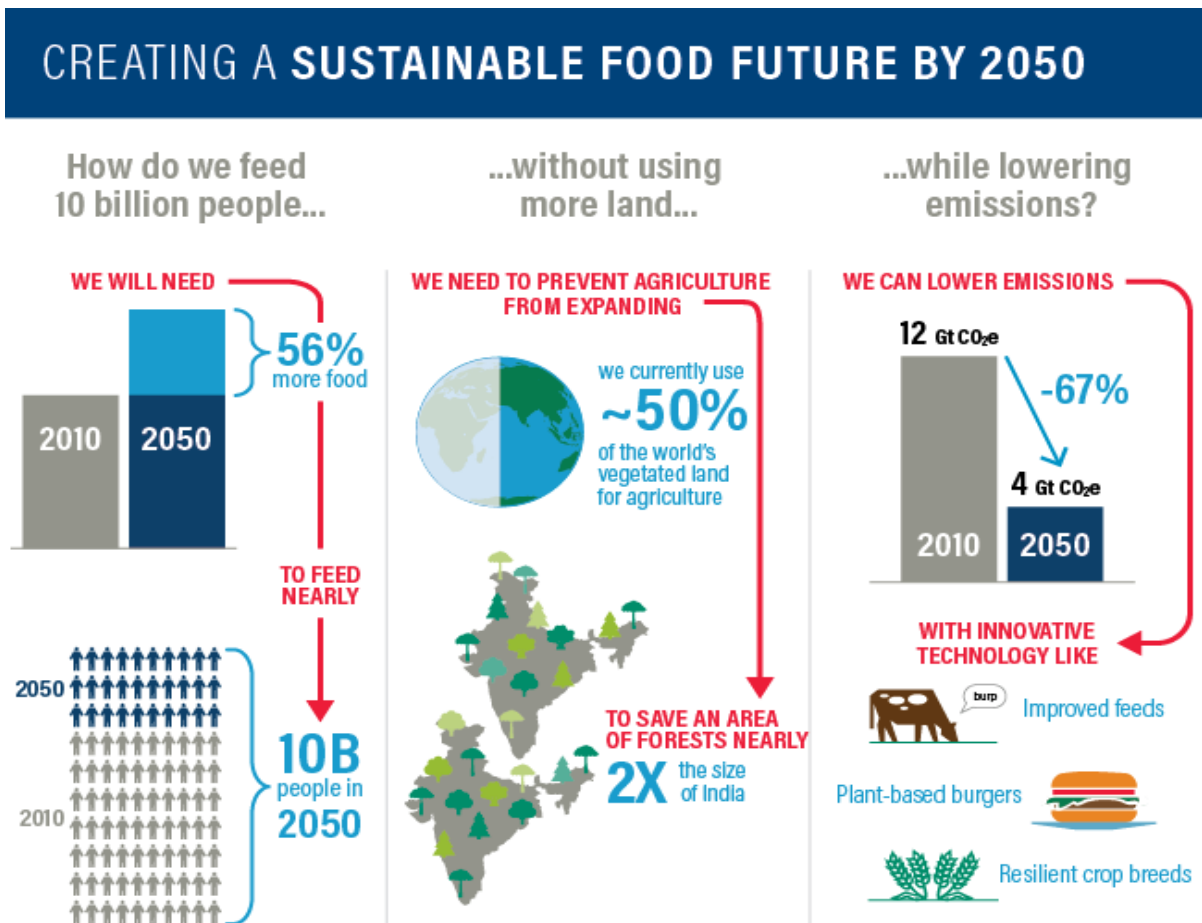
Agriculture potential for solutions

Agriculture and forestry have the potential to provide workable solutions to climate change. For example, agriculture and forestry can enable opportunities for increasing soil carbon sequestration, providing renewable fuels and bio-based materials and developing specific climate mitigation actions (Copa - Cogeca, 2018). Sustainable conditions for enough food production can be created by reducing environmental impacts, improving efficiency and recirculating by-products and side streams (DAFC, n.d.).


The illustration in Figure 2 depicts how agriculture and forestry can play a role in creating a sustainable food future by 2050. Combining agroforestry and forestry practices with agriculture can generate income, provide ecosystem services (e.g., pollination and carbon sequestration) and regulating services (e.g., protection against wind, erosion, water retention and nitrogen fixation) (FAO, 2017).

Additionally, it is widely accepted that mitigation measures implemented by smallholder should contribute to the structural transformation of the economy that would simultaneously reduce costs, improve incomes and support livelihood improvements, resulting in people being lifted out of poverty and engaging in employment opportunities created outside of agriculture.

Figure 2: Creating a sustainable food future by 2050



Source: wri.org/sustfoodfuture

 **WORLD RESOURCES INSTITUTE**

Source: World Resources Institute

Worldwide, a billion farmers are expected to leave agriculture when economic development allows them to attain jobs outside agriculture. An additional 800 million youngsters will enter the labour market in Africa alone in the next 30 years. This calls for employment creation in- and outside agriculture.

