INTESA SANPAOLO
INNOVATION CENTER

INDUSTRY TRENDS REPORT

REGENERATIVE AGRICULTURE

FROST & SULLIVAN

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EXECUTIVE SUMMARY

Overall, the agriculture and nutrition industry is responsible for approximately 23% of global greenhouse gases (GHGs) of which 56% is attributable to crop production and land use. In addition to emissions, overuse of natural resources is creating water stress whilst also resulting in a reduction in biodiversity.

Calls for changes in farming practices are stemming from the supply and the demand side with consumers seeking organic and locally-sourced products and all of the main food & beverage producers boasting ambitious carbon dioxide (CO2) emissions reduction targets which span their operations from the "farm to the fork".

The UN's Sustainable Development Goals (SDSs) provide a further source of impetus,

Sustainable farming – of which **regenerative agriculture** forms a part – is emerging as a response, aiming to both satisfy food needs and enhance the environment.

Regenerative agriculture is a concept which is focused on soil rehabilitation, dates back to the 1980s and consist of six main principles.

Minimizing soil disturbance via the use of ***"no-till" farming*** is the most widely adopted approach and will account for 204 million (m) hectares of land globally by 2026. Other effective measures include ***cover cropping*** and the introduction of ***crop-livestock systems.*** Overall, ***organic farming*** practices are taking off on a global basis and demonstrating a compound annual growth rate (CAGR, 2020-26) of 5.5%.

The successful implementation of regenerative farming requires the collaboration of both public and private sector stakeholders. Most of the not-for-profit and non-governmental organizations in the sector are focused on training famers to switch from conventional to regenerative practices whilst a supportive regulatory environment is also key.

The Carbon Farming Project in India and the Regenerative Coconuts Agriculture Project in Thailand represent powerful regenerative agriculture use cases. They and other market participants are being supported in their transition by tech innovations, notably in the area of soil and crop mapping and monitoring. EarthOptics' (United States) GroundOwl solution plays into this field as does Agricolus's (Italy) with its Easy platform for small farms.

Technology innovations are enabling regenerative agriculture with sensors capturing data and artificial intelligence (AI) providing analysis and actionable insights.

In addition to soil and crops, ***sensors*** are increasingly deployed to track changes in weather, measure pollution and identify pests whilst ***AI*** algorithms facilitate the execution of multiple new and existing tasks. Together, they notably allow the operation of unmanned agricultural machinery (tractors, drones and robots) which drive efficiency and sustainability.

For regenerative agriculture, sensor/AI use cases include ***crop maturity tracking*** as well as ***"intelligent spraying", automatic weeding*** and ***produce grading.***

In Europe, smart farming is supported by regional initiatives, like the EU's Rons4Crops, and national platforms, such as the UK's Farming Innovation Program. They are also pushed from the supply side by many of the established tech giants and complemented by a range of sensor/AI specialists focused on sustainability. ***Sensor*** suppliers for regenerative agriculture include Grownetics (US) while Aerobotics (South Africa) uses ***AI*** to identify crop diseases and tackle irrigation issues.

Minimizing the use of chemicals in farming is one of the central planks of regenerative agriculture and encompasses **agrochemical innovations** across fertilizer, seed treatment and pesticide solutions.

Successful and sustainable crop management is fundamental to feeding the world's growing population whilst also protecting the environment. This is reflected in the level of innovation activity with over 25 thousand patents filed globally between 2018 and 2022 which pertain to "green" agrochemicals.

Fertilizers contribute towards 2.5% of annual GHG emissions of which about 1.5% stems from application and 1.0% from production processes. As a response, market participants are developing enhanced efficiency fertilizers which improve nutrient uptake by plants and reduce losses to the environment. There has also been an increased focus on producing fertilizers by upcycling waste products.

For ***seed treatment***, replacing petroleum-based binders with sustainable encapsulation materials promises to make a significant difference. Film coating and seed pelleting or encrusting offer environmentally friendly alternatives.

Pesticides play an important role in protecting crops against losses but conventional solutions are damaging and their use is increasingly subject to regulation. Biopesticides provide a low cost and high potential substitute. They are joined by the emergence of bio-material-based nanopesticides which combine performance advantages with greater sustainability.

Across all three chemicals, research & development (R&D) is at an early stage and innovation is currently primarily funded by the public sector but the growing number of collaborations between corporates such as GreenLight Biosciences (Australia) and academia bodes well for more accelerated roll-out.

