ISSN 2176-3364

CADERNOS DA UNIVERSIDADE DO CAFÉ

Volume 11
2021

FONDAZIONE ERNESTO ILLY

illy UNIVERSITÀ del CAFFÈ Brazil

Cadernos da Universidade do Café

2021

Cadernos da Universidade do Café 2021

Volume 11

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1 Introduction

2020 was a special year for the Università del Caffè Brazil (UdC Brazil): We celebrated twenty years of activities following the mission of generating and dissemination knowledge in the Brazilian coffee chain.

For two decades UDC Brazil has conducted state-of-the-art studies of topics relevant to coffee growing. In order to celebrate, the research model carried out in 2020 was different. We invited recognized scholars to produce four positions papers about the big theme "The virtuous agriculture and the carbon balance".

More than a closed concept, Virtuous Agriculture represents a movement that translates into an agenda of actions whose goal is to ensure that agricultural production will not be harmful to renewable and non-renewable natural resources, with a regenerative character, in order to keep/recover the capacity of soils and water resources.

This publication also covered two important aspects about carbon balance. The first aspect focuses on expanding the mechanisms for trading carbon credits. In this regard, the study assumes that some market failures can be corrected by mechanisms to reduce transaction costs between economic actors. Such solutions include the creation of formal institutions that generate incentives for the creation of markets. The carbon credit market results from the establishment of rights over a dimension associated with production, which was previously ignored. Agents willing to pay for carbon sequestration can generate incentives in production systems motivating the adoption of low impact technologies. Another focus is related to soil carbon sequestration. According to the agricultural practices, the soil can maintain high levels of carbon, contributing to the decarbonization of the atmosphere.

The publication is structured in six parts, starting with this Introduction. The second chapter is "Agricultural systems in the 20th and 21st centuries", the author is Dr. Samuel Ribeiro Giordano. The third chapter is "Emissions trade systems: how effective are they?", it was written by Mr. Marco Antônio Fujihara. The fourth chapter is "Overview of policies and institutional frameworks on GHG emissions in EU, China, Africa with special reference to the role of agriculture", the author is Dr. Konstantinos Karantininis. The fifth chapter brings the title: “State of art about methods of measuring soil carbon stocks: Agriculture in general and coffee production”, the author is Dr. Carlos Eduardo Cerri. The sixth and final chapter contains our final considerations.

We would like to emphasize that the views, interpretations and opinions expressed in these position papers are the sole responsibility of the authors and do not necessarily reflect the views of PENSA.

In this way, this set of position papers on virtuous agriculture and carbon balance is offered to producers, researchers and those interested in coffee activities of Brazil and worldwide. We hope to contribute to the expansion of this knowledge and continue to add value to the participants of the coffee agribusiness.

We wish you a pleasant reading!

Prof. Dr. Decio Zylbersztajn

Prof. Dr. Samuel Ribeiro Giordano

Profa. Dra. Christiane Leles Rezende De Vita

2 Agricultural Systems in the 20th and 21st Centuries

Samuel Ribeiro Giordano[1]

2.1 Introduction

The concept of virtuous agriculture is new, in fact, its definition is still to be better delineated. This article intends, among other points, to discuss approaches to agriculture and to contribute to the clarification of this concept.

The concept of virtuous agriculture is linked to some well-defined axes which are: sustainable use of resources, balanced use of chemical inputs, harmonious relations between human beings-soil-plants.

This chapter deals with the themes of conventional agriculture, non-conventional agriculture, and presents a diagram with the main currents of organic, sustainable movements, and their precursors. The goal of this chapter is to publication about these different currents of agriculture and the diagram gives an overview in time of the different streams of non-conventional agriculture. One of the points to consider in this study is: healthy soils generate healthy food.

Healthy food plays an important role in human nutrition. The prevention of diseases through balanced nutrition, when these act as disease preventives, advances more and more on the medical agenda. Nutraceutical is a term used to name bioactive compounds present in foods that play important roles in health, are advancing with new research. Organic and biodynamic agriculture also has virtuous components from its concepts of environmental management, to those of preserving natural resources and not introducing synthetic components. The result would be to obtain food free from contamination and unwanted residues, in other words, healthy food.

The integration of livestock farming, and forests plays an important role in the production of food – from cereals and proteins – in the production of wood and cellulose

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fiber and also in the fixation of carbon in the soil depending on the use of the land. Regenerative agriculture is a relevant concept related to farming practices that cares for the conservation and regeneration of degraded soils, water, nutrients, fauna and flora of the soil, and, as its name says, in its regeneration.

At this intersection of practices, the concept of Virtuous Agriculture as a term with potential interest deserves to be further elaborated, including its definition contours, and limits. Aiming for a satisfactory communication, it needs to be elaborated and an effort is needed to define its limits.

As an aid for this lack of definition, this report starts with a comparison between conventional and non-conventional agriculture. The diagram with the timeline of different non – conventional movements since the beginning of the XXth century up to now is presented. The section of non-conventional agriculture explores its different formats in a topic named; sustainable systems and their fundamental characteristics**.** These systems are biodynamic agriculture, organic agriculture, biological agriculture, organo-biologic agriculture natural agriculture, permaculture, regenerative agriculture, ecological agriculture, alternative agriculture, and agroecology.

2.1.1 Conventional Agriculture

As well as other economic sectors, agriculture has taken the productivist path at the turn of the 20th century. Non-renewable resources started to be used intensively. These ways of producing might be associated with good agronomic practices, provided that the rational use of these resources is considered. Otherwise in certain situations, the same resources might be associated with non-rational use. There are examples of uses of good practices such as European wine-growing[2] which has been practiced for many centuries settled in the same locations and remains productive. There are also examples of misuse of natural resources, among which the case of the Aral Sea, in which the excessive use of irrigation water for cotton crop and others, led to the reduction of this inland sea to a size around 10% of its original area[3]. Another example is the occupation of tropical forests replaced by pastures.

The path of productivist agriculture was mainly due to several factors:

1. The technological advancement of mechanization, which freed agriculture from dependence on animal traction and steam engines, taking the production to a higher level of efficiency through the development and adoption of combined tractors, planters, and other implements.

2. Corbo, C., Lamastra, L. e Capri, E. From Environmental to Sustainability Programs: A Review of Sustainability Initiatives in the Italian Wine Sector Sustainability 2014, 6, 2133-2159; doi:10.3390/su6042133 disponível em https://www.mdpi.com/2071-1050/6/4/2133

3. Glantz, M.H.; Rubisnstein, A.Z. ;Zonn, I. Tragedy in the Aral Sea basin: Looking back to plan ahead? Elsevier, Global Environmental Change, Volume 3, Issue 2, June 1993, Pages 174-198 disponível em https://www.sciencedirect.com/science/article/abs/pii/0959378093900056

2. The intensive use of chemical-based inputs that already followed the technological advance of chemical fertilizers with the theory of Justus Von Liebig in the middle of the sec. XIX increasing the productivity exponentially and the reconversion of the industry of explosives in the industry of chemical inputs, giving a boost in agricultural productivity.
3. The post-World War II reconversion of the heavy arms industry of tanks, cannons, and airplanes in tractors, implements, and agricultural aircraft, boosted productivity even more.
4. The advance of bio-based inputs through classical genetics, introduced in the 1930s, being the classical example of the hybrid corn. This added to the other technological factors and achieved results never seen before. The green revolution was in place. This advance did not cease and the seeds, individual elements that most carry technology to the field, started to carry technology from biotechnology, genetic engineering, and the modification of genetics to organisms.

2.1.2 Non-conventional agriculture

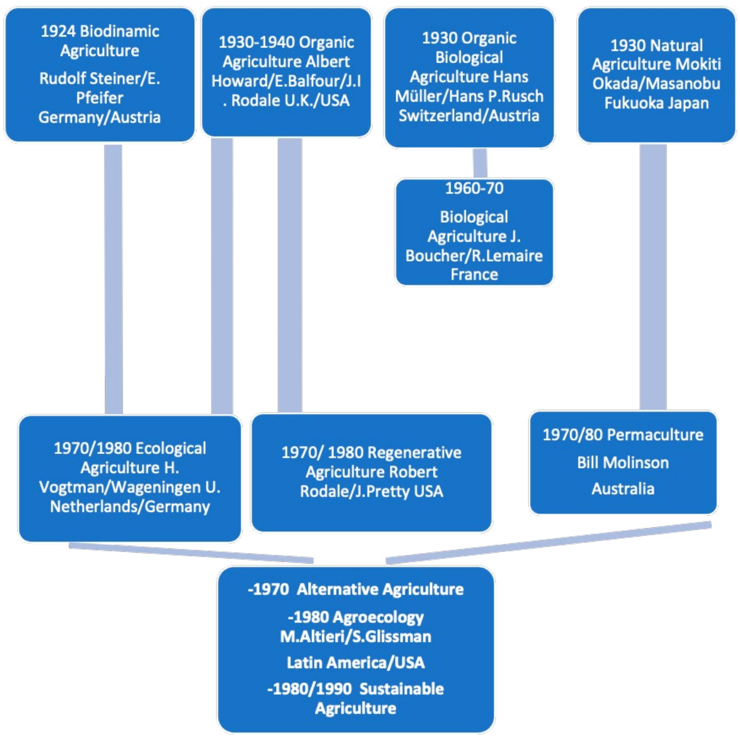
The non-conventional agriculture has several strands and it can be said that the common elements to all of them are:

1. Sustainability (Environmental, Social and Economic)
2. Holistic/ Humanistic Concern
3. Health /Nutrition Concern
4. Regulation Standards (sustainability rules)
5. Synthetic Inputs
6. Synthetic inputs/organic matter from outside the property
7. Use of microorganisms
8. Natural inputs
9. Special Calendar
10. Carbon fixation in soil

Non-conventional agriculture refers to agriculture based on biology and the enrichment of soil with organic carbon that brings sustainability benefits to the environment. These practices help to reduce the effects of climate change with fewer emissions and higher level of neutralization of carbon derived from crop agronomic practices. Non-conventional agriculture deals also with fertility through carbon enrichment practices in the soil. Technologies of soil conservation and management could bring health benefits to those who consume food is also a fundamental element of this concept. Some consider these effects yet to be supported by literature, setting them as an ideological decision of the consumer. Either being ideological or not, the strands are important and grow all over the world. They support the producers' economy generating more income with their healthy products and more healthy food for the population, Fonseca 2000[4]. Depending on the currents of thought from movements that appeared simultaneously in different locations, independent of each other, one can find other names for alternative agriculture. Alternative agriculture movements with different denominations had simultaneous initiatives in different countries. One can mention a multiplicity of movements in this direction. These movements began in the 1920s with the so-called Rebel Movements. Figure 2.1, based on Darolt, M.C. 2004, shows a temporal diagram with the main currents of thought linked to organic, sustainable movements, and their precursors.

2.1.3 Diagram with the main currents of organic, sustainable movements and their precursors

Figure 2.1. Diagram with the main currents of organic, sustainable movements and their precursors



Source: Darolt, M.C. 2004

4. Fonseca, M. F. A. e. A *Construção social do mercado de alimentos orgânicos:* estratégias dos diferentes atores da rede de produção e comercializaçao de frutas, legumes e verduras (FLV) in natura no estado do Rio de Janeiro. Rio de Janeiro, 2000, 235 p. Dissertação (Mestrado) – Universidade Federal Rural do Rio de Janeiro (UFRRJ).

This shows the simultaneity of the movements, their derivations in several places of the globe and the advance of the ideas along the XXth century.

2.2 Sustainable systems: fundamental characteristics

2.2.1 Biodynamic Agriculture.

This movement started in Germany with Rudolph Steiner (1861-1925) in 1924, founder of Anthroposophy[5], and it was presented in 1924, at a congress the Biodynamic Movement in the form of a cycle of 8 lectures for farmers. Biodynamic Agriculture, being linked to anthroposophy, proposes the renewal of agricultural management, the cure of the environment, and the production of healthy foods for human beings.

Anthroposophical thinking, according to his followers, proposes to restore agriculture to its original creative, cultural, and social strength, which was lost in the path of industrialization and also in monoculture and the mass creation of animals outside their natural environment.

The central point of Biodynamic Agriculture[6] is the human being who concludes the creation from his spiritual intentions based on a true cognition of nature. It aims to transform his farm or farm into an organism in itself, completed and diversified; an organism that forms itself is capable of producing renewal. The natural environment must be elevated to a kind of agricultural individuality. Among its practices, it makes the interaction between animal and vegetable production, the use of a biodynamic calendar, the use of biodynamic preparations, mineral and vegetable substances. The use of organic compounds is essential as well as hedges, green manure through legumes, crop intercropping, mixed cereal crops, fodder, and medicinal herbs for animals, crop borders, winter crops, healthy housing, reforestation, hot air dried concentrate, and many other practices. Biodynamic agriculture differs from other organic currents basically in two points. The first is the use of biodynamic preparations, which are highly diluted mineral, vegetable, and animal substances, according to the principles of homeopathy, applied to the soil, plants, and compounds. These preparations have the objective of vitalizing the plants and stimulating their growth. The second is the fact of carrying out agricultural operations (planting, pruning, thinning, other cultural treatments, and harvesting) according to an astral calendar, paying special attention to the disposition of the moon and planets. Another group, the "Association for Research in Anthroposophical Agriculture", directed by the German agronomist Erhard Bartsch,

5. Anthroposophy. Term that comes from the Greek meaning "knowledge of the human being", was introduced at the beginning of the 20th century by the Austrian Rudolf Steiner and can be characterized as a method of knowledge of the nature of the human being and of the universe, which expands the knowledge obtained by the scientific method as well as its application in practically all areas of human life. SAB-Sociedade Antroposófica no Brasil www.sab.org.br
6. Steiner, R. Fundamentals of Biodynamic Agriculture. 8 lectures given at Korberwitz, 7-16 / 6/1924, GA 327. Trad. Gerard Bannwart. São Paulo: Editora Antroposófica, 1993.

was formed to test the effects of biodynamic methods on the life and health of soil, plants, and animals. This group published a monthly journal, Demeter, which also named a sales organization, created by the same Dr. Bartsch, for biodynamic products which still exists today. The Research Association was renamed the Imperial Association for Biodynamic Agriculture in 1933. It was dissolved by the German governmentin 1941under the Nazi ideology.