THE PROPOSITION

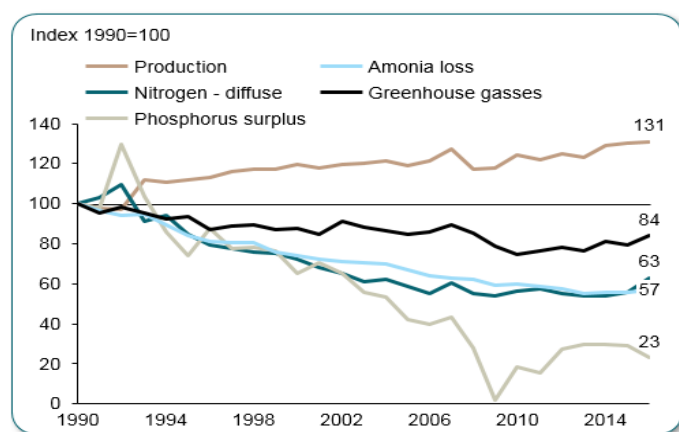
Northwest Europe as an inspiration

The European Commission (EC) acknowledges in its 2050 long-term climate action strategy that agriculture and forestry are two of the few sectors able to deliver solutions for removing GHGs from the atmosphere while also reducing emissions (Copa - Cogeca, 2018). Since 1990, European farmers have been able to reduce their emissions by more than 20% while increasing production (Copa - Cogeca, 2018).

European leaders in climate action in agriculture and forestry are Denmark and the Netherlands. And, farmers and cooperatives in Denmark and the Netherlands are among the world and European leaders in climate action in agriculture and forestry and sustainable intensive production. In fact, the Netherlands produces food five times more efficiently than the average of the European Union (ZLTO, 2014).

Denmark has reduced overall environmental impacts, enhanced and increased production (Figure 3) and gained good experience with recycling of agro-industrial by-products. Agricultural production in Denmark increased by 31% while GHG emissions decreased by 16% between 1990 – 2016 (DAFC, 2019). From 1990 to 2014, the value of Danish agricultural production increased by 22% and nitrogen loss to coast water was cut by 43%, the phosphorus excess went down 83% and greenhouse gas emissions decreased by 16% (DAFC, 2016). Sustainable intensification has contributed to Danish agricultural production over the years. For example, since 1995, the milk yield per dairy cow has increased by 45% since 1995 (Figure 4) and the number of piglets per sow per year has increased to 33 piglets (Figure 5). The Danish food industry has committed to becoming climate-neutral by 2050, no longer emitting more greenhouse gases than it absorbs, and will contribute to achieving this goal through green and sustainable energy.

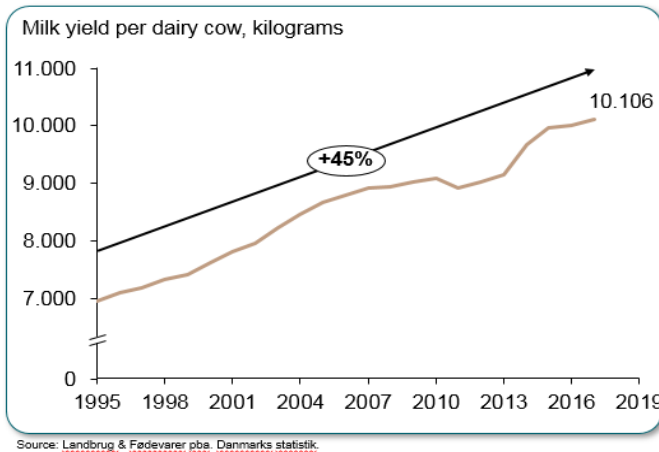
Figure 3: Decline in Danish agricultural GHG emissions (1990 – 2014)



Source: DCE rapporter nr. 205 og 206 (2016); DCE: Agriculture (<http://envs.au.dk>); UNFCCC: National Inventory Submissions 2016; Danmarks Statistiks Nationalregnskab; EIONET Central Data Repository; Inventories for the Convention on Long-range Transboundary Air Pollution.

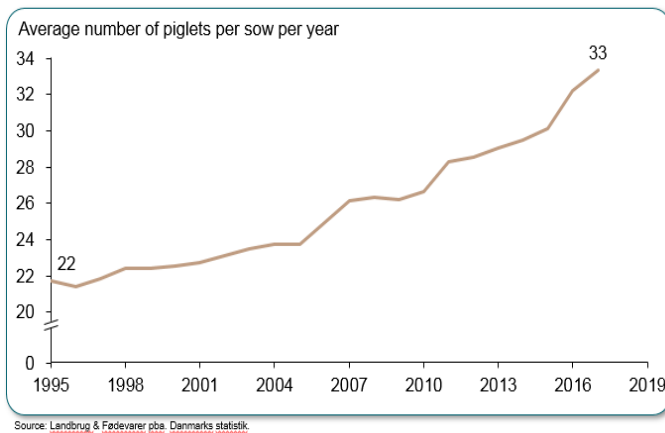
Source: (DAFC, 2016)

Figure 4: Increase in Milk Yield per cow (kilograms) in Denmark (1995 – 2016)



Source: (DAFC, 2016)

Figure 5: Increase in average number of piglets per sow per year in Denmark (1995 – 2016)