This report examines the various drivers behind and differing approaches to **regenerative agriculture** practices. With sustainable farming sitting at the intersection of **technological** and **agrochemical innovations**, it also explores the emerging solutions that are enabling the evolution of a broader form of more efficient and environmentally-friendly agriculture.

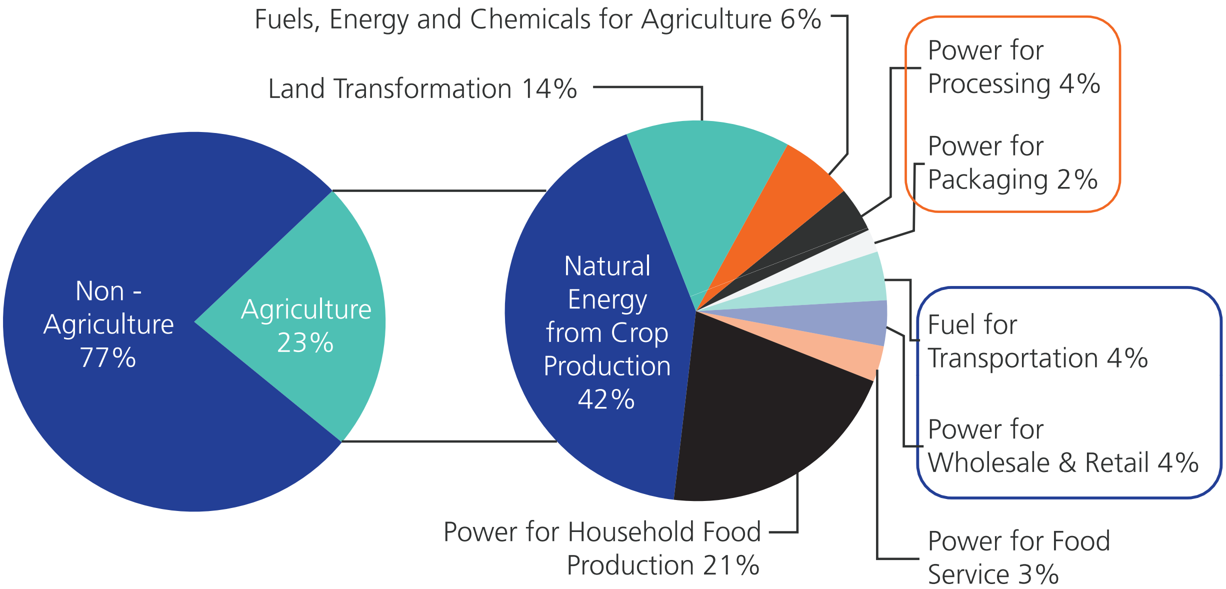
INTRODUCTION

Overall, the agriculture and nutrition industry is responsible for ~23% of global greenhouse gases of which 56% is attributable to crop production and land use

Some 42% of greenhouse gases (GHGs), including carbon dioxide (CO2) and methane (CH4), produced in the sector during the period from 2016-2021 derived from biomass which in turn generates its energy from photosynthesis. In other words, nearly 5 billion (b) tons of GHG emissions in the agriculture and nutrition industry stem from the sun.

After power for household food production (21%), land transformation (14%) is the second largest contributor, followed by fuel, energy and chemicals for agriculture (6%), transport and retailing (8%) and processed food production (6%). Power for food service is 3%.

AGRICULTURE AND NUTRITION INDUSTRY GHG EMISSIONS (GLOBAL ANNUAL AVERAGE, 2016 TO 2021)



In addition to emissions, overuse of natural resources is creating water stress …

Agricultural production is responsible for 70% of the freshwater withdrawals globally, which leads to water scarcity. Rates vary between regions with several countries across South Asia, Africa and Latin America using more than 90% of water withdrawals for farming.

Agriculture is also one of the key sources of river and stream pollution. The Organization of Economic Cooperation and Development (OECD) estimates the environmental and social cost of contamination caused by farming to be more than a billion dollars per year.

- **28%** of global cropland is found in water-stressed regions

In addition, the impact of agriculture is not limited to water. According to the Food and Agriculture Organization (FAO), more than 33% of soil globally is already degraded, and more than 90% could be damaged by 2050. Intensive farming practices, deforestation, overgrazing and other improper land use can accelerate soil erosion by 100 to 1,000 times. This in turn can lead to loss of crop yield and have far-reaching implications beyond agriculture.