Bering the same name, the Demetria Farm in the state of São Paulo Brazil, was one of the icons of Biodynamic Agriculture in Brazil. Founded in 1967 with the name of Tobias Charity Foundation, by a german immigrant, Mr. Pedro Schmidt. This Foundation was aimed at social projects and Mr. Schmidt started with a production and educational Project of biodynamic vegetables at the Demetria Farm in Botucatu, São Paulo. It lasted up to 2020 when was transformed into a real state investment project. Several agronomists that worked at Demetria Farm were trained at Emerson College in England, an important reference place for Biodynamics studies. Emerson College was founded in 1962 by Francis Edmunds on Pixton Hill, Forest Row in East Sussex. It was named after Ralph Waldo Emerson, American poet and transcendentalist. For the past 50 years, there has been an international community of students, teachers, and researchers living and studying on the site inspired by the philosophy and teachings of Rudolf Steiner, the creator of Anthroposophy. Biodynamic agriculture is a different form of organic agriculture in many forms mainly in its spiritual, mystical, and astrological orientation. It shares a spiritual focus, as well as its view toward improving humanity, with the "natural farming" movement in Japan.

Biodynamic agricultural practices have their certification, inspection, and accreditation system for farmers. However, biodynamic production units are grouped under the generic name of organic agriculture. According to the members of the movement, a biodynamic production unit is also organic, but the opposite does not hold.

2.2.2 Organic Agriculture

Between 1925 and 1930, in England, Albert Howard, an English botanist with experience in India where he studied Vedic farming practices, discovered that he had a lot to learn in Indian traditional culture. Howard noted the connection between healthy soil and healthy crops, people, animals in Indian villages. According to Patrick Holden, Director of the Soil Association of Great Britain quoting Howard, stated that "the health of the soil, plant, animal, and man is one and indivisible". Howard proposed a process improvement which he called the Indore composting process. The essential factor in eliminating diseases in plants and animals is, according to Howard, the fertility of the soil. This method was widespread in the USA after 1940 by Jerome Irving Rodale, consisting of the adoption of a production system, involved in soil-plant-environment relations ordered by principles of respect for natural resources and consumers. The AAO-Association of Organic Agriculture of São Paulo, founded in 1989 had the encouragement of two exponents of organic agriculture in Brazil, José Lutzemberger and Ana Maria Primavesi, both renowned plant and soil specialists. The AAO definition of Organic Agriculture is a productive process committed to the organicity and health of the production of live food to guarantee the health of human beings. It uses and develops technologies appropriate to the local reality of soil, topography, climate, water, radiation, and biodiversity specific to each context, maintaining the harmony of all these elements among themselves and with human beings. This mode of production ensures the supply of healthy, tastier, and more durable organic foods.

According to the association, avoiding the use of synthetic chemicals preserves the quality of the water used for irrigation and does not pollute the soil or the water table with toxic substances. The use of a minimum soil management system ensures soil structure and fertility, preventing erosion and degradation, contributing to promote and restore local biodiversity. Due to this set of factors, organic agriculture enables general sustainability and expands the capacity of local ecosystems to provide environmental services to the entire surrounding community, contributing to reduce global warming. Agriculture has undergone modifications and has been getting closer to Biodynamic Agriculture in the use of inputs considered organic, produced on an industrial scale by several industries in the country and also by Israel.

2.2.3 Organo-Biologic Agriculture

In the early 1930s, the biologist and politician Dr. Hans Müller worked in Switzerland on studies on soil fertility and microbiology, and in a kind farming that was later known as organic farming. Their initial objectives were socioeconomic and political, that is, they sought the farmer's autonomy and direct marketing. These ideas came to fruition many years later, around the 1960s, when the Austrian physician Hans Peter Rusch spread this method. At that time, the concerns of the organic farming chain met with those of the ecological movement, that is, protection of the environment, biological quality of food, and development of renewable energy sources. On the other hand, unlike the biodynamic school, Rusch renounced the principle of complete autonomy of the agricultural production unit. In other words, he thought the association of agriculture with livestock was important, but he did not consider it essential. The use of organic matter was recommended, but the material could come from other sources outside the production unit, differently from what the biodynamic ones recommended. According to Rusch, the most important was the integration of the production units with a set of regional socioeconomic activities.

2.2.4 Biological Agriculture

In the early 1960s, agronomist Jean Boucher and doctor Raoul Lemaire gave the movement a commercial connotation, creating the "Lemaire-Boucher method", which recommended, among other things, the use of substances of marine origin, that were commercialized by the society formed between them. The principles of organic farming were introduced in France, after the Second World War, by consumers and doctors concerned about the effects of food on human health. From the 1960s onwards, the development of organic farming took place in several stages linked to socioeconomic contexts and the movement of ideas of the corresponding times. Within this trend, it is worth mentioning the participation of two French researchers considered as key figures in the scientific development of organic agriculture. The first is the researcher Claude Aubert, who published L'Agriculture Biologique or "The Organic Agriculture", in which he highlights the importance of maintaining the health of the soils to improve the health of the plants (biological quality of the food) and, consequently, to improve man's health. The second important character is Francis Chaboussou, who published in 1980, "Plants sick from the use of pesticides: The theory of trophobiosis". His work shows that a plant in good nutritional condition becomes more resistant to attack by pests and diseases. It can be said that the technical proposals of organic and organic farming are identical. Currently, differentiation is more in the sense of the word's origin than in terms of production and commercialization norms.

2.2.5 Natural Agriculture

Natural agriculture is linked to the work carried out in Japan, and these currents can be divided into two main groups: Mokiti Okada and Fukuoka.

According to Ehlers (1993)[7], in 1935, Mokiti Okada started his work in this area, aligned with the development of a religious practice that had "natural" methods of agriculture as one of its bases. This religion argued that the purification of the spirit should be accompanied by the purification of the body, hence the need to avoid the consumption of potentially toxic products. Initially, this movement was restricted to Japan, but in 1982, the International Center for the Development of Natural Agriculture was founded, and in 1976, two research stations had already been founded in Japan. Mokiti Okada International (MOA), was founded in Washington, DC, in the United States of America, and currently the World Sustainable Agriculture Association (WSAA), an NGO with headquarters in the United States of America and offices in New York, at the headquarters of the United Nations (UN) and in the capital American, Washington, DC, among other cities, has been organizing this movement. WSAA has 56 branches in 36 countries – including Brazil – where there are followers and practitioners of both the religion and its agricultural system, including research facilities in the State of São Paulo. The Brazilian researcher, Dr. Shiro Myasaka, led the work on research in natural agriculture – MOA, in Brazil. From a practical point of view, what differentiates natural agriculture-MOA from other forms is the adoption of special products for the prepa-

7. Ehlers, E. What is meant by sustainable agriculture? 51 p. Dissertation (Master's) –Postgraduate Program in Environmental Science, USP, São Paulo, 1993.

ration of organic compost. These are the so-called efficient microorganisms, BYM or Eokomit, products marketed, and of formula and paternity held by the manufacturer (Myasaka; Nakamura, 1989)[8]. It is a set of microorganisms (fungi, bacteria, and actinomycetes), specialized in the decomposition of organic matter, which are mixed with rice or wheat bran and then used in the preparation of organic compost or the preparation of substrate for seedlings. The use of Bayodo is also an integral part of the natural agriculture-MOA system. It is a mixture of virgin soil (subsurface soil, without stones or roots, and rich in clay and nutrients) and rice bran, which is put to ferment (Myasaka; Nakamura, 1989). Typically, BYM is used to speed up the process. According to these same authors, Bayodo improves the chemical conditions of the soil and provides more balanced nutrition to plants. Also, damage caused by fungi, bacteria, and nematodes has been controlled, without a clear explanation. Some authors had classified the Fukuoka method as permaculture, given the similarities between these systems. However, Fukuoka himself (1985, 1987)[9] in his works, adopted the name of Natural Agriculture. Fukuoka's approach is far removed from the other lines, as it does not allow the soil to be plowed. Fukuoka advises not to use any type of fertilizer or organic compost, or even to plow the soil. The use of industrialized inputs is out of the question. Unlike natural agriculture-MOA, Fukuoka, being a scientist, takes a philosophical-scientific-ethical approach, not having the same religious character, although adopting some oriental principles (yin – yang), in his discussions in search of unity in agriculture.

2.2.6 Permaculture

In Australia, in the 1970s and 1980s, Mokiti Okada's ideas evolved with Dr. Bill Mollison whose work developed with David Holmgren gave rise to a new method known as permaculture. This was done in parallel with a pioneering Course of Ecological Design in Tasmania. The term was a contraction in English, of the terms "permanent" with "agriculture", or permanent agriculture. These two scientists pre-viewed, more than 30 years ago that it would not be possible to have a long lasting society without a permanent agriculture basis (today it would be called a sustainable society). By this permanent agriculture basis, they referred to a way of producing food, fiber, construction supplies, and fuel in a way that would not be impacting the ecosystems, instead it would be in harmony with them.

The method proposes an integrated evolutionary system of perennial plant and animal species (hence the name permaculture) or self-perpetuating useful to man. It has some peculiarities, which differentiate it from other models. One of them is the use of efficient microorganisms, known as EM, effective microorganisms. These microorganisms are used as inoculants for soil, plants, and compounds. Another particularity is

8. Myasaka, S .; Nakamura, Y. Moa natural agriculture. São Paulo: Associação Mokiti Okada do Brasil, AN-MOA Research Center, 1989. 64 p.

9. Fukuoka, M. The natural way of farming: theory and practice of green philosophy. Tokyo: Japan Publications, 1985. 280 p. Fukuoka, M. The road back to nature: regaining the paradise lost. Tokyo: Japan Publications, 1987. 377 p.

the non-use of animal waste in the compounds under the argument that animal waste increases the level of nitrates in drinking water, attracts insects, and gives rise to the proliferation of parasites.

The permaculture movement has evolved through three phases, each represented by a key book. "Permaculture One" (1978)[10] emphasizes the replacement of annual crops with perennials. Mollison and Holmgren say that permaculture is "an integrated, evolving system of perennial or self-perpetuating plant and animal species useful to humankind. [sic]".

The fertility of agricultural soils depends on the humus laid down by centuries of forest cover. Once this land is cleared to grow cereals, this topsoil is progressively used up. Permaculture attempts to escape this trap, using perennials to provide food and build soil.

By the second phase, this definition by perennials is quietly abandoned. In "Permaculture: A Designers' Manual" (1988) Mollison defines permaculture in two sentences[11]:

> *Permaculture (permanent agriculture) is the conscious design and maintenance of agriculturally productive ecosystems which have the diversity, stability, and resilience of natural ecosystems.*

This equates to a definition in terms of agricultural sustainability – stability and resilience. The next sentence broadens permaculture substantially:

> *It is the harmonious integration of landscape and people providing their food, energy, shelter, and other material and non-material needs sustainably.*

This is not just talking about agricultural systems but about every kind of technology that humans may use to relate to nature. It includes energy, the use of metals, pottery, even computers, so long as all these things can be produced sustainably! But in fact, the book is almost entirely about agricultural strategies, with a brief discussion of solar passive design for housing. Mollison also adds four "permaculture ethics"

- care for the earth;
- care for other people;
- set limits to population and consumption;
- distribute the surplus. These ethical positions are common to other strands of the environmentalist movements as well.

10. Mollison, B. and Holmgren, D. (1978) Permaculture One, Uxbridge: Corgi
11. Mollison, B. (1988) Permaculture: A Designers' Manual, Tyalgum: Tagari Publications

The most recent phase of the permaculture movement comes out of Holmgren's book, "Permaculture: Principles and Pathways Beyond Sustainability" (2002)[12]. This book continues the drift away from permaculture defined purely as an agricultural strategy. Instead, it develops a set of "design principles" relevant to all decision making – personal, economic, social, and political. For example, "produce no waste" and "obtain a yield". Permaculture has become a movement for the popular science of sustainable agriculture and settlement design.