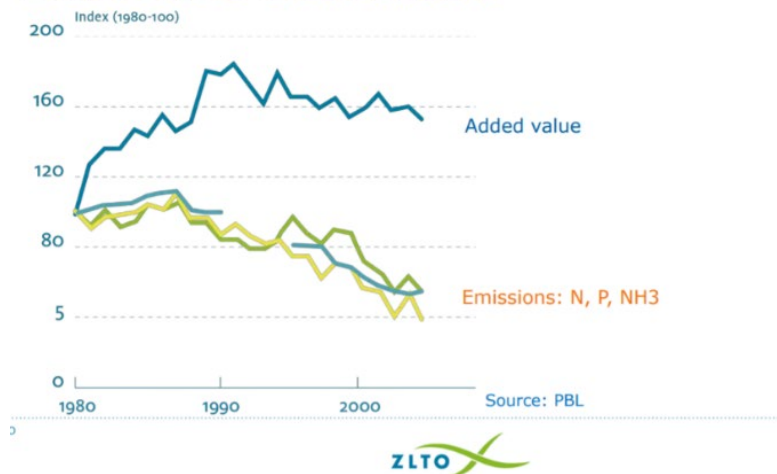


Source: (DAFC, 2016)

In the Netherlands, the agricultural sector accounts for approximately 10% of total GHG emissions (ZLTO, n.d.). Between 1990 – 2016, total GHG emissions from agriculture decreased by approximately 23% (National Institute for Public Health and the Environment (RIVM), 2018), and ammonia emissions decreased by almost 70% and nitrogen oxides decreased by approximately 40% (ZLTO, n.d.). Figure 6 depicts the increase in added value while nitrogen (N), phosphorus (P), and ammonia (NH₃) emissions decreased. In 2018, GHG emissions in the Netherlands amounted to 189.5 billion CO₂ equivalents, which is 4.2 billion CO₂ equivalents (2 percent) less than the prior year. Of this reduction, 25% is attributed to a reduced cattle herd (lower methane emissions), which in turn is related to the introduction of the phosphate rights trading system and to lower CO₂ emissions by the manufacturing industry (Statistics Netherlands (CBS), 2019).

Figure 6: Decline in Dutch agricultural nitrogen (N), phosphorus (P), ammonia (NH3) emissions

Decrease emissions



Source: (ZLTO, 2014)

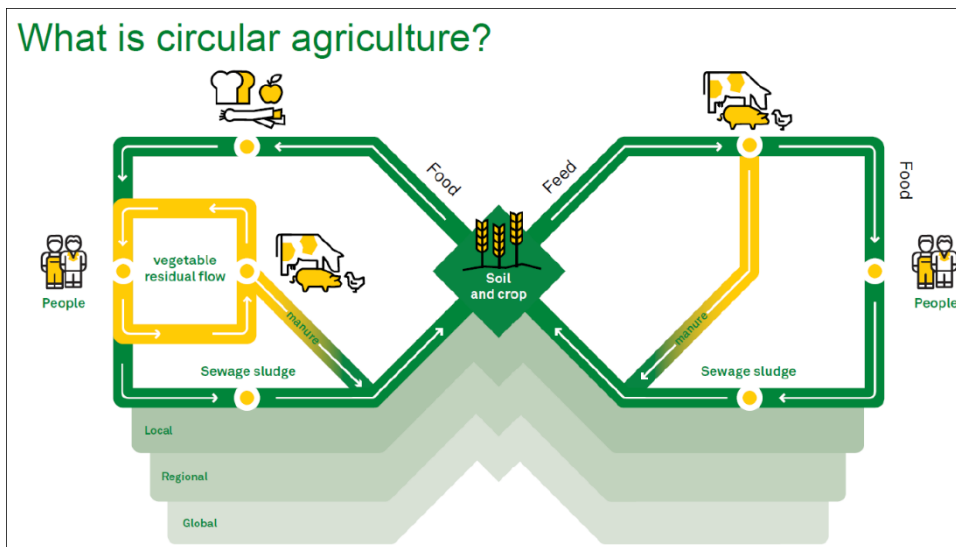
Measures being undertaken in the Netherlands to lower emissions from agriculture and horticulture include the innovation programme for climate-neutral greenhouses, encouraging livestock farmers to use sustainable animal feed, and use fertiliser as efficiently as possible and generating biogas from manure (Government of the Netherlands, 2019). For example, the innovation and action programme for the greenhouse horticulture sector in the Netherlands (Kas als Energiebron) aims to reduce greenhouse horticulture CO₂ emissions by 2 – 3 % per year, with maximum 6.2 Mton CO₂ emissions in 2020 (Kas als Energiebron, n.d.).

There continue to be high opportunities for sustainable intensification, considering both the society and the environment, on 34% of the arable area in Europe. Multiple cropping, combined with water storage in areas of water scarcity, is a promising way to close harvest gaps. And, implementing a combination of sustainable intensification measures — such as multiple cropping, no-till farming, deficit irrigation, and the abandonment of luxury crop cultivation — at continental scale can save land, water, and soil resources, while increasing food security. (Scherer, et al., 2018).

The Danish and Dutch models are based on high levels of “knowledge per hectare,” which has been developed as a result of deployment of world class agricultural advisory services; forward looking investments in research and genetics; development of world class cooperatives and integrated resource efficient supply chains; diversification of risk and added value in product development; and global openness from sourcing sustainable imports, processing and carbon efficient exports.

A new perspective is the transition towards circularity in agriculture. Circular agriculture is a collective search by farmers, interested citizens, businesses, scientists and researchers for the optimum combination of ecological principles with modern technology, with new partnerships, new economic models, and credible social services (Wageningen University & Research, 2018). Circular agriculture stresses the importance of putting as little pressure on the environment, nature and climate as possible by focusing on good yields, sparing use of resources and energy, and keeping residuals of agricultural biomass and food processing within the food system as renewable resources. (Wageningen University & Research, 2018). As depicted in Figure 7, a primary component of circular agriculture is managing manure effectively as fertiliser, an area where Dutch and Danish agriculture is particularly strong.