- **50%** of global crop yield could be lost due to soil erosion

Source: Frost & Sullivan

… whilst resulting in a reduction in biodiversity

The loss and fragmentation of natural habitats due to the land clearing activities that are associated with cropland expansion, intensive agricultural practices and construction activities are the key drivers of biodiversity reduction. According to the FAO, the growth in farming "drives almost 90% of global deforestation" which, in turn, has led to the loss of "420 million (m) hectares globally" between 1990 and 2021."

Indeed, land clearing has also led to a drastic decline in the population of pollinators and other invertebrates and micro-organisms that support soil fertility, pollination, water and air purification, and pest and disease management with the loss of biodiversity recognized as a threat to food security under the UN's Sustainable Development Goals (UN SDGs).

Furthermore, a growing overreliance on chemical pesticides and insecticides has provoked an increase in resistant species that have caused several disease outbreaks and impacted crop yield over the years. The excessive use of crop treatment solutions harms biodiversity and the wider environment, driving the need for sustainable management practices.

Calls for changes in farming practices are stemming from the supply and the demand side with consumers seeking organic and locally-sourced products …

Interest in the origin of fruits, vegetables and other foods has increased significantly in the last decade with a paradigm shift occurring during the pandemic, notably in India and China. North America remains the largest market in revenue terms for organic food & beverages (F&B) but Asia-Pacific (APAC) is expected to offer higher growth moving forwards.

In addition to organic foods, and in particular fruits and vegetables, products with sustainable ingredients are also gaining heightened consumer attention. Awareness of product label claims is rising steadily, causing stakeholders across the value chain to focus more on raw material sourcing and sustainable farming practices.

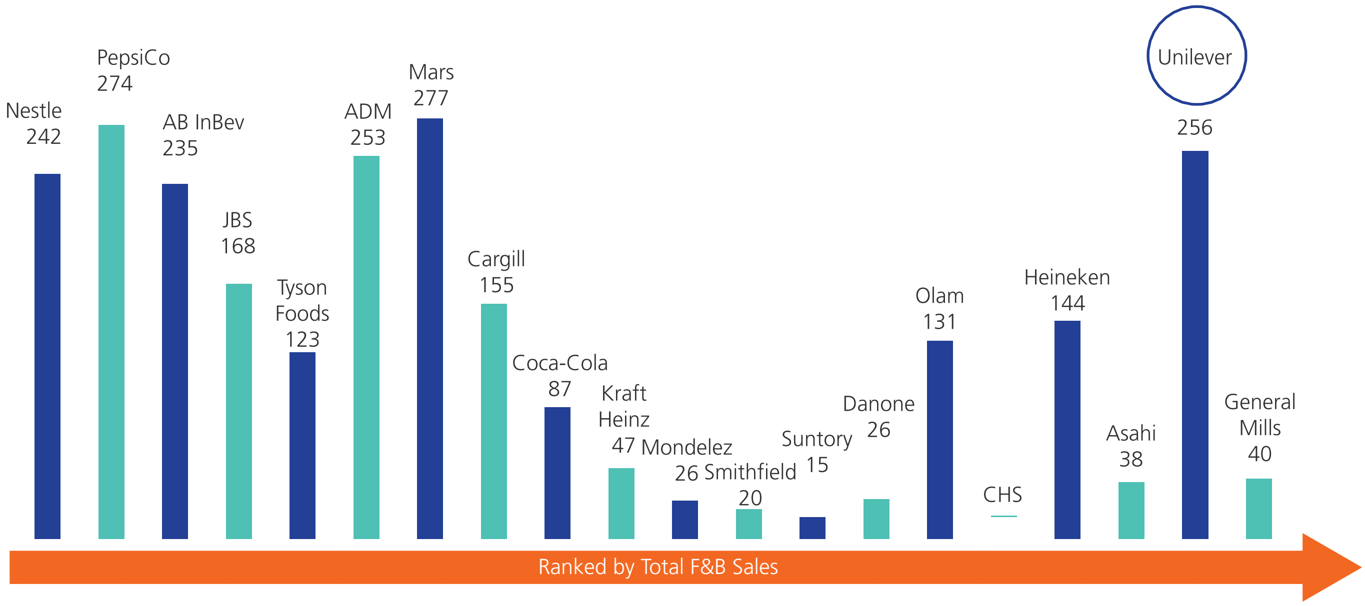
Source: Frost & Sullivan

... and all of the main food & beverage producers boasting ambitious CO2 emissions reduction targets which span their operations from "the farm to the fork"

Many market participants are setting goals to reduce their carbon footprints. This will drive the adoption of sustainable farming practices and aligns with the aims of UN SDG 13 which also highlights the challenges stemming from the rise of single-use plastics and food waste. To ensure greater and enduring sustainability, stakeholders will also need to adopt new and more efficient F&B production and processing technologies.