This is a summary of the principles of permaculture:

- Permaculture favors organic agriculture – synthetic chemical fertilizers, pesticides, and herbicides damage the soil, the health, and other species.
- Permaculture designs must include and emphasize perennial crops – to maintain and retain soils, to provide fodder, fuel, and food.
- A polyculture is an agricultural strategy to maximize biodiversity and to deal with pests and diseases without using harmful chemicals. Integration of livestock and cropping is required so resources from both can be readily interchanged.
- Services must be done without machinery, transport, and inputs dependent on fossil fuels. There is a scarcity of oil and global warming is a big problem.
- Agriculture must surround and interpenetrate settlements – so all food transport can be on foot or by animal traction.
- Local agriculture permits recycling of the nutrients in human and animal manure and avoids the need to refrigerate meat or vegetable foods.
- Permaculture emphasizes plants and animals that are robust in a particular locale, not ones that depend on irrigation and synthetic inputs.
- Agricultural jobs must be diverse and labor-intensive, requiring knowledge of a range of species and their interactions.
- Permaculture emphasizes building structures to retain and use water in the landscape rather than pumping water over long distances, using fossil fuel energy.

Beginning permaculture strategies emphasizes local agriculture for local consumption, and organic strategy for subsistence farmers who cannot afford commercial inputs. Perennial crops feed animals, fix nitrogen and provide mulch. The labor required by a polyculture is available when there are no jobs. A variety of crops prevents a pest species from wiping out the whole harvest. Local agriculture does not depend on long supply chains and oil-based transport. Proximity makes it easy to link crops and animals, recycling nutrients. Permaculture makes for an engaging experience of agricultural work. Irrigation and supply of water can be done with earthworks built locally.

12. Holmgren, D. (2002) *Permaculture: Principles and Pathways Beyond Sustainability,* Hepburn: Holmgren Design Services

Examples of permaculture designs have been appearing around the world. The Loess Plateau of China had been turned into a desert by generations of farming and has been restored using techniques promoted by permaculture. In Niger, World Vision has pioneered 'farmer-managed natural regeneration' to re-establish a mixed agricultural regime of woodland with cropping. In the Philippines, peasant farmers taking the path of cash cropping had been driven into debt. They established MASIPAG, a movement to abandon high input agriculture and concentrate on local food security. In Zimbabwe, the Chikukwa clan has restored the food security of six villages with a permaculture project – initiated by local people and still going after more than twenty years. Experiments like this could proliferate as the growth economy falters.

2.2.7 Regenerative Agriculture

The main intention of regenerative agriculture is to restore degraded soils or improve soil health, which improves water quality, vegetation, land productivity, as well as increasing the amount of organic carbon in the soil while reducing the amount of carbon of the atmosphere[13]. The origin of the term comes from the United States in the 1980s when Robert Rodale studied the regeneration processes of agricultural systems and defined the concept relating the possibility of producing at the same time that the soil is recovered[14]. Soil health is considered a key to sustainable agriculture. Another characteristic inherent to the concept mentioned in the literature is the incentive to biodiversity, with practices and principles that keep the maintenance of the entire system, holistically.

Proponents of regenerative agriculture argue that agricultural production, if well managed, can generate, in addition to products, soil sustainability, protection of biodiversity, the guarantee of water supply, protection of rural communities and consumers. These objectives are achieved from sustainable production with integration between plants, animals, water, soil, microorganisms, and insects[15, 16].

Some practices normally used in regenerative agriculture to restore and increase quality and productivity are[17, 18]:

13. Rhodes, Christopher J. The imperative for regenerative agriculture. Science Progress (2017), 100 (1), 80–129.
14. Assis, Renato Linhares. Organic agriculture and agroecology: conceptual issues and conversion process. Seropédica: Embrapa Agrobiologia, 2005. 35 p. (Embrapa Agrobiologia. Documents, 196).
15. Louise E. Buck; Sara J. Scherr. Moving Ecoagriculture into the Mainstream. In book: State of the World 2011: Innovations that Nourish the Planet Edition: First Edition Chapter: 2Publisher: W. W. Norton & Company Editors: Worldwatch Institute. December 2010.
16. Redação Pensamento Verde -19/09/2017. Entenda o conceito de agricultura regenerativa e sua contribuição para a natureza. Disponível em: https://www.pensamentoverde.com.br/sustentabilidade/entenda-o-conceito-de-agricultura-regenerativa-e-sua-contribuicao-para-natureza/
17. Why regenerative agriculture is the future of sustainable food. Well Good, translated and adapted by the BeefPoint Team. 11/8/2019. Available at: www.beefpoint.com.br/por-que-a-agricultura-regenerativa -e-o-futuro-dos-alimentos-sustentaveis
18. Yale Center for Business and the Environment. Program Regenerative Agriculture Initiative. Available at: Access in 30/07/2020.

- Increase in the supply of organic matter to the soil,
- Crop Rotation,
- Association of Cultures,
- Cover cultivation,
- Use of fertilizers of animal origin,
- Composting
- Rotation of pastures,
- Use of biofertilizers,
- Decrease in the use of chemical fertilizers and pesticides,
- Absence of genetically modified organisms,
- Guarantee of animal welfare,
- Social responsibility with farmers and their employees

There is also a trend that sees regenerative agriculture as a derivation of organic agriculture. In this case, what characterizes it is the search for independence from external resources, leveraging resources developed within the production unit[19] .

A study by the Regenerative Agriculture Initiative (RAI) team at the Yale Center for Business and the Environment Yale (CBEY) identified that, among all barriers to the transition to regenerative agriculture, the cost was the most cited obstacle between farmers and organizations serving farmers[20].

This study considered that the main barriers to the adoption of large-scale regenerative agriculture are:

- Misinformation on the part of producers, as well as a lack of training programs. To be stimulated to change their production paradigm, farmers need information, evidence, and specific models for the transition in each region;
- The high cost of arable land;
- The market still in its infancy for products from regenerative agriculture. Farmers face uncertain demand, so financial incentives are insufficient. Regenerative agricultural products, like organic ones, cost more because they require more labor.
- Lack of agricultural insurance that supports alternative production systems.

Regenerative agriculture has not yet spread widely in Brazil. A pioneering experience cited in the literature was by the Swiss Ernest Götsch who developed an agroforest-

19. Darolt, Moacir Roberto. The main chains of organic movement and their particularities In: Planeta Orgânico, 2004.
20. Renton, Cortney Ahern; Lafave, Claire Huntley; Sierks, Kathryn. The State of Regenerative Agriculture: Growing With Room to Grow More. Conservation Finance Network. March 24, 2020. Available at :https://conservationfinance-network.org/2020/03/24/the-state-of-regenerative-agriculture-growing-with-room-to-grow-more .

ry system in Bahia to recover degraded areas. However, Ernest himself later coined the term Syntropic Agriculture[21]. The concepts of regenerative and syntropic agriculture share principles and objectives for restoring environments, so that the example can be attributed to the two currents.

2.2.8 Ecological Agriculture

In the early 1980s, Dr. H. Vogtmann established formal teaching work in this area at the University of Kassel-Witzenhauzen. Initially, it was just a subject and it was called Alternative Agriculture Methods. More recently, it came to be called ecological agriculture. Vogtmann organized the book Ecological Agriculture: Agricultural Management with a Future, from 1992, in which he presents the contribution of several authors addressing various theoretical-philosophical and practical aspects of Ecological Agriculture.

In Brazil, the issue of ecological agriculture is linked to the work of agronomist José Lutzenberger. Artur and Ana Maria Primavesi also had a relevant influence on the use of the name of Ecological Agriculture working on tropical soils in an innovative and differentiated way. Generally, ecological agriculture seeks a balance with the environment, integrated agricultural designs, rational soil management, but it is less restrictive concerning the use of inputs than biological agriculture and organic agriculture, as well as being directed to medium and large properties and not just small ones.

2.2.9 Alternative Agriculture

In the 1970s, this set of trends seen previously came to be called alternative agriculture. The term appeared in 1977, in the Netherlands, when the Ministry of Agriculture and Fisheries published a report, known as the "Dutch Report", containing the analysis of all unconventional streams of agriculture, which were brought together under the generic name of alternative agriculture. Thus, this term does not constitute a current or a well-defined philosophy of agriculture, it is only useful for bringing together the currents that differ from conventional agriculture. Even so, according to EHLERS (1994) opus cit. The expression was increasingly used, especially after the United Nations Conference on Environment and Development, Rio-92, which reinforced the idea of sustainability.

21. Santos Pasini, Felipe. Ernst Götsch's Syntropic Agriculture: history, foundations and its niche in the universe of Sustainable Agriculture. Dissertation (master's degree) – Federal University of Rio de Janeiro, Postgraduate Program in Environmental Sciences and Conservation, 2017– Rio de Janeiro, 2017.

2.2.10 Agroecology

Agroecology is seen as a field of knowledge of a multidisciplinary nature, whose teachings intend to contribute to the construction of ecologically based farming styles and the development of rural development strategies, having as reference the ideals of sustainability in a multidimensional perspective. The three synthesized concepts of Agroecology described below, are definitions of outstanding researchers in agroecology, (Miguel A. Altieri, Stephen R. Gliessman, and Eduardo Sevilla Guzmán). Miguel Altieri and other scientists who collaborated in his book, are perhaps the most important authors about the popularization of the use of the word agroecology, as a new scientific and development conceptual framework, incorporating the notion of indigenous knowledge, cultural aspects, ecological management of pests, management of biodiversity, socioeconomic aspects, education in agroecology, etc., making a decisive contribution to conceptual evolution, concerning forms of non-conventional agriculture. The participatory methods of rural diagnosis, research, planning, monitoring, and evaluation are part of the protocol of Ecological Agriculture. These protocols are important for the incorporation of farmers as subjects of their development process, as well as the dialogue between advisors and the community according to Ehlers (1994)[22]. According to Norgaard (1987)[23], "Agroecology presents an epistemological basis different from that of Western science. The traditional agronomic paradigm considers the development of agriculture and farmers based on the diffusion of scientifically produced technologies. The agroecological paradigm seeks to understand how traditional agricultural systems developed and on what ecological bases, looking for a more sustainable modern agriculture". According to this same author, "agroecologists are changing the one-way direction that existed in the paths between science and development, introducing a two-way".

For Miguel A. Altieri[24] , Agroecology is the science or scientific discipline that presents a series of principles, concepts, and methodologies for studying, analyzing, directing, designing, and evaluating agroecosystems, to allow the implantation and development of agricultural styles with higher levels of sustainability. Agroecology then provides the scientific basis to support the transition to sustainable agriculture in its various manifestations and/or denominations.

For Stephen R. Gliessman, the agroecological approach corresponds to the application of Ecology concepts and principles in the management and design of sustainable agroecosystems.

Eduardo Sevilla Guzmán approaches a rural development dimension when he affirms that Agroecology is the field of knowledge that promotes the ecological man-

22. Ehlers, E. What is meant by sustainable agriculture. Dissertation presented to the Graduate Program in Environmental Science at the University of São Paulo to obtain the Master's Degree in Environmental Science. 1994.
23. Norgaard, R. B. The epistemological basis of agroecology. In: Altieri, M. A. (Ed.). Agroecology: the scientific basis of alternative agriculture. Boulder, CO, USA: West Press, 1987. p. 21-27
24. Altieri, M.A. (1989) Agroecology: The scientific bases of Alternative Agriculture. Rio de Janeiro. PTA-FASE.240 p.

agement of natural resources, through forms of collective social action that present alternatives to the current crisis of modernity, through proposals for participatory development since the areas of production and alternative circulation of their products, aiming to establish forms of production and consumption that contribute to face the ecological and social crisis and, thus, restore the altered course of social and ecological coevolution.

Its strategy has a systemic nature when considering a property, community organization, and the rest of the landmarks of rural societies articulated around the local dimension, where are the knowledge systems with endogenous and sociocultural potential. Such diversity is the starting point of their alternative agriculture, from which the participatory design of endogenous development methods is intended to establish dynamics of transformation towards sustainable societies.

Therefore, Agroecology brings us the expectation of a form of agriculture capable of promoting the production of food, fibers, and environmental preservation, differentiating itself, therefore, from the dominant orientation of agriculture with industrial production characteristics, based on intensive use capital, energy, and non-renewable natural resources, thus being aggressive to the environment, excluding, socially seen and causing economic dependence.

Although combinations of traditional management methods and the physical, chemical, and biological balance of the agroecosystem are used, it may include new technologies, such as rescuing managements and techniques used in similar ecosystems, water conservation practices, and animal management, among others.