Figure 7: What is circular agriculture?



Source: (Tijssens, n.d.)

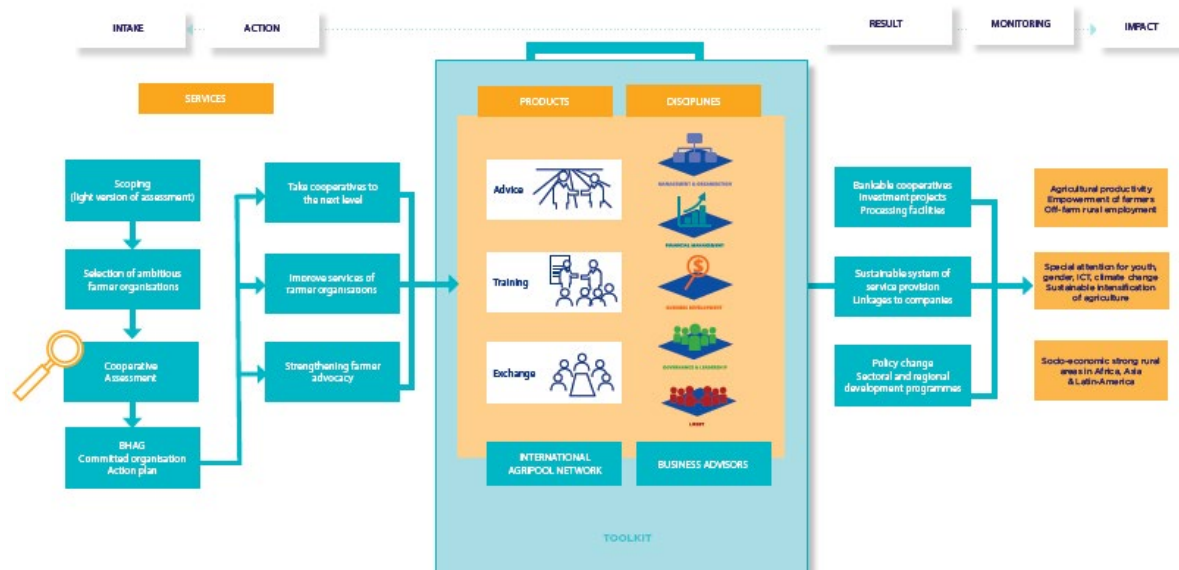
Agricultural cooperatives

At the heart of Dutch and Danish agricultural successes are strong democratically run cooperatives and farmers organizations that are poised to participate in public-private partnerships for sustainable development. Cooperatives, rural SMEs and farmers' organisations can serve as potential drivers for development and enhancing economic growth, leading to new jobs in manufacturing, processing, marketing and quality management and better jobs in agriculture — farmer-led rural industrialisation.

Farmers' associations and cooperatives can have a positive influence on agricultural communities by accelerating the development process, ensuring a more equal distribution of income and enhancing democratic decision-making and relations. Agricultural cooperatives help to improve rural resilience to climate change. They spur the structural transformation of economies by transforming them in modern, industrialised and service-based ones. They also provide opportunities for women and young people to become empowered through their participation in these collaborative organisations.

The improvement of productivity in the agricultural sector, once the structural transformation is underway, has everything to do with the exodus of unproductive smallholders that now work the land, basically because there is no other employment option. Their extreme low productivity reduces the overall sector productivity and once they leave agriculture, economic growth is accelerating as they become employed in sectors where they can make a better economic contribution, also manufacturing goods and providing services that boost further productivity growth in agriculture. So, the development of these other sectors also enables the continued increase of farm productivity, a process that started with the plough but continues even in high developed countries; think for instance of high precision agriculture, the integration of ICT, GPS and blockchain technology in agriculture.

Agriterra's intervention model



Source: Agriterra

Therefore, Agriterra’s work concentrates on farmers’ organisations and cooperatives and involves three approaches: advocacy, farmer entrepreneurship and bankable co-ops. Agriterra improves advocacy of the farmers’ organisations and cooperatives by connecting them to governments and companies that can support their members’ interests. As the farmers’ organisations and cooperatives develop truly sustainable income-generating models, Agriterra supports them by making connections to opportunities with local and multi-national companies with sourcing and selling aspirations at the ‘base of the pyramid’ and with banks and investment funds seeking to increase their agriculture and agribusiness portfolios in developing countries. Agriterra helps farmers’ organisations and cooperatives get to the next level to make them bankable, both by offering them the expertise and knowledge needed to tap into funds available from different sources as well as by producing financial strategies that underpin actions to further their members’ interests.

Agriterra is particularly successful in driving the ambitions of cooperatives to new investments and the establishment of factories, by improving governance, financial management and increasing internal capitalisation. It is leading the technical assistance facility of the Agribusiness Capital Fund that is supposed to raise 200 million investments in rural cooperatives and SMEs. The new ventures offer new employment in rural areas, but also spur new farmer investments. In Ethiopia the capital contributions of the members to their cooperatives increased with 50%, lifting with 200 million Euro total member equity. And this capital mobilization among cooperative members is a direct consequence of governmental action to bring the Agriterra methods for internal capitalisation to cooperatives all over the country.