Among the top 20 global food & beverage players, the current average targeted reduction in scope 1 and 2 GHG emissions is 134,000 tons per year, with many aiming at falls of more than 200,000 tons per year. Unilever, for example, will need to achieve 256,000 tons per year between now and 2030 to meet its goal of zero scope 1 and 2 emissions.

TOP 20 GLOBAL F&B COMPANIES' EXPECTED SCOPE 1 AND 2 GHG EMISSIONS REDUCTION TARGETS (THOUSAND TONS OF CO2-EQ) PER YEAR, 2020 TO 2030



The UN's Sustainable Development Goals provide a further source of impetus

In addition to **SDG 13** on *Climate Action*, which encourages a reduction of market participants' overall carbon footprint by the adoption of sustainable farming approaches, **SGD 12** on ***Responsible Consumption and Production*** is also pertinent, driving the adoption of technology in agriculture. **SDG 2** on *Zero Hunger* is similarly encouraging innovation to improve production yield while **SDG 11** on *Sustainable Cities and Communities* is having an impact on urban farming. Finally, **SDG 15** on *Life on Land* is key to supporting the adoption of regenerative farming practices to save biodiversity.

Source: Frost & Sullivan

Sustainable farming – of which regenerative agriculture forms a part – is emerging as a response, aiming to both satisfy food needs and enhance the environment

Sustainable agriculture is a broad term with different schools of thought. As per US Code Title 7, Section 3103 it is defined as an "integrated system of plant and animal production practices having a site-specific application that will over the long term;

- Satisfy human food and fibre needs
- Enhance environmental quality and the natural resource base upon which the agricultural economy depends
- Make the most efficient use of non-renewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls.
- Sustain the economic viability of farm operations.
- Enhance the quality of life for farmers and society as a whole"

Frost & Sullivan recognizes **regenerative agriculture** as sitting at the intersection of sustainable agriculture practices and **technological** and **agrochemical innovations** which are enabling the evolution of a broader form of smart agriculture.

Source: Frost & Sullivan

REGENERATIVE AGRICULTURE

PRINCIPAL ABBREVIATIONS

AI	*Artificial Intelligence*	**M**	*Million*
APAC	*Asia-Pacific*	**MDU**	*Methylene diurea*
B	*Billion*	**ML**	*Machine Learning*
Bt	*Bacillus thuringiensis*	**MoU**	*Memorandum of Understanding*
CH4	*Methane*	**MU**	*Methylene urea*
CNN	*Convolutional Neural Network*	**NLP**	*Natural Language Processing*
CO2	*Carbon dioxide*	**PEG**	*Polyethylene glycol*
CRF	*Controlled-release Fertilizer*	**pH**	*Acidity*
DMTU	*Dimethylene triurea*	**PIP**	*Plant-incorporated Protectant*
dsRNA	*Double-stranded ribonucleic acid*	**R&D**	*Research & Development*
EEF	*Enhanced Efficiency Fertilizer*	**RNAi**	*Ribonucleic acid interference*
F&B	*Food & Beverage*	**RoI**	*Return on Investment*
F2F	*Farm to Fork*	**SDG**	*Sustainable Development Goal*
FMCG	*Fast Moving Consumer Good*	**SRF**	*Slow-release Fertilizer*
GHG	*Greenhouse gas*	**SRT**	*Saguna Rice Technique*
GMO	*Genetically Modified Organism*	**UF**	*Ureaformaldahyde*
GPS	*Global Positioning System*	**US**	*United States*

Source: Frost & Sullivan

ABOUT INTESA SANPAOLO INNOVATION CENTER:

Intesa Sanpaolo Innovation Center is the company of Intesa Sanpaolo Group dedicated to innovation: it explores and learns new business and research models and acts as a stimulus and engine for the new economy in Italy. The company invests in applied research projects and high potential start-ups, to foster the competitiveness of the Group and its customers and accelerate the development of the circular economy in Italy.

Based in the Turin skyscraper designed by Renzo Piano, with its national and international network of hubs and laboratories, the Innovation Center is an enabler of relations with other stakeholders of the innovation ecosystem - such as tech companies, start-ups, incubators, research centres and universities - and a promoter of new forms of entrepreneurship in accessing venture capital. Intesa Sanpaolo Innovation Center focuses mainly on circular economy, development of the most promising start-ups, venture capital investments of the management company Neva SGR and applied research

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