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2.2.11 Sustainable Agriculture

The term Sustainable Agriculture is controversial, since there are about 60 definitions of sustainable development. This indicates that either none serves or that each serves a specific purpose and interest. The classic definition of sustainable development came up with the document Our Common Future[25]. This document states that sustainable development is: "the possibility of meeting the needs of the present, without compromising the survival possibilities of future generations". Hence, we could deduce that Sustainable Agriculture would be the one capable of producing food for the current world population without, however, compromising the production and food of fu-

25. Document prepared in 1987, by the World Commission on Environment and Development, commissioned by the Prime Minister of Norway, Gro Brundtland. For this reason, the document is also known as the Brundtland Report.

ture generations. It is worth asking: can conventional productive agriculture guarantee this principle? According to Campbell, quoted by Pretty (1995)[26]: "attempts to define sustainability fail because, like beauty, sustainability is in the eyes of the observer (...) the definition of sustainability is inevitably socially constructed and, therefore, reason, there are so many definitions". Indeed, the definition of Sustainable Agriculture that non-governmental organizations produced during the Global Forum (Rio 92) in 1992, states: "Sustainable Agriculture is the one that is ecologically correct, economically viable, socially just, culturally adapted, that develops as a process, in a democratic and participatory condition "(Global Forum, 1992). Today, it is known that all multilateral organizations (UN, World Bank, FAO, etc.), and even the Brazilian government, have adopted Sustainable Development and Sustainable Agriculture as jargon. Everyone talks about new paradigms and holism, but there is a huge difference between real-world speech and practice. It is known that the industrial agriculture model is firmly based on the petrochemical industry, both for the production of inputs and its application and transportation. It is known that oil is a non-renewable resource and that, in the coming years, its costs are expected to reach very high values, even if new deposits are discovered. And there is also a scenario in which the oil paradigm could be substituted by alternative technology before the prices rise. It is known that a good part of these inputs – including, also, a good part of the management of intensive agriculture has been causing environmental degradation, threats to human health, erosion, compromised water reserves, salinization of soils, etc. Some experiences in agroecology on the micro-scale are applied successfully to a macro scale, being the goal to achieve real sustainability in agriculture. Generally, rich countries, which practice intensive agriculture more systematically, consume most of the planet's non-renewable natural resources. The United States of America is estimated to consume about 33% of all the world's energy, with a population that represents only 4% of the world population. Since Pimentel (1973)[27], it has been known that the energy balance of intensive agriculture is negative, that is, there is a higher calorie expenditure than its production. Also, according to Pimentel and Pimentel (1996)[28], 17% of all energy consumed in the United States of America is directed to the food production sector, with 6% in production, 6% in processing and packaging, and 5% in distribution and preparation. Is that the development system model for the entire planet? Is the AI of the so-called developed countries the recipe for the entire planet? Certainly not, because the results of the Green Revolution made that very clear. According to the former Swedish environment minister, Gro Harlem Brundtland, in an interview shortly before the Global Forum (1992), the planet's resources would be able to expand the pattern of development and consumption in the First World, to just 500 million human beings, the majority of the population being condemned to lower or at least differentiated levels of consumption

26. Pretty, J. N. Regenerative agriculture: policies and practice for sustainability and self-reliance. London: Earthscan, 1995. 320 p.
27. Pimentel, D. Food production and the energy crisis. Science, Washington, v. 182, p. 443-449, 1973.
28. Pimentel, D.; PIMENTEL, M. Food, energy and society. Niwot: University Press of Colorado, 1996. 363 p.

and development. It is necessary to develop patterns of agricultural production and development that are sustainable if a promising future is desired for humanity.

2.2.12 Carbon farming

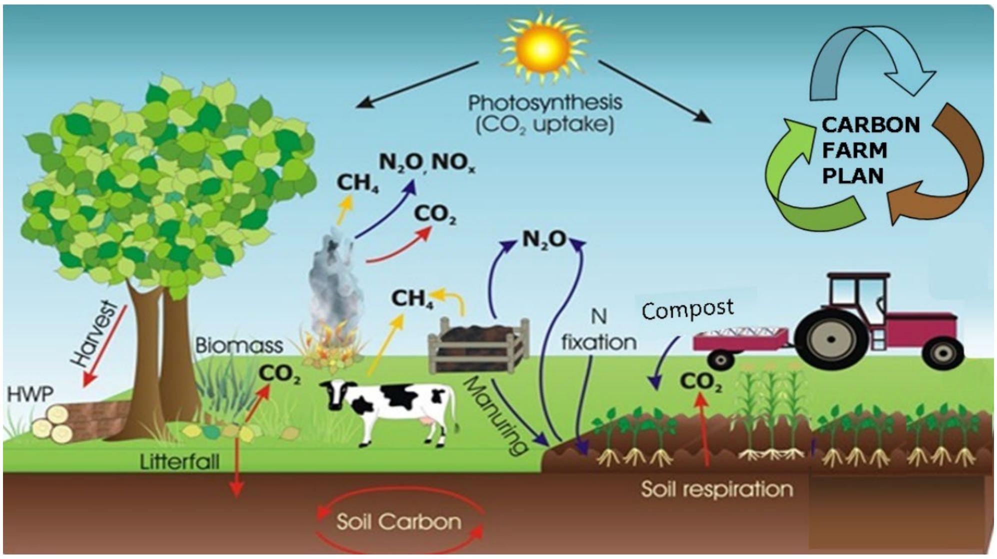
Carbon farming is the process of changing agricultural practices or land use.

This is made to improve the amount of carbon present in the soil and plants. The aim is to reduce the GHG emissions from livestock, soil and vegetation. Common agricultural practices as driving a tractor, tilling the soil, clearing forests, making overgrazing result in the release of this soil and biomass CO2 to the atmosphere. It is estimated by the IPCC that 1/3 of the surplus CO2 in the atmosphere, that is causing climate change, has come from agriculture and change of land practices and use.

Potentially this kind of farming gives financial incentives to landowners to reduce carbon pollution. It could offer additionalities to the environment and the economy.

It looks like there is a growing number of farmers that are already in the attempt to capture and store amounts of CO2 in the soil as means to fight against climate change.

And of course, if there are financial incentives involved it will be more easy to convince and to spread the practices of fixing CO2. Some amounts of carbon are naturally stored in the soil and the origins are almost always from Organic matter, decomposition of plants and animal matter.



Source :2018 https://www.marincarbonproject.org/carbon-farming

According to MIT-Massachussets Institute of Technology, the National Academy of Sciences estimated in a study in 2019 that global farmland could capture and store as much as 3 billion tons of additional carbon dioxide. This could happen if farmers adopted a number of practices, such as: adding organic matter like manure or compost, shifting cultivation to favor crops that contribute more of their carbon to the soil, or using off seasons to plant cover crops that will then break down.

California has started providing small grants from the state's **carbon cap-and-trade fund** to farmers who employ techniques that promise to store more carbon. Meanwhile, a Boston startup known as **Indigo AG** recently announced a plan to pay farmers to pursue similar practices and **then sell carbon credits to companies or individuals looking for ways to offset their climate impacts.**

This is key thing of this system:

1. Financial Incentives to farmers who adopt these techniques.
2. A market regulated that provides juridical safety to the participants trough clear rules of the game.
3. The metrics to see how much of a climate benefit these practices provide. Which practices are better under different climate and soil conditions?
4. Are there more efficient ways to balance out the industry's GHG emissions?

This system seems ok but there are cons and pros.

Noah Deich, executive director of Carbon180, a think tank promoting carbon removal and recycling, said that:

> *… since the onset of agriculture, the planet has released about 500 billion tons of carbon dioxide from soil—about 14 times the amount released from all fossil-fuel energy sources globally last year. It's a huge pool that could potentially be refilled, if those ecosystems can be made to take up higher levels of carbon dioxide. But from that basic premise it gets much, much more complicated.*

The Unknowns about this farming are about "how soil microbe ecosystems actually work and what practices are most effective at capturing and storing carbon dioxide", Deich said. He added that what we most need right now is a lot of field experiments in a lot of places exploring these things in greater detail.

Tim Searchinger, a researcher at Princeton who closely studied the potential of carbon farming for an upcoming World Resources Institute report, took an even more skeptical stance. He said there are limits on how much farmers can change their soil management practices, and other restrictions on how much more carbon we can reliably store in soils that we continue to farm. In addition, some efforts that could be credited as carbon farming might have taken place anyway. "Our view generally is that it's been a huge diversion, " he said. "We have … an enormous number of things that need to done to be solve agriculture and climate change, and soil carbon ain't it, at least from a mitigation standpoint."

The first and most important priority for minimizing the climate impact of agriculture is to stop clearing more land for it, Searchinger stressed.

"There's no scientific uncertainty about that, " he said. "You clear a forest and you lose a lot of carbon."

In particular, he said, we need to make extra efforts to conserve or restore peatlands, a type of wetland that releases vast amounts of carbon dioxide when it's dried out and converted to agricultural uses.

Boosting productivity on grazing and croplands—through, say, better processes, nutrients, crops, or seeds—can deliver bigger benefits, he argued, by easing pressure to expand agricultural operations. Better still would be for farmers to convert some fields back to grasslands and forests, which store far more carbon in their leaves, trunks, roots, and soil.

According to Calla Rose Ostrander of the Marin Carbon Project (a research effort to improve carbon sequestration in the soil of Marin [29], California county) said it's difficult to make generalized global conclusions about carbon farming. "When it comes to soil carbon science … you have to:

- take a specific approach to the landscape that you're in,
- to that crop system that you're in,
- to the climate that you're in,

She remarks that California's soil program is based on a decade of peer-reviewed research exploring carbon uptake at varying soil depths throughout the state. She added that the goal of such efforts isn't simply capturing and storing carbon, **but creating soils that can be both agriculturally productive and climate friendly.**

2.2.13 Conclusion

After running through the different movements and their strands it is possible to realize that they have many points of convergence. These agro-industrial systems propose to have food free of contamination of any kind, biological or chemical and also avoiding genetic modification and or irradiation of any kind. At the same time there is the questioning and arguing about the principles of no-tillage, minimum transportation leading to local production and consumption, incorporation of carbon in the soil, use of beneficial micro-organisms, yeasts, composts, organic matter, and so on. Not all movements of non-conventional agriculture reached the point of transforming ideas into products and businesses. It is interesting to note that the founders of Biodynamic Agriculture were already concerned with the spreading of their concept starting with educational programs and scientific journals, which were the most advanced way, at the time, of divulging and congregating more affiliates to the biodinamyc foundations.

29. https://www.marincarbonproject.org/carbon-farming

The concern about the commercialization of the products, in the decade of 1920, was also a visionary proceeding, anticipating the importance of the distribution for specific agribusiness systems, to keep them alive. Without social networks a hundred years ago, these instruments like, Journals, Meetings, Courses, Trips constituted the basis for spreading their principles.

When discussing the concepts and trends of non-conventional there was a rapid replacement of the adjective "alternative" that, since the 1970s, designated the opposition to conventional agriculture, by the use of the adjective "sustainable". This observation brought with it some questions. Would the notion of "sustainable agriculture" simply be a new expression to designate all the trends previously embedded in "alternative" agriculture? Or, on the contrary, the growing popularity of the expression "sustainable agriculture" would be more reflecting the need for the evolution of "conventional" agriculture itself in response to the pressure of society for a "cleaner" production, that is, with the preservation of natural resources and guarantee of nutritional quality of food? In this case, would the search for this sustainability lead to the adoption of practices hitherto considered "alternative" or, on the other hand, would it lead to a new technological standard "superior" to both "conventional" and so-called "alternative" systems? It was seen that none of these concepts prevailed or took precedence over others. The more radical supporters of Agroecology claim that this is not a subdivision of alternative agriculture in endless semantic and philosophical discussions.

To organize the common practices of the different movements and have a better visualization of the different streams of non-conventional agriculture it was prepared a table with the different systems and their specific characteristics.

Table 2.1 Different Strands and Characteristics of Non-Conventional Agriculture

Characteristics / Systems	Sustainability Environmental Social Economic	Holistic/ Humanistic Concern	Health /Nutrition Concern	Regulation Standards (With sustainability elements)	Synthetic inputs/ Organic matter from outside	Special Yeasts/Microorganisms	Natural Inputs From industry	Special Calendar	Religious Basis	Carbon Fixation in soil /GHG Emissions
Organo-Biologic Agriculture	Y	Y	Y	Y	N/Y	N	Y	N	N	N
Biological Agriculture	Y	Y	Y	Y	N/Y	N	Y	N	N	N
Natural Agriculture	Y	Y	Y	Y	N/Y	Y	N	N	N	N
Permaculture	Y	Y	Y	Y	N/Y	Y	N	N	N	N
Ecological Agriculture	Y	Y	Y	Y	N/Y	N	Y	N	N	Y
Alternative Agriculture (Does not have practices)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Biodynamic Agriculture	Y	Y	Y	Y	N/N	Y	N	Y	Y	N
Organic Agriculture	Y	Y	Y	Y	N/Y	N	Y	N	N	Y
Agroecology	Y	Y	Y	Y	N/Y	N	N	Y	N	Y
Sustainable agriculture	Y	Y	Y	N	N/Y	Y	Y	N	N	Y
Regenerative Agriculture	Y	Y	Y	Y	N/Y	Y	Y	N	N	Y
Virtuous Agriculture	Y	Y	Y	N	Y/Y	Y	Y	N	N	Y

Y= Yes Source: The Authors,2020
N=No
NA=Not applicable

It can be seen in Table 1 that the topics of sustainability, holistic and humanistic concern, health /nutrition concern, and regulatory standards and to avoid the use of synthetic inputs are common to all systems. The variations came in the topics of use of organic matter coming from outside the property, use of special microorganisms, yeasts and natural inputs, the use of special calendars, a religious basis, and the concern with fixation of carbon in the soil and emission of GHG.

In order to pursuit the objectives of this study it will be seen in the next chapters the organizational standards like certification, contracts, licenses, denomination of origin, cases regarding IFOAM-Organics International and AAO-Organic Agriculture Association of São Paulo and finally the perspectives of the Future of Virtuous Agriculture.