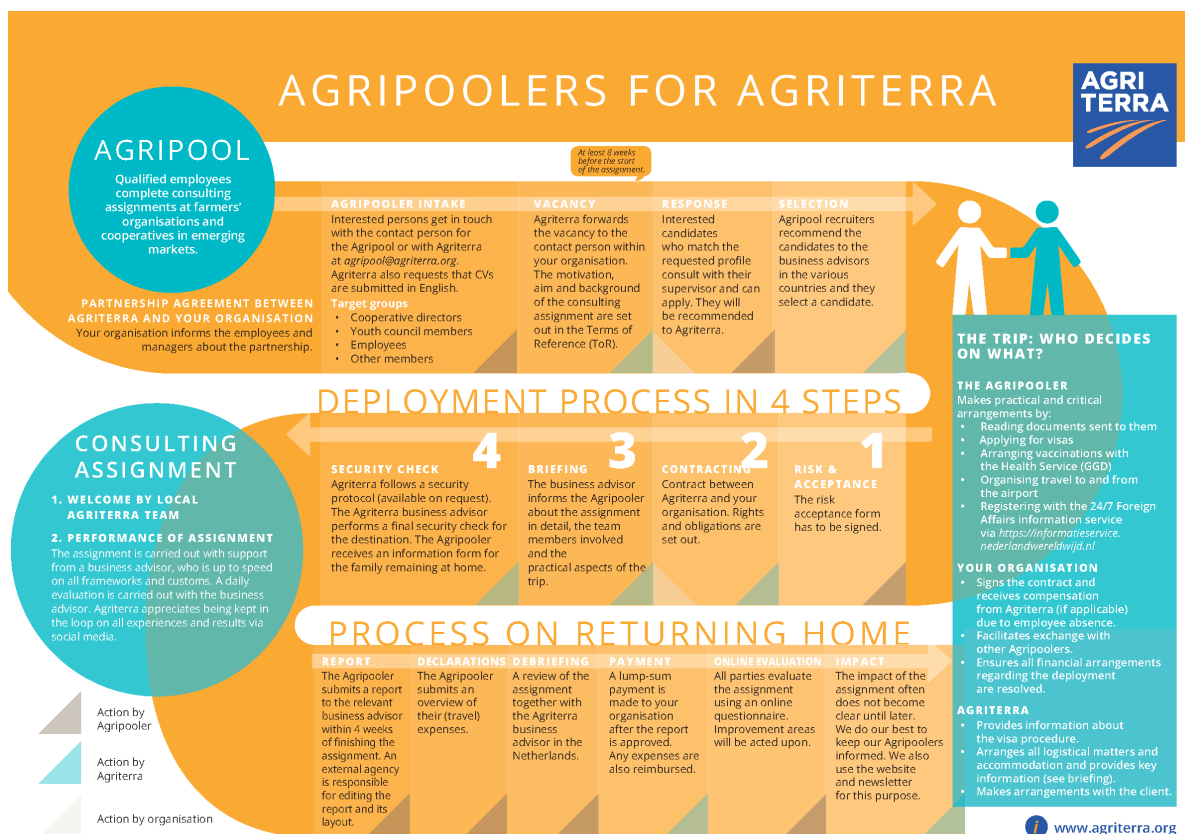
Raya Wakena cooperative grain processing plant Ethiopia - Photo: Agriterra

SEGES builds bridges between research and practical farming and at the same time, aims to develop products and services in partnership with users. SEGES ensures that the latest knowledge and technology is deployed by Danish farmers on their farms as rapidly and efficiently as possible. Some of SEGES' findings are the result of their participation in national and international projects and through extensive research work. SEGES collaborates with research institutions, public authorities and private companies from across the world, which enables them to draw on public research and development funds to promote innovation within the agriculture and food sector.

Success of collaborative work with farmers and farmers' organisations has been evidenced in Europe (e.g., Copa-Cogeca), in Denmark (e.g., Landbrug & Fødevarer) and in the Netherlands (e.g. LTO Nederland). Copa-Cogeca acknowledges that it is critical to build capacity in farmers' organisations by collaborating with European farmers and cooperatives for sustainable agricultural intensification, appropriate mechanisation and agri-food systems (Copa - Cogeca, 2018).

The collaborating organisations will leverage this expertise with cooperatives in Africa, Asia and Latin America. The demand for more and better-quality products by the farmer-led cooperatives triggers a demand for sustainable intensification of agriculture to yield higher output with fewer inputs, while at the same time decreasing GHG emissions.

Agriterra in the last 20 years has developed an efficient and effective Agripool of top-notch experts and an infrastructure to recruit, deploy and obtain results. On a yearly basis over 350 experts perform advice missions and participate in training sessions. The Agripoolers are also the natural entry point when the cooperatives host exchange visits from developing countries' cooperative study tours.



Sustainable intensification

Increased global food supply can be produced on smaller areas with agricultural land use per capita — almost 1.5 hectares per capita in 1961 and 0.7 per capita in 2013, for example. (Roser & Ritchie, 2019). It is also well acknowledged that the target of agricultural R&D must embrace the twin goals of agricultural productivity and the environmental performance which accompanies agricultural production (The RISE Foundation, n.d.). One approach is sustainable intensification, which is a process or system where agricultural yields are increased without adverse environmental impact and without the conversion of additional non-agricultural land, with sustainable agroecosystems having a positive impact on natural, social and human capital (Pretty & Pervez Bharucha, 2014).