2.3 Organizational Standards

2.3.1 Introduction

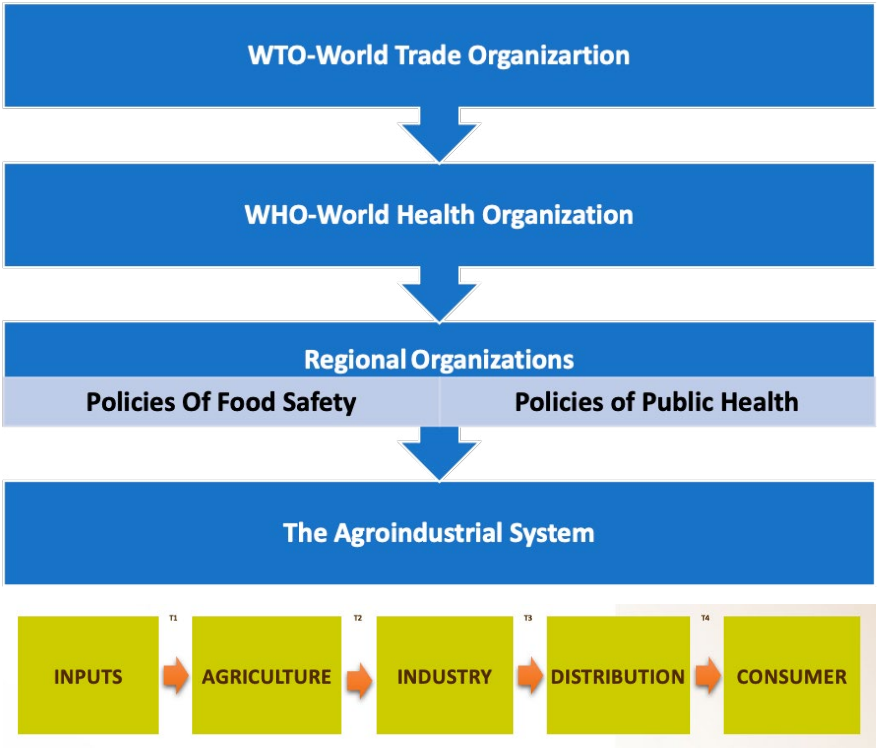
This chapter will deal with some aspects of the organizational arrangements that are done to carry on with the non-conventional agricultural production. First, it will be seen some aspects of organizational standards and arrangements used worldwide to organize the safety of food produced in non-conventional ways. Then there will be some new trends asked by the consumers and the agrosystems that have elements of sustainability involved in its activities. It will be also shown some internet platforms that are important for non-conventional systems to exist.

Virtuous agriculture and sustainable agriculture do not have a set of standards. The other group of systems does have their own set of standards and protocols to carry on in a minimum uniformized way of moving along the agrichain system. The organizations related to safety and quality of food at the world level are, according to Spers (2000)[30] WTO-World Trade Organization, WHO-World Health Organization, Regional Organizations, Policies of Food Safety, and Policies of Public Health, influencing the AIS-Agro-industrial Systems as seen in figure 2.2 below. In other words, there is an international hierarchy to regulate food safety, based on major regulations like the Codex Alimentarius[31].

30. Spers, E. Food Quality and Safety Chapter 13, P. 311. In Economics and Manegement Agrifood Business. Zylbersztajn, D. and Neves, M.F Ed. Pioneira Thomson Learning. 2000

31. Codex Alimentarius, according to ANVISA(Brazilian Health Surveillance Agency) is a joint United Nations program to Agriculture and Food (FAO) and the World Health Organization (WHO), created in 1963, with the objective of establishing international standards in the area of food, including standards, guidelines and guides on Good Practices and Safety Assessment and Efficiency. Its main objectives are to protect the health of consumers and ensure fair trade practices between countries. Currently participating in Codex Alimentarius 187 member countries and the European Union, in addition to 238 observers (57 intergovernmental organizations, 165 non-governmental organizations and 16 United Nations organizations).

Figure 2.2 Organizations Responsible for Food Safety at World Level



Source: Spers, E. (2.000) adapted by the authors

The authorities of Food worldwide follow the directives of the World Trade Organization, that are common to its members. Then, the general rules of the Codex Alimentarius, implemented by the World Health Organization of the United Nations are followed. After that, the instances of regional authorities take the helm in regions and/or countries to regulate the policies of public health and food safety that control directly the agroindustrial systems of each activity (plant or animal) along with its agri-food systems, in each sub-division of the system.

2.3.2 New trends

According to Giordano (2009)[32] consumers of agribusiness goods demand products that have been produced using accepted socioenvironmental practices. In this way, the wishes of the consumers are for a minimum of guarantee that environment-friendly procedures were used in the production processes. Many segments of the agrichain such as distributors, retailers, industry, agricultural production- started to attach seals informing the consumers that their products were produced employing good prac-

32. Giordano, S.R. The importance of socioenvironmental certification in agrichains, p 167-185 in Advances in upply chain analysis in agri-food systems. Edited by Decio Zylbersztajn e Onno Omta, São Paulo : Singular, 2009.

tices. The new trend in Europe and the USA is to offer carbon-neutral products and processes, anticipating global demand for products that will harmless the atmosphere and reduce the amount of CO2 gases or CO2 equivalent gases. The concern of the consumers in this direction is the fear that the overwhelming emission of this GHG could contribute to an acceleration of the climate changes, leading to a situation of non-returning point in global heating and modification of the earth pattern in the next years. There are also concerns of the consumers about sanity and the origin of the agricultural products, in many cases avoiding genetically modified (GMO) products assuming a precaution position.

One trend that is gaining a body among the consumers is the concept of nutrient density in food[33]. According to the World Health Organization, nutrient profiling classifies and/or ranks foods by their nutritional composition to promote human (and/or animal) health and to prevent disease. Ranking by nutrient density is one such nutrient profiling strategy. Ordering foods by nutrient density is a statistical method of comparing foods by the proportion of nutrients in foods. Some such comparisons can be the glycemic index and the Overall Nutritional Quality Index. Nutrient-dense foods such as fruits and vegetables are the opposite of energy-dense food (also called "empty calorie" food), such as alcohol and foods high in added sugar or processed cereals. Beyond its use to distinguish different types of food from each other, nutrient density allows comparison to be made for different examples or samples of the same kind of food. Nutrient density is correlated with soil quality and mineralization levels of the soil, although the relationship is complex and incorporates other dimensions. Here is, maybe, the liaison of healthy, uncontaminated food (by microorganisms, chemical products/residues, segments of genes from other species) that could be supplied by non-conventional agriculture, adding the concept of nutrient density that could be called the food originated by Virtuous Agriculture in a broad sense and spectrum.

Several kinds of certification can be classified according to Nassar (2003)[34] regulating agents and by certification objective. The regulating agent can be governmental, national, or international organizations. When the certification is by objective, it can aim to attain various aspects such as certification of processes, certification of products, and multi-stakeholder certification. The possible benefits of the certification could be for the producer, the government, the exporter, and the final consumer, which is no more than the regular citizen or the society as a whole. Almost all non-conventional strands, as was seen in Table 2.1 have regulation standards except for Virtuous Agriculture which is still in a trial to be defined, and sustainable agriculture.

33. Nutrient density identifies the proportion of nutrients in foods, with terms such as nutrient rich and micronutrient dense referring to similar properties. Several different national and international standards have been developed and are in use. Clark, M.S. Harvard T.H. Chan School of Public Health

34. Nassar, A.M. Certificação no Agribusiness .In: Zylbersztajn, D. e Scare, R.F. Gestão da qualidade no Agribusiness :estudos e casos. São Paulo:Atlas. P 30-46

Internet Support Platforms

Several International Platforms give support to the different strands of non-conventional agriculture. The most recognized platforms are:

IFOAM – Organics International -The International Federation of Organic Agriculture Movements is the worldwide umbrella organization for the organic agriculture movement, which represents close to 800 affiliates in 117 countries. Its mission, according to their site, is to, "Lead, unite and assist the organic movement in its full diversity." and vision is the "worldwide adoption of ecologically, socially, and economically sound systems, based on the principles of organic agriculture[35]. Among its wide range of activities, the federation maintains an organic farming standard, and an organic accreditation and certification service.

Rain Forest Alliance-UTZ[36]. The Rainforest Alliance-UTZ is an international non-profit organization working at the intersection business, agriculture, and forests to make responsible business. There the creation of an alliance to protect forests, improve the livelihoods of farmers and forest communities, promoting their human rights, and helping them to mitigate adapt to the climate crisis. The Rainforest Alliance certification seal means that the product (or an ingredient) was produced by farmers, foresters, and /or companies working together to create a more balanced and harmonica world. It means that the product or an ingredient specified on the packaging was grown on farms certified to either the Rainforest Alliance Sustainable Agriculture Standard[37] or the UTZ Code of conduct[38]. These standards encompass all three pillars of sustainability—social, economic, and environmental—and have credible systems in place to verify that their requirements are followed. These standards help to address four main areas of sustainability:

- Preservation of forests
- Advance the human rights of rural people
- Improve the livelihood of farmers and forest communities
- Build climate resilience

35. The **Principles of Organic Agriculture** were established by the International Federation of Organic Agriculture Movements-IFOAM General Assembly in September, 2005. They are the direction for organic farming. The principles is both to inspire the organic movement and to describe the purpose of organic agriculture to the wider world. The four Principles of Organic Farming are:
– Organic farming should sustain and enhance the health of soil, plants, animals and humans as one and indivisible.
– Organic farming should be based on the living ecological systems and cycles, work with them, emulate them and help sustain them.
– Organic agriculture should build on relationships that ensure fairness with regard to common environment and life processes.
– Organic farming should be managed in a precautionary and responsible manner to protect the health and well being of current and future generations and the environment.

36. These two organizations Rain Forest Alliance and UTZ made a merging becoming only one.

37. For more information about the standards of RainForest Alliance refer to https://www.rainforest-alliance.org/

38. For more information about the code of conduct of UTZ refer to https://utz.org/

IBD-Association of Certification Biodynamic Institute is an organization that develops activities of certification of organic and biodynamic products. The Association was created in 1991 separating from the Biodynamic Institute of Rural Development. The organic production certified by IBD encompasses agriculture projects, inputs production, industrial food processing, cattle growing, fish production, forestry, and so on. In 2019 there were 700 certified projects associated with IBD, in all regions of Brazil and some countries of South America, involving more than 4.500 workers in 300 thousand ha. Their clients range from big producers and exporters to a growing number of medium and small producers, some indigenous communities. IBD certification has international accreditation monitored by IFOAM A (International Federation of Organic Agriculture Movements), from England; DAR, from Germany; USDA, from the United States; JAS, from Japan and DEMETER International. Besides those entities, the Association supplies certification for the Standard Eurepgap (fruit, vegetables, and animals for meat and beef production).

The IBD certified products are exported to Germany, Austria, Belgium, Denmark, USA, France, The Netherlands, Japan, United Kingdom, Sweden, Switzerland, and Canada. The products are coffee, soya, sugar, citric products, oils, cashew nuts, tropical fruit, mushrooms, the heart of palm, cocoa, and guaraná.

2.3.3 Conclusion

Consumers play an important in role demanding the safety of food goods and new trends in non-conventional production systems. These necessities must be fully fulfilled by authorities, governmental or private regulation involving several agencies depending on the particularities of the label or sealing system that is being focused. Organic, biodynamic, and several other standards have their own set of rules, very similar among them. The virtuous agriculture is still to be defined as a system and therefore there is not yet any set of regulations. But it can be expected to absorb several directions of the existing systems.

In the following chapter, it will be shown two cases dealing with the growth worldwide of non-conventional systems and how one of the hubs of organic production advanced in Brazil. One is the IFOAM and the other is AAO-Association of Organic Agriculture.

2.4 Cases

2.4.1 The case of IFOAM-Organics International[39]

Introduction

Roland Chevriot, president of Nature et Progrès-European Association of Agriculture and Biologic Hygiene, envisioned the need for organic agriculture movements to coordinate their actions as well as to enable scientific and experimental data on organic to cross borders. To realize this vision, he invited organic pioneers including Lady Eve Balfour, founder of the UK Soil Association, Kjell Arman from the Swedish Biodynamic Association, and Jerome Goldstein from the Rodale Institute to join him in Versailles to set the International Federation of Organic Agriculture Movements (IFOAM – Organics International) in motion. The year was 1972. In his invitation to his piers, Mr. Chevriot emphasized that the organic movements should make themselves known and coordinate their actions. He also showed concern for the ecological crisis worldwide stating that the problems were going global. He made a call for the presence of international representatives in a Congress that happened in Versailles at the Palais des Congrès on 3.4 and 5 of November 1972. It was expected to have more than 2.000 people participating. Members of the movement Organic Gardening and Farming from the USA, with 2 million readers would participate. Of course, this event was a boost to the organic movements worldwide. What IFOAM call Organic 1.0 was started by numerous pioneers, who observed the problems with the direction agriculture was taking at the end of the 19th century and beginning of the 20th century. They saw the need for a radical change. Lady Eve Balfour, from the Soil Association, was one of these pioneers. She believed the characteristics of truly sustainable agriculture can be summed up by the word "permanence". She used to say "The health of soil, plant, animal, and man is one and indivisible So-called Organic 2.0 started in the 1970s when the writings and agricultural systems developed by the pioneers were codified into standards and then later into legally-mandated regulatory systems.

It is a time where awareness of organic farming increased considerably and the market for organic products grew significantly. There is more and more evidence highlighting the positive impacts of organic on a range of important issues including consumer health, biodiversity, animal welfare, and the improved livelihoods of producers. Despite the increasing success, certified organic agriculture has not reached 1% of global agricultural land. At the same time, there is increasing awareness that organic can be a solution to global challenges such as soil contamination, loss of biodiversity, and climate change. IFOAM says it is time to pose organics as a modern, innovative system that can bring true sustainability to food and farming systems.

39. Information available at https://www.ifoam.bio/

Approved by the General Assembly in 2017, the overall goal of Organic 3.0 is to enable widespread uptake of truly sustainable farming systems and markets based on the principles of organic agriculture.

There are six features to guide the pathway to implementation:

1. A Culture of Innovation

To stimulate farmer conversion and adoption of best practices. Organic 3.0 proactively combines the best traditional practices with modern innovations. It assesses practice, knowledge, and innovation against impact risks and potentials.

2. Continuous Improvement towards best practice

For operators along the whole value chain. Continuous improvement covers all dimensions of sustainability: ecology, society, economy, culture, and accountability.

3. Diversity of ways to ensure transparent integrity

To broaden the uptake of organic agriculture beyond third-party certification. Trust instilled by transparency and integrity develops acceptance and builds the market.

4. Inclusion of sustainability interests

Through proactively building alliances with the many movements and organizations that have complementary approaches to truly sustainable food and farming. However, it also clearly distinguishes itself from unsustainable agriculture systems and 'greenwashing' initiatives.

5. Empowerment from the farm to the final consumer

To recognize the interdependence and real partnerships along the value chain and also on a territorial basis. It particularly acknowledges the core position of small-scale family farmers, gender-equality, and fair trade.

6. True value and cost accounting

To internalize costs and benefits of external effects, to encourage transparency for consumers and policymakers, and to empower farmers as partners with rights.

Organic Agriculture Key indicators and Top countries

According to the Fibil[40] survey of 2020, there are:

Countries with organic activities: 186

Organic Agricultural: 71, 5 million ha[41]

Australia: 35, 7 million ha
Argentina: 3, 6 million ha
China: 3, 1 million ha

Producers Worldwide: 8, 5 million

India: 1, 1 million

Uganda: 210 thousand

Ethiopia: 203 thousand

Organic market: 96, 7 billion Euros

US: 40, 6 billion Euros

Germany: 10, 9 billion Euros

France: 9, 1 billion Euros

Per capita consumption: 12, 8 Euros

Switzerland: 312 euros

Denmark: 312 euros

Sweden: 231 euros

Number of Countries with Organic Regulation: 103 (55, 4 % of the total that has organic farming)

Number of affiliates of IFOAM: 779 affiliates from 186 countries

Germany: 79 affiliates

India: 55 affiliates

USA: 48 affiliates

China: 45 affiliates

The Journey of the Organics

The evolution of the organic farming actions took place on a long journey, from 1972 on. IFOAM calls them the three phases of their organic movement.

40. Research Institute of Organic Agriculture FiBL

41. According to date from FAO-Food and Agriculture organization from the United Nations the total land cultivated with crops (arable land and land under permanent crops) is around 13, 4 billion ha . So the area cultivated with organic agriculture represents 0, 53% of the total land cultivated in the planet. In Europe organic farming represents 7, 5% of the total land cultivated.

The Organic 1.0 The Founders Visionaries.

The concept arose in several places around the world. 'Organic' was one of several terms the visionaries used to describe and define their diverse approaches. Looking back, one century on, IFOAM has termed this first phase of the organic movement Organic 1.0.

Pioneers

Albert Howard (U.K.), Anna Primavesi (Brazil), Bill Mollison (Australia), Bhaskar Save (India), Efraim Hernandez Xolocotzi (Mexico), Eve Balfour (U.K.), Hans & Maria Müller (Switzerland), Jerome Rodale (U.S.A.), Rachel Carson (U.S.A.), Masanobu Fukuoka (Japan), Raoul Lemaire (France) and Rudolf Steiner (Germany, Austria, Switzerland).

Organic 2.0

Over the following decades, production and processing standards were developed and certification schemes were introduced by organic organizations around the world. Organic claims became regulated in great detail. Official regulation was first introduced in Europe and the United States of America in the 1980s. By 2018, 103 countries in Africa, the Americas, Asia, u rope and, Oceania had implemented organic regulations. Organic standards and control through inspection and certification have the trust of consumers and policymakers. The consumer purchases of certified organic food, textiles, and body care products reached 96, 7 billion euros worldwide in 2018. On top of those figures, there are non-certified organic systems in place, which should not be underestimated. Numerous smallholder and peasant farmers (oftentimes women) are largely organic at their core and ensure that there is enough to eat for their families and communities. The past decades have also seen a concerted effort to enable political and administrative support, market development, and therefore access to and availability of better food, textiles, personal care, and other healthy products. Many technical challenges have been overcome through research and development, in institutes, universities, and on farmers' fields in participatory programs.

Achievements of Organic 1.0 &2.0

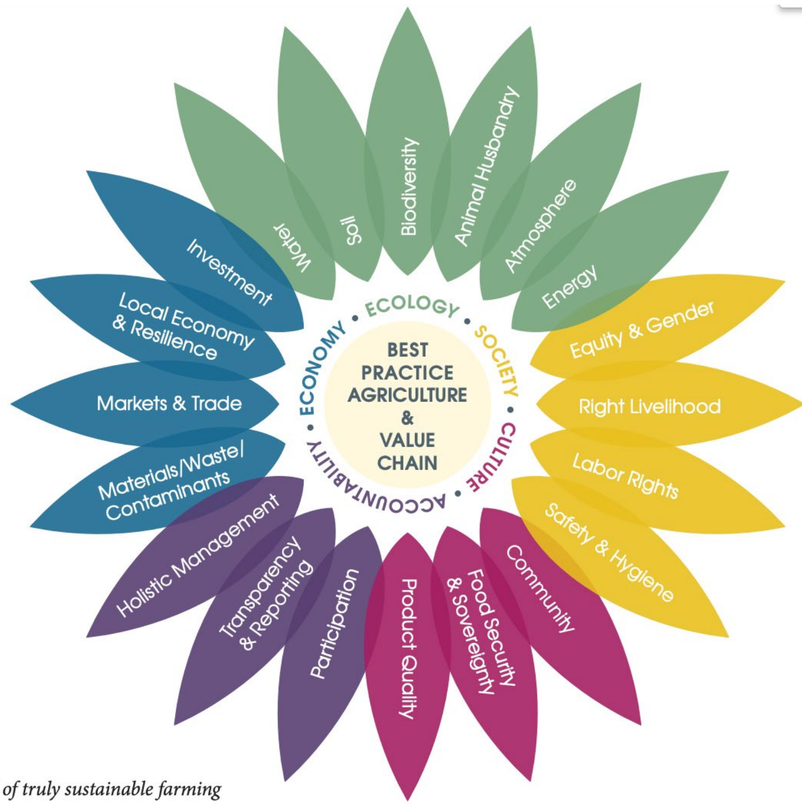
- The growth in scale from a very small recognition in policy to a widespread uptake of a clear and detailed legal framework.
- In some countries in Europe the area of certified organic land accounts for up to 20% of the agricultural land, while in some alpine regions there is even a majority of farmers managing their land organically.
- Organic baby food represents up to 80% of the baby food market in many countries.
- In some countries in Latin America exports of certified organic crops like coffee, cacao and banana are greater than non-organic.
- The introduction of internal control systems and group certifications has improved access to international markets and connections with smallholders.
- Some Himalayan states have pledged to become 100% organic.
- Many organic farming models are high yielding and provide a range of highly effective ecosystem services.
- There is evidence that organic produce has improved health qualities.
- Proven positive effects on soil fertility and biodiversity.
- Organic is increasingly proven to be a better economic model for farmers.

Organic 3.0

The overall goal of Organic 3.0 is to enable widespread uptake of truly sustainable farming systems and markets based on organic principles and imbued with a culture of innovation, of progressive improvement towards best practice, of transparent integrity, of inclusive collaboration, of holistic systems, and true value pricing. Organic 3.0 expands the participation options and positions organic as a modern, innovative farming system that holistically integrates ecology, economy, society, culture and, accountability into local and regional contexts. Regeneration of resources, responsibility in production, sufficiency in consumption, and ethical and spiritual development of human values, practices, and habits are concepts that guide the building of a new organic culture, which can drive societal development. The core of Organic 3.0 is the living relationships between consumers and producers, which includes the stories of products and production and the multiple benefits of organic agriculture. While Organic 2.0 focused on clearly defined minimum requirements and organic claims on products, Organic 3.0 puts the impact of and on the farming system in the foreground. Organic 1.0 and Organic 2.0 approaches and achievements are not abandoned. Organic 3.0 retains the original bedrock concept of Organic 1.0 and expands the progress made under Organic 2.0. Through the new Organic 3.0 understanding and strategy, the organic movement wants to showcase its ability to an have impact on issues of critical importance to billions of people – e.g. ensuring climate change mitigation, resilient adaptation, access to capital and adequate income, availability of land, water, seeds, adequate and healthy diets, and avoidance of waste in production and consumption. Fertile soils, clean water, appropriate and diverse genetic resources, social and economic opportunities for both genders, and cultural heritage that reveals the identity and accessibility of traditional and scientific knowledge are just a few examples of vulnerable resources that matter to future generations. The organic movement is ready and keen to ally with and be seen as a partner of all those with the vision of truly sustainable agriculture.

The next two figure exemplifies and resumes the goals of Organic 3.0 with its five pillars: ecology, society, culture, accountability, and economy, and also the subjects related to the pillars as can be seen in figure 2.3.

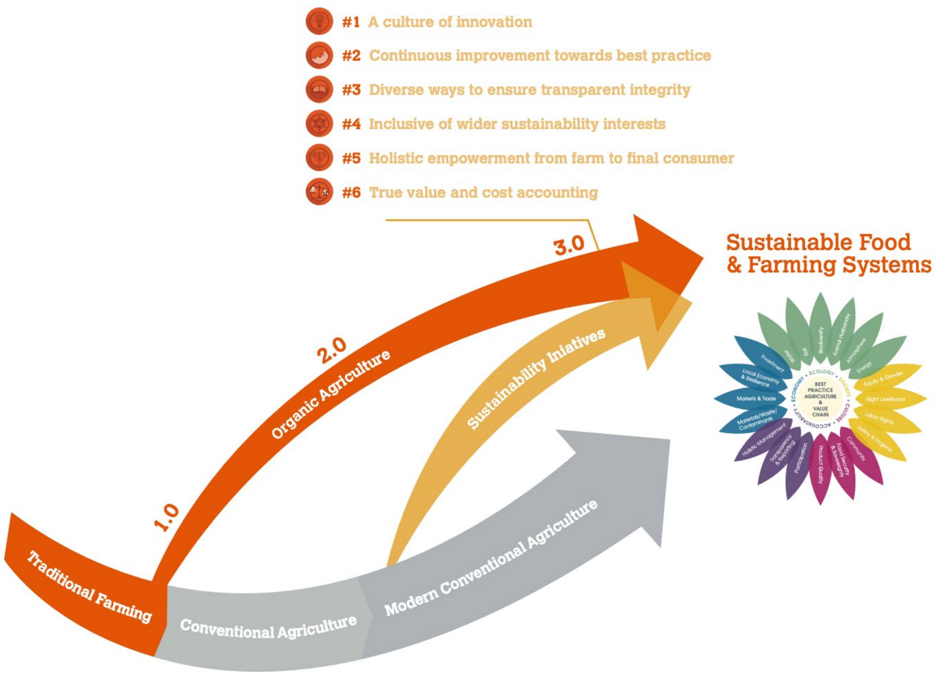
Figure 2.3 The 5 Pillars and 20 Criteria of Organic 3.0



Symbol of truly sustainable farming and value chains. It visualizes the five dimensions and 20 criteria of sustainability as described in the IFOAM Best Practice Guideline for Agriculture and Value Chains.

In this way, IFOAM proposes a roadmap to reach its objectives including Conventional Agriculture, as can be seen in Figure 2.4.

Figure 2.4



Conclusion

IFOAM is trying to make joints with sustainability initiatives to widen its horizons and range. It's a strategic move and may include several other initiatives like eventually Virtuous Agriculture. After all, the main concepts are very similar. The case of IFOAM shows how organized movements can advance with their ideas and criteria, remembering that these movements take a lot of effort from its participants, need regulation and control of the brand involved, and take a long time to reach sustainable conditions of existence.

2.4.2 Case AAO-Organic Agriculture Association of São Paulo[42]:

In 1977, the Association of Agricultural Engineers of the State of São Paulo, AEASP, promoted the 1st Congress of Agronomy in São Paulo. Agronomist José Lutzenberger was invited to give a lecture at the Congress on the indiscriminate use of chemicals in agriculture. Lutzenberger, until then little known in São Paulo, made a huge impact on the five hundred participants in the Congress and was applauded standing up. In 1978, Lutzenberger is chosen by AEASP to receive the "Agricultural Engineer of the Year"

42. Information available at http://aao.org.br/aao/index.php

Award. The reaction comes quickly: under pressure from national and multinational companies, a request is submitted to AEASP requesting a General Assembly to try to annul the choice and avoid giving the prize. AEASP, following its Statute, calls the Assembly. Several groups linked with the inputs industry plans for the same day of the Assembly, its traditional Agricultural Engineers Lunch, to encourage and facilitate the participation of its employees in the meeting and, of course, to vote for forfeiture of the award. In a historic Assembly, with four hundred and twenty participants, no less than 414 agronomists voted for the maintenance of the Lutzenberger prize, and only 6 voted against it.

In 1979, Lutzemberger proposes to the directors of AEASP the formation of a group that initially sets up a register of people and initiatives related to Alternative Agriculture in Brazil (the name Organic Agriculture was still little used), and then work to promote the movement. One of the first names that Lutzemberger suggests to compose the group is Ana Maria Primavesi.