Although some perceive that successes in increasing food production per unit of resource have led to environmental harm and disruption to social systems, others view intensification as a necessary means to avoid conversion of non-agricultural land to meet food production needs and (Pretty & Pervez Bharucha, 2014). The Paris Agreement “aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production” (United Nations, 2015). The European Council acknowledges the multiple objectives of the agriculture and land use sector, their lower mitigation potential and the need to ensure coherence between food security and climate change objectives (European Council, 2014). Sustainable intensification can be a means to deliver on these global and regional objectives, and the approach can be informed by advancements in other sectors and provides an opportunity to transition towards greener economies (Pretty & Pervez Bharucha, 2014).

An emerging opportunity for sustainable intensification to increase food production and address climate change involves utilizing existing arable land to grow more crops more frequently by shifting from annual crops to perennial crops. Perennial crops are productive, healthy for soils and highly efficient for CO₂ storage and photosynthesis (Shepard, 2013). For example, the intermediate wheatgrass, Kernza, has been proven to be successful and other crops, such as rice, wheat and sorghum, are being pursued through research collaborations in both developed and developing countries, such as the United States, South Africa, Turkey, Italy, China, Germany, Mali, India, Ethiopia, Canada, Sweden, Uganda, Argentina, Australia, France, Uruguay, and Denmark (Eisler, 2019).

Another approach to utilize existing land for agriculture production is agroforestry, the interaction of agriculture and trees, including the agricultural use of trees, and approach which embraces agroecology, applying ecological principles to agriculture, polyculture systems, growing multiple crops on the same land, and protects biodiversity loss (World Agroforestry, 2019). There is support in Europe to examine the best means of encouraging the sustainable intensification of food production, while optimising the sector's contribution to greenhouse gas mitigation and sequestration, including through afforestation (European Council, 2014). And, agroforestry is increasingly being subsidised and promoted in developed countries, such as the Netherlands. The approach has also been identified to have a great potential to contribute to growth and jobs, food security, resilience, environmental sustainability and climate action in developing countries, such as those in Africa (Taskforce Rural Africa, 2019).

In Africa, sustainable intensive agricultural production can move farmers out of subsistence agriculture and into higher income jobs in the manufacturing and service industry and to employment in reforestation and infrastructure works for road, electricity and broadband communications (Taskforce Rural Africa, 2019). In the economies dominated by agriculture-based livelihoods, farm and rural non-farm employment continues to play an important role. And, it is clear that a wealthier agricultural sector that is investing on adding value to produce, has better possibilities of creating job opportunities that open up with economic growth and rural transformation (IFAD, 2016). African farmers are already investing in sustainable intensification of agriculture and agro-industrialisation and additional support can build on that effort (Copa – Cogeca, 2018).



In Asia, methods have been identified to sustainably increase agricultural output without expanding agricultural land. Examples include improving food quality for livestock to gain higher ruminant productivity by growing a wide variety of improved forage grasses and shrubs with high protein leaves using the already utilized 'cut and carry' system (also common in Africa) and also proper fertilization, growing legumes, rotational grazing and adding supplemental feeds in dry seasons and during the last few months of 'finishing' (Searchinger, et al., 2018).

Approximately 70% of the grazing areas of Latin America and the Caribbean are undergoing degradation processes to various degrees. There is need for technological and management strategies to ensure the sustainable intensification of livestock production, prevention of and prevent deforestation and expansion of the livestock frontier (Masson-Delmotte, et al., 2016). In Latin America, there are several promising sustainable agriculture options that could be applied to increase yields, reduce land use change and store carbon.

One method is to raise cropping intensity — the ratio of harvests each year (harvested area) to quantity of cropland — which, if increased by an additional 5%, the land gap would shrink by 81 Mha, or 14% (Searchinger, et al., 2018). There is also potential to reduce emissions from manure left on livestock pastures by building on findings that showed biological nitrification inhibition took place when manure was deposited on one variety of the productive *Brachiaria* grass, generating almost no nitrous oxide emissions (Searchinger, et al., 2018). Looking forward, carbon storage is possible by restoring and rewetting the large peatlands consisting of carbon-rich soils that are predicted to exist in Latin America rather than releasing large quantities of carbon into the atmosphere through conversion to agriculture and plantation forestry. (Searchinger, et al., 2018).

Innovations and technologies

Denmark is at the forefront of resource efficiency in agriculture and examples include approaches as simple as applying manure to farm land and optimizing grass seeds to more complex, such as using the energy potential of manure by degassing it in biogas plants and turning slaughterhouse waste into biogas and biodiesel (DAFC, n.d.). SEGES spearheads an initiative, Future Farming, to identify and examine trends in agriculture, food production and consumer behaviour which are expected to be important drivers in creating healthy business foundation for farmers in the next 5-15 years. Future Farming has been tracking technologies and innovations from robot technology to the future of protein supply.

More efficient agroforestry and forestry land use practices are being developed using a combination of technologies. These include the use of satellites for imaging the biomass, preparing forest management plans, forest certification and audits, assessing carbon sequestration, thinning and pruning decision making and the use of virtual tools for modelling and planning agroforestry activities and analysing the profitability of agroforestry farming. One example of an agroforestry farming technique being used to boost productivity in planted forests is to cultivate food crops during the first three years before the canopy becomes too dense, which can be the best option for farmers in terms of income (Palacios, et al., 2014).

In the Netherlands, examples of innovations in the sector include high tech and design in agriculture through precision agriculture (e.g., employing robots, remote sensing, tracking and tracing) and grow-tech horticulture (cultivation technology); logistics and marketing in the agri-food chain (e.g., sustainable foods, distribution, market concepts, packaging); and new chemistry and energy products, such as bio-based (e.g., raw materials), agro-biotech (e.g., breeding improvements, coating, basic materials) and life science (e.g., functional food, green medicine) (ZLTO, 2014).