The Alternative Agriculture Group:

The group dreamed by Lutzenberger starts to meet at AEASP in the second half of 1979. On February 25, 1980, at the meeting of the board of that Association, the proposal for the creation of the Alternative Agriculture Group – GAA is presented, within the scope of the Technical Scientific Board at AEASP. The Group starts with agronomists Ana Maria Primavesi, and six or seven other collaborators. Soon after, it receives new members. The Group's name is chosen to encompass and house the different currents: Organic, Biodynamic, Natural, and Organic Agriculture. GAA starts to meet every two weeks. The launch at AEASP of the book "Ecological Soil Management", by Ana Primavesi, excites the Group and the public with the new concepts. The work, a milestone in global tropical agriculture, sensitizes rural producers, agronomists, and Students of Agrarian Sciences and other courses, who were beginning to be interested in the so-called Alternative Agriculture. The book also provokes contrary reactions by traditional researchers.

FAEAB expands the movement:

In 1979, Mr. Lazzarini former President of AEASP assumed the presidency of the Federation of Associations of Agricultural Engineers of Brazil, FAEAB. AEASP is now chaired by Luiz Fernando de Mattos Pimenta. He, and the entire new board, fully support the work of the Alternative Agriculture Group. FAEAB proposes to hold a large national meeting to discuss and present proposals for the development of Alternative Agriculture. It is thought to hold ta national meeting.

Curitiba is the most viable option, with the liberal Jaime Lerner at City Hall, and the active AEAPR – Association of Agricultural Engineers of Paraná preaching the reduction of the use of pesticides and the implementation of the Agronomic Recipe.

The mayor of Curitiba Mr. Lerner offers support and venue for the event. Thus, from April 20 to 24, 1981, the 1st Brazilian Meeting on Alternative Agriculture is held. The mayor Jaime Lerner solemnly opens the Meeting.

Alternative Agriculture

In October 1981, the Alternative Agriculture Group made Lutzenberger's dream come true: it began to survey, in the State of São Paulo and in neighboring states, the experiences developed by rural producers and NGOs, for production without pesticides, soluble fertilizers, and other chemical inputs, using environment-friendly farming technologies. A good number of alternative production units were discovered and cataloged.

On May 25, 1980, the Alternative Agriculture Group proposes to the AESP board of directors to hold the 1st Biological Agriculture Course, which takes place in August of that year. From March 1 to 6, 1982, GAA promotes the 2nd Alternative Agriculture Course, also at AEASP.

Technically supported by Ana Primavesi's teachings and Tsuzuki's practical courses, members of the Group write articles every month for JEA – Jornal do Engenheiro Agrônomo, edited by AEASP, write articles for other newspapers and magazines, hold technical meetings, and divulge Alternative Agriculture. Another pioneer, the Japanese agronomist based in Brazil, Yoshio Tsuzuki, gives GAA members free practical courses in organic horticulture on his farm in Tijuco Preto, in Cotia, SP.

In 1984, FAEAB and AEARJ – Association of Agricultural Engineers of Rio de Janeiro, promoted in Petrópolis the 2nd Brazilian Meeting of Alternative Agriculture, with an even greater number of participants than that of the 1st Meeting. There, a commission is formed to create a national entity representing the movement. The suggested name is the Brazilian Association of Organic Agriculture. Meetings follow in Piracicaba, Campinas, and São Paulo, and many people and entities in the country are consulted by mail. 333 completed questionnaires return, but the movement is not mature enough to take this step. The book "Ecological Land Management" is already studied in most Agronomy Courses and its innovative theses gain a large number of followers. At the same time, Lutzenberger, Ana Primavesi, Luiz Carlos Pinheiro Machado, Yoshio Tsuzuki, Sebastião Pinheiro, Shiro Miyasaka, and many other professors and researchers participate in congresses, meetings, lectures, and other events, across the country, publicizing and discussing Alternative Agriculture with agronomists, agronomy students, rural producers, environmentalists, and the general public.

AAO

On May 28, 1989, after Yoshio Tsuzuki's insistent advice (he thought of a cooperative) and extensive national consultation on the viability of an association representing the movement, AAO – Associação de Agricultura Orgânica was created in São Paulo. Granja Tsuzuki hosts the historic foundation assembly. There are 84 founding partners. The first president is José Pedro Santiago, who coordinated the Alternative Agriculture Group for almost ten years. Ana Primavesi is associated with membership record number 1 and elected the first technical director of the Association that was just born. In the 10 years of GAA and the first two years of AAO, we see the uninterrupted and tireless work of several agronomists. The board of AAO manages to bring to Brazil the 1992 IFOAM Congress.

In 1989, AAO has no headquarters yet and meetings are held in the private houses of the directors. In 1989, Walter Lazzarini, then Secretary of Agriculture of the State of São Paulo, in articulation with Moacir de Almeida and with the coordinator of the Água Branca Park, Alberto Alves Santiago, signs an agreement with AAO, providing a room in that Park for its headquarters. The inauguration takes place on March 27, 1990, when José Lutzenberger (newly appointed Special Secretary for the Environment of the Collor government) and Walter Lazzarini are honored. Also in 1990, Secretary Antonio Felix Domingues signed an agreement with AAO for the implantation of the Organic Producers Market Água Branca Park, inaugurated on February 23, 1991. The fast acceptance of the Market by consumers consolidates the Organic Agriculture movement in the São Paulo State, after just over ten years since the formation of the Alternative Agriculture Group. In the other Brazilian states, mainly in the Southeast and South, the movement reaches maturity, winning the hearts and minds of an increasing number of technicians and students from the most diverse backgrounds, consumers, rural producers, scientists, politicians, and other segments related to agriculture.

Throughout this process AAO counts on the permanent and inspiring presence of two women: Ana Primavesi, author of the "Ecological Soil Management" and great technical reference for the consolidation of Organic Agriculture in Brazil, and Ondalva Serrano, always firm and serene, a beacon illuminating difficult times and brightening up AAO's mild times.

AAO was the first Brazilian NGO to create organic production standards centered on the local reality, contemplating the basic criteria for farmers to be accredited at the Organic Producer's Market. It should be noted that the original AAO rules had an educational, guiding, and normative character; not punitive. Since the beginning of the 90s, AAO has been very involved in articulations and actions with the alternative and agroecological agriculture movement in Brazil and Latin America. It participated in the idealization, in the foundation, and the first board of the Latin American Agroecological Movement – MAELA, constituted in São Paulo in 1992, the week before the IFOAM International Conference. Conducted research on organic agriculture supported by the National Environment Fund, in partnership with FUNDACENTRO, produced a video on the problem of pesticides and organic production, joined the Atlantic Forest NGO Network, participated in the organization and organization of Regional Agriculture Meetings Alternative – ERAA, the 1st held in Taubaté in July 1990, and the 2nd. in

Botucatu in 1993, and the I Ecological Agriculture Symposium held at IAC-Instituto Agronômico de Campinas. AAO collaborated with Cuba, participating in the 1st Meeting of Organic Agriculture in Cuba as an official guest. AAO's trajectory also includes the fight against the privatization of Água Branca Park in partnership with the Associação dos Amigos do Parque, support for the constitution of COOPERNATURA, which brought together organic producers and was headquartered in São Roque, an entity which was not consolidated, possibly because it was created before its real need. The Institution collaborated in the creation and execution of the two versions of the Environmental Award, and throughout its existence, it has made efforts in the training and qualification of human resources, including technicians, farmers, students, lay people. The entity also had a seat on the 1st. National Organic Products Committee, a group that consolidated Normative Ordinance 007 of the Ministry of Agriculture in Brazil, in 1999, which was the basis for the preparation of the National Organic Production Law, in the regulation phase. In its trajectory, AAO has gained credibility and expression due to a fundamental, independent, critical political and technical-scientific stance and action, guided by the collective interest, and having as its central focus the promotion of organic agriculture as a coherent and sustainable alternative in the socio-environmental sphere. The expression and political dimension achieved by AAO must be credited to the commitment of its members, to farmers, to managers, to supporters and collaborators in the technical, productive, political, scientific, organizational spheres. AAO was responsible for creating the Ecological Agriculture Technical Commission of the São Paulo State Secretariat of Agriculture, in which it played an important role in organizing and carrying out actions in the scope of research, public policies, standardization and commercialization of organic products, and in the training of human resources.

AAO Objectives

The purpose of AAO is:

I – Promotion of the practice of Organic Agriculture and Agroecology throughout their fullness and scope respecting and applying the Laws, Decrees, Norms and Normative Instructions that direct agricultural activities organic farming, agroecology, and the environment, as well as developing it's standards for organic production;

II – Promotion and training of familiar and non-familiar producers organized in groups or isolated, aimed at organic agricultural production or any other system that seeks agricultural production in balance with nature, through projects, programs and, activities subsidized by public or private bodies, or of competence and own resources;

III – Advisory, Provision of Advisory Services and Transfer of Information in Agroecological and Production knowledge in Organic Agriculture, or any other system that seeks agricultural production in balance with the nature for Associates and Non-Associates, as well as Consumers, Distributors, Wholesalers, and Traders;

IV – Promotion of the values of the organic product to the population and the facilitation of opening channels and paths for permanent commercialization or temporary product to consumers;

V – Defense, preservation, and conservation of the environment and promotion of sustainable development;

VI – Promoting economic and social development and combating poverty;

VII – Experimentation, non-profit, of new socio-productive models and alternative production, trade, employment, and credit systems;

VIII – Studies and research, development of alternative technologies, production and dissemination of technical and scientific information and knowledge concerning the activities mentioned in part II;

IX – Promotion, supervision, and coordination of Organic Products Fairs, restricted to its Associates, at the national level, following the Internal of AAO Organic Fairs.

X – To guarantee the quality of organic products, AAO may form a OPAC – Participative Conformity Assessment Body and an OCS – Social Control Organization, in participatory guarantee systems, of accordance with current legislation.

Conclusion

This case shows how in a country distant from the historical center of the non-conventional movements, a group of people moved only by their principles, with scarce resources, with no incentives of any kind, but strong willpower performed the creation of an important movement that helped to create the basis for this kind of agriculture in Brazil. Besides, that helped to set the basis for the regulation and organic institutions, with the creation of the Organics Bill in Brazil. The Brazilian Ministry of agriculture is today a certifier for organics, in many aspects thanks to the collaboration and cooperation of several NGO's and among them the AAO. Attuned with the strategies of IFOAM of congregating the various movements into one large front was the initiative of creating the Brasil Organic Institute[43]. As the Institute position itself, they were created to promote, protect, and, incentivize the Brazilian organic movement. Interesting to note that its Directory is composed of members coming from Biodynamic, Movements, Organic Movements like AAO, Agroecologic movements, Mokiti Okada Movements, Brazilian Government Ministry of Agriculture, Consumers Movements, Media personalities, Organic Inputs Certified Industries, Organic Cooperative Distributors, and many other scientists and agronomy technicians engaged in the non-conventional production. Certainly, this initiative can be of great impact on any tentative of initiating a virtuous agriculture formation process.

43. https://institutobrasilorganico.org/

2.5 Perspectives: The future of virtuous agriculture

The basis of this paradigm, as we have seen, is not new and has been changing over the decades since the beginning of the XX century. The segments of non-conventional agriculture are trying to do movements in the same direction of virtuous agriculture. They are taking steps to congregate in a big front, bringing together their interest and dealing with their differences in the best possible way. It is interesting to know how the millennials, this generation born from 1980 to 1990 on, react to the trends of consumption.

They know exactly what suits them, and among their desires, the need for a cleaner and simpler world is urgent. Their attitudes reflect negationism of the consuming society, embedding heavy criticism in several "cultures" inherited from the past. Some of them are:

- Natural formulas and products
- Local food
- Minimally processed food
- Slow cooking
- No to animal testing in any kind of product
- Concern with the origins of the food products
- Safe and healthy food products
- CO2 neutral
- Concern with the climate
- Ecological packaging or no packaging at all
- Respect for the natural resources-Soil-Air-Water
- Respect for the human being
- Concern for future generations

The Pandemic and the Millennials

The new Covid-19 has completely reconfigured the way the Millennials and Generation Z relate to brands and how they consume their content, services, and products. Thus, it is assumed that the approach of companies must change dramatically to meet not only the new logistical and sanitary demands, but also to correspond to the new values of the population. According to American consultant Amelie Karam, a specialist in the Millennial Mindset answers how global changes are affecting younger generations – and how companies and brands should behave in order not to lose sight of them:" While it was possible to observe young people very loyal and attuned to brands and their hypes and trends, now we see a huge search for two new values for these generations: practicality, meaning, and stock". "They already looked for meaning in the brands, but now they also want available stock, convenience, relevance, security, and accessibility. They want things that can cope with current needs because we are living in an unknown world", says Amelie Karam. In addition to these words, others that stand out when generations Y and Z talk about what they are looking for in brands are diversity, inclusion, sustainability, and urban revitalization, according to the expert. This is mainly because these consumers need to see themselves and others in brands and companies to be able to develop identification and trust. "They want to see in-depth what they have to offer; what their motivations are and what they do to help the world, the nation, and small communities. So they cannot see not only themselves in the brands, but also the humanity represented in them", he says. So these observations, by this expert, are important when thinking about launching the concept of virtuous agriculture. Millennials and Generation Z, at this point of the pandemic, realized that they can't sit around waiting for a big global event that will cause a revolution and transform the entire planet – they need to be an active part of that change themselves, even that is to demand more responsible attitudes from brands or their leaders. According to Amelie, is the resignification of the economy. The consultant says that Millennials are much less likely to spend money frivolously after the global events of 2020. "Since many Millennials have lost their jobs or had a pay cut in the pandemic, they are not only saving money but also looking at it with other eyes", he says. This kind of attitude could modify briskly the profile of preferences in several things like, in what kind of food and beverage I spend my income? Or is there any investment aligned with my points of view other than profits? Consuming with a cause and investing for a cause seems to be new trends here. Thanks to the sense of social responsibility, Amelie expects good things to come in the future from these generations, both in terms of economy, social responsibility, and individual values. When Millennials say they want communication with brands, they say it in a very literal sense. That is, they want to hear and communicate with corporations as spokespeople, not with their leaders and CEOs. For Amelie, brands and organizations must have a well-structured mission and know intimately how to transmit this message. The expert cites, for example, that Millennials are not particularly interested in listening to business leaders talking about their personal views, since this view does not necessarily reflect the actions of the company they lead. They want to know about the brand and not the leader. Institutionalized communication is the key, therefore. These views of these generations, the present and future consumers of all goods, represent some key points when planning the ways to reach and to turn them loyal to brands.[44]

But, on the other hand, it still persists the hunger in the world in all continents, specially in the rural areas. These populations have low income, low educational level and still persists the consumption without restrictions , due to risk situation they live.