An example of how a Dutch innovation has been applied in developing countries is the use of the Dutch agro-tech company, AgroCares, Near InfraRed (NIR) soil scanner in Kenya. The NIR scanner gives farmers real-time information on the nutrient status of their soil by utilizing an app to translate the soil data on the spot into fertilizer recommendations for selected crops. Based on an evaluation carried out jointly with Agriterra on the use of the soil scanner at cooperative and farmer level, farmers reported higher fertilizer efficiency, increased yields and, in general, willingness to pay for scans (Beek, et al., 2018).

An example of how a Danish innovation optimizes fertilizer application is SEGES' development of an advanced decision support system to predict the expected nutritional effect of applying livestock manure in field crops. Experiments have shown that the nitrogen effect under field conditions varies greatly depending of the soil type, crop stage and the weather conditions. Therefore, the ability to predict the actual nutritional effect of the applied livestock manure, enables farmers to optimize the subsequent fertilizer application much more precisely, reducing inputs and environmental impact.

Farm data is becoming more important as a means of implementing precision agriculture techniques. This includes using GPS, drone and satellite (e.g., Copernicus Programme) data for reconnaissance of the land and remote sensing services to map fields, determine the amount and timing of inputs (e.g., nutrients), identify pests and diseases and determine when to cultivate crops. Once the farm data is gathered, mechanisation of farms for activities such as nutrient application and crop cultivation can increase efficiency and yields and reduce input costs for farmers. Some of the technologies being used are autosteer tractors, variable rate and section control spreaders and crop monitoring systems linked to online applications to enable planning for the following season.

In Denmark, for example, all spatial and tabular field information gained through farmer reporting on soil type, crop type, variety and field operations is handled by SEGES in a

centralized farm management system, Mark Online (Bligaard, 2014). This information serves as the basis for precision farming in the software package CropManager, which is maintained by SEGES. Sentinel satellite images with a 10x10 m resolution are used together with the field information to create variable rate application (VRA) maps for fertilizer and pesticide applications as well as for seeding and soil tillage. After the VRA maps are created, the prescription files are seamlessly distributed to the field equipment through a cloud-based data hub. This web-based system not only provides access of the farmers' field data to their local farm advisor, but also enables the farmer to easily access advisory assistance if needed.

Farm data is also becoming more valuable to private sector agriculture product and service providers. Questions have been raised in terms of who owns the data when a product or service is provided, and blockchain technology is emerging as a potential solution to this challenge. Blockchains, databases that are open, cannot be altered, distributed evenly without one particular controller and gives everyone access to the same information, is an emerging technology that can support cooperatives and can provide a means to involve small-scale farmers (Blokland, 2018).

Value addition within the supply chain

With climate change having a different effect on different geographic regions, as well as different crops, it requires concerted efforts and joint investments by the supply chain partners, as well as public partners and support agencies, in the different food crop sectors to support effective adaptation and mitigation strategies. Economic gains for farmers, agri-SME's and other supply chain partners will provide the incentives for the required change processes.



For example, with the use of precision agriculture on the supply side of the value chain (e.g., farmers, collectives), value can be added through improved farming practices that can result in more efficient operations and reduced operating costs (e.g., inputs, labour), higher yields, more consistent products (e.g., shape, size, quantity) and also through processing products themselves rather than outsourcing this step of the value chain. On the demand side of the value chain, if buyers demand more quantities of consistent products, farmers will be motivated to improve their farming practices. These changes can support the development of new skills and contribute to upward mobility in

employment, increased and more consistent incomes year on year and improved food security for families and communities.

In the forestry sector, certification schemes (e.g., FSC and PEFC) or carbon sequestration schemes can be used to add value to production. The challenge for smallholders is the third-party audit, which in remote rural areas can increase the verification and auditing costs to a level that is not economically feasible. However, the transactions costs can be reduced to a feasible level with satellite detection, drones, applications to calculate biomass or tree density and using blockchain or other data systems that limit possibilities of altering the data (Huvio, 2019).

An example of an approach utilized by Agriterra and SNV Netherlands Development Organisation with agricultural cooperatives to assess climate risks and identify climate actions in a value chain is depicted in Figure 8.

Additionally, Agriterra is looking to develop new business models like applied blockchain projects, bringing all parties in a chain together in one business case to build one technology package of different services for farmers (Blokland, 2018). This theory and practice of convening in one business case all relevant chain partners, from the seed supplier to the off taker, with Information and Communication Technologies (ICT) service providers is called Applied Chain Economics. Using the latest ICT technology, it aggregates many smallholder plots into one profitable business under one planting plan, boosts plot potential, brings services to scale and optimises yield results with the involved off-taker guaranteeing the market. The economic results, like the risks and costs, are distributed over all involved chain partners and service providers.

Figure 8: Climate risk assessment in a value chain



Source: Agriterra

Application of Dutch and Danish expertise in developing countries

Expertise from Dutch and Danish farmers, their cooperatives and agricultural advisory services can be leveraged to help farmers and cooperatives in developing countries become more sustainable, more climate efficient, and ultimately more profitable and prosperous.

The organisations formed this collaboration in response to the urgent need for climate action, recognizing the need to reduce the planet's GHG emissions and the potential of the agricultural sector to play a pivotal role in this while also contributing to livelihoods and food security. The collaborating organisations' vision is to promote sustainable intensification in developing countries as a way of demonstrating that there is an economically sustainable path to climate-neutral food production. Adoption of sustainable intensification, particularly with IT tools, feed efficiency, genetics, plant breeding and manure management, can result in higher yields per hectare, thereby a lower GHG emissions footprint per kilogram of product. Although the approach can result in a higher footprint per farm, it positively contributes to food security and food safety, supporting the UN's Sustainable Development Goals.

There is a need, desire and opportunity for this expertise in developing regions of the world. For example, it has been identified that "developing adequate options for the modernisation of African agriculture will require major investment in research, involving farmers and their organisations, and adequate policy design. This focus is also central to the Europe-Africa Research and Innovation Partnership or the DeSIRA123 initiative with the development of research and innovation platforms for Food and Nutrition Security and Sustainable agriculture (FNSSA). Africa could take a leading role towards inventing a new sustainable agricultural model, which could contribute to agricultural change in other regions." (Taskforce Rural Africa, 2019)

However, sustainable intensification is just the beginning of the collaborating organisations' efforts in the developing world. The combined demands of an increasing population, income rise, climate, environmental, biodiversity and nutritional objectives set by societies will require agricultural technologies that have not yet been invented. The accumulated experience and expertise, as well as the top-notch research and development capacity of Danish and Dutch farmers will be put at the service of finding solutions together with agricultural family farmers in Africa, Asia and Latin America.

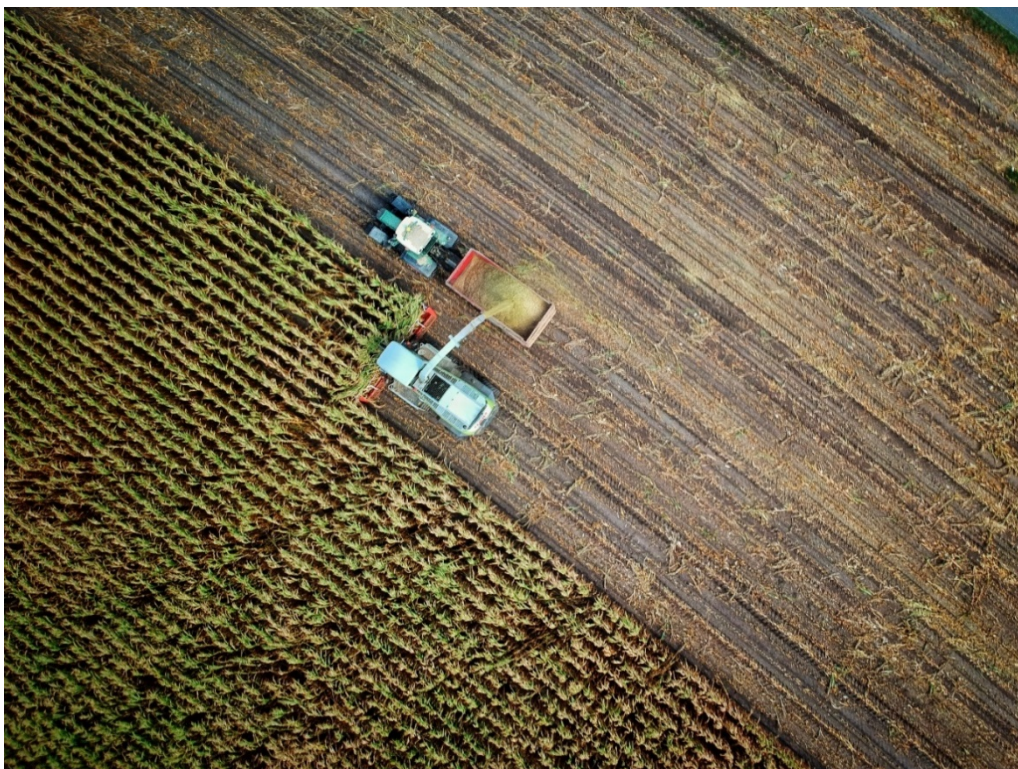
SUMMARY

Through this collaboration, Agriterra and DAFC / SEGES will address the climate challenge by leveraging their knowledge sharing and implementation expertise and technology solutions to promote sustainable intensive agricultural production in developing countries in Africa, Asia and Latin America.

The best practices in agriculture and forestry in Europe, particularly in Denmark and the Netherlands, can be leveraged to help mitigate and adapt to climate change and meet the increasing demand for food. The utilization of precision agriculture techniques and technologies when applied properly can increase agricultural production and add value within the supply chain while reducing operating costs and land use change. These solutions can be scaled via farmers' organisations to maximize the number of farmers able to reap the benefits of increased livelihoods and food security and to seize opportunities to move beyond subsistence agriculture into higher income employment.

Adequate and predictable funding from a dedicated share of the Green Climate Fund will be necessary for the solutions outlined above to have a real impact on climate change adaptation and mitigation for agriculture in developing countries. Funding should be also be allocated to agriculture adaptation activities, since it can be of greatest assistance to smallholder farmers and currently around 75% of all climate funds is used for mitigation (Taskforce Rural Africa, 2019).

Support of the Agriterra DAFC / SEGES collaboration will enable Agriterra to pursue accreditation for the Green Climate Fund, a critical step for the agricultural community to be included in climate finance investments moving forward.



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