44. Ideas based in an article from "Modern Consumer" 09/2020

These populations live is a situation of food insecurity in which any food is acceptable , no matter where it came from , and as long as nourishes them .

Virtuous Agriculture and the Rural Producer

After this overview of the millennials consumers, it would be useful to make some projections about the sensitivity of the producers towards the idea of virtuous agriculture. The University of Coffee Brazil produced a survey, in 2019, about the new Technical Assistance[45]. The main conclusions of this diagnose of the Technical Assistance and Rural Extension, have a lot to do with the possible introduction of the Concept of Virtuous Agriculture in the production sector. The conclusions of this work targets the situation of Rural Extension in Brazil, but for the purpose of this article, they could be used for an international perspective for the coffee-producing countries. This survey about Technical Assistance explored the aspects that suggest the necessity of reorganization of this activity, at different levels. Here are some thematic macro-axis that serve as drivers to elaborate on private strategies and public policies. Some of the drivers are the Heterogeneity of the agricultural sector

- The role of the Universities in the work of technical Assistance and Rural Extension
- The creation of pilot programs at several levels like communities, state, and country.
- The integration of public and private sector in an endeavor like this
- Investments in collective actions and Digital communication with a focus on Technical Assistance and Rural Extension.

The suggestion of these points are to remember that any move or initiative in the direction of spreading the idea and concepts of Virtuous Agriculture, will necessarily have to deal and work side by side the Technical Assistance and Rural Extensionists, in order to implement these ideas in the rural environment. The rural producer is, by the nature of his activity, a person very traditional and conservative in their moves. This happens because agriculture is full of risks, expected and unexpected. The convincing process for a change in directions is hard and requires a lot of work, trust, and skills from the technicians involve in projects like this.

45. Available at http://pensa.org.br/wp-content/uploads/2020/03/Cadernos-UdC-2020-Site.pdf Cadernos da Universidade do café Número 10 , Chapter 3, The new technical Assistance to Agriculture

2.6 Strategic implications for Illycaffè

1. There are a lot of non-conventional agriculture movements in the world with several denominations, that have a very similar focus of the virtuous agriculture. It will be difficult to define what are differences of one another.
2. These non-conventional agriculture movements adopted the strategy of uniting their strength in a common front. This movement is typical to happen, when there are so many different movements leading almost all of them to loose their energy due to the diversity of objectives and dispersion of actions.
3. There will be a need to unite forces withs some of these Movements (I. E. IFOAM) to reach the producers that can be responsive to the idea of virtuous agriculture.
4. Another necessity is to join forces with several different means of technical assistance like: Official System, Cooperatives, Independent consultants, universities, Research Institutes and others.
5. Coffee production is as heterogeneous as the remaining of Brazilian agriculture. Illy counts on suppliers that can be classified in the different categories of producers, who present production methods that vary from the simplest techniques to the most sophisticated practices. Technical assistance provided by illy's technicians could include principles of Virtuous Agriculture, jointly with other agencies by agreements and exchange of information.
6. In the same direction as item 5, it is suggested the creation of protocols of orientative actions for the technical assistance services of illy technicians considering the characteristics of Virtuous Agriculture.

3 Emissions Trade Systems: How Effective Are They?[1]

Marco Antônio Fujihara[2]

3.1 Introduction

A carbon offset is a reduction in emissions of carbon dioxide or other greenhouse gases made in order to compensate for emissions made elsewhere. Offsets are measured in tonnes of carbon dioxide-equivalent (CO2e). One tonne of carbon offset represents the reduction of one tonne of carbon dioxide or its equivalent in other greenhouse gases. Carbon offsets represent multiple categories of greenhouse gases, including carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), and sulfur hexafluoride (SF6)).

There are two markets for carbon offsets. In the larger, compliance market, companies, governments, or other entities buy carbon offsets in order to comply with caps on the total amount of carbon dioxide they are allowed to emit. For instance, an entity could be complying with obligations of Annex 1 Parties under the Kyoto Protocol or of liable entities under the EU Emission Trading Scheme, among others.

In the much smaller, voluntary market, individuals, companies, or governments purchase carbon offsets to mitigate their own greenhouse gas emissions from transportation, electricity use, and other sources. For example, an individual might purchase carbon offsets to compensate for the greenhouse gas emissions caused by personal air

1. Disclaimer: Legal notice: It is the sole responsibility and obligation of the reader of this report to make sure as to the accuracy, adequacy and content of the information contained therein. The reader is strongly advised to seek appropriate legal and professional advice before starting business transactions based on the information contained in this report. Because it is information collected from various sources and bibliographic references and compiled in order to facilitate the understanding of the reader. The author does not recommend any specific procedure to test the assumptions listed in the report therefore exempting itself from any eventual responsibilities.

2. Marco Antônio Fujihara is agronomist, with over 35 years of experience in the agricultural and forestry sector, he develops business qualification projects in the parameters recommended by Kyoto and in the Paris agreements since 1998 for the energy and forest-based sectors. IPCC from 2002 to 2009 as reviewer of WG2, Board Member in CDP – Carbon Disclosure Project, Board Member CIF – Climate Investment Fund (World Bank and MDB) and Key man of the Brazil Sustainability Fund of the Clean Development Program of BNDES and Performa / Key – Technological Innovation for Sustainability. Currently working with the World Economic Forum on payment for environmental services in Brazil.

travel. Carbon offset vendors offer direct purchase of carbon offsets, often also offering other services such as designating a carbon offset project to support or measuring a purchaser's carbon footprint.

Offsets typically support projects that reduce the emission of greenhouse gases in the short- or long-term. A common project type is renewable energy, such as wind farms, biomass energy, biogas digesters, or hydroelectric dams. Others include energy efficiency projects like efficient cookstoves, the destruction of industrial pollutants or agricultural byproducts, destruction of landfill methane, and forestry projects. Some of the most popular carbon offset projects from a corporate perspective are energy efficiency and wind turbine projects.

The Kyoto Protocol has sanctioned offsets as a way for governments and private companies to earn carbon credits that can be traded on a marketplace. The protocol established the Clean Development Mechanism (CDM), which validates and measures projects to ensure they produce authentic benefits and are genuinely "additional" activities that would not otherwise have been undertaken. Organizations that are unable to meet their emissions quota can offset their emissions by buying CDM-approved Certified Emissions Reductions.

Offsets may be cheaper or more convenient alternatives to reducing one's own fossil-fuel consumption. However, some critics object to carbon offsets, and question the benefits of certain types of offsets. Due diligence is recommended to help businesses in the assessment and identification of "good quality" offsets to ensure offsetting provides the desired additional environmental benefits, and to avoid reputational risk associated with poor quality offsets.

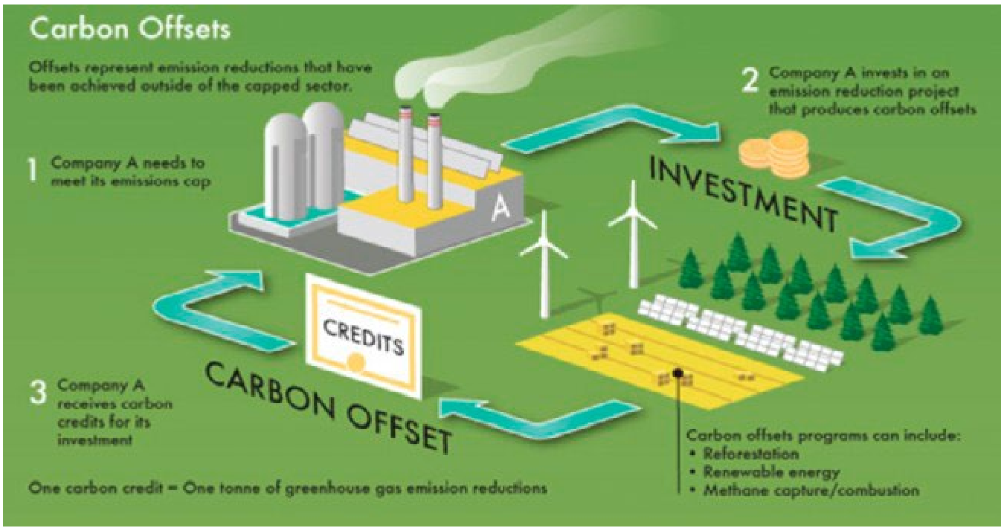
Offsets are viewed as an important policy tool to maintain stable economies and to improve sustainability. One of the hidden dangers of climate change policy is unequal prices of carbon in the economy, which can cause economic collateral damage if production.

3.2 Some definitions

3.2.1 Carbon credit

A carbon credit is a generic term for any tradable certificate or permit representing the right to emit one tonne of carbon dioxide or the equivalent amount of a different greenhouse gas (tCO2e).

Carbon credits and carbon markets are a component of national and international attempts to mitigate the growth in concentrations of greenhouse gases (GHGs). One carbon credit is equal to one tonne of carbon dioxide, or in some markets, carbon dioxide equivalent gases.



3.2.2 Carbon footprint

Today, the term "carbon footprint" is often used as shorthand for the amount of carbon (usually in tonnes) being emitted by an activity or organization.

3.2.3 Carbon negative

Carbon negative: The reduction of an entity's carbon footprint to less than neutral, so that the entity has a net effect of removing carbon dioxide from the atmosphere rather than adding it.

3.2.4 Carbon neutral

Few companies have actually attained Climate Neutral Certification, applying to a rigorous review process and establishing that they have achieved absolute net zero or better impact on the world's climate. Shaklee Corporation became the first Climate

Neutral certified company in April 2000. The company employs a variety of investments, and offset activities, including tree-planting, use of solar energy, methane capture in abandoned mines and its manufacturing processes.

Climate Neutral Business Network states that it certified Dave Matthews Band's concert tour as Climate Neutral. The Christian Science Monitor criticized the use of NativeEnergy, a for-profit company that sells offset credits to businesses and celebrities like Dave Matthews.

Salt Spring Coffee became carbon neutral by lowering emissions through reducing long-range trucking and using bio-diesel fuel in delivery trucks, upgrading to energy efficient equipment and purchasing carbon offsets from its offset provider, Offsetters. The company claims to the first carbon neutral coffee sold in Canada. Salt Spring Coffee was recognized by the David Suzuki Foundation in their 2010 report Doing Business in a New Climate.

Some corporate examples of self-proclaimed carbon neutral and climate neutral initiatives include Dell, Google, HSBC, ING Group, PepsiCo, Sky, Tesco, Toronto-Dominion Bank, Asos and Bank of Montreal.

But after all what carbon neutral: Carbon neutrality, or having a net zero carbon footprint, refers to achieving net zero carbon dioxide emissions by balancing carbon emissions with carbon removal (often through carbon offsetting) or simply eliminating carbon emissions altogether (the transition to the "post-carbon economy"). It is used in the context of carbon dioxide-releasing processes associated with transportation, energy production, agriculture, and industrial processes. Carbon-neutral status can be achieved in two ways:

- Balancing carbon dioxide emissions with carbon removal beyond natural processes,
- Reducing carbon emissions through changing energy sources and industry processes.

Box 3.1 The Carbon, Climate and Coffee Initiative

A CoopCoffees drum-roll please…. Today we are delighted to announce the launch of our Carbon, Climate and Coffee Initiative!

Calculating and tracking our collective carbono footprint and contributing a corresponding financial "offset" amount to our producer-support fund links us to a broader conversation around climate justice. And directly investing in carbon-sequestering, agricultural practices and other innovative, environmental-service projects contributes to the health and sustainable development in producer communities, while strengthening our connections across the supply chain.

In bringing Carbon, Climate and Coffee under this umbrella initiative — we hope to create a positive example of how our industry could become regenerative.

What began in 2013, as a CoopCoffees internal "5-cents for Roya" emergency-relief fund, has grown and continues to develop into an increasingly collaborative initiative. From 2014 – 2017 CoopCoffees has partnered with the Root Capital/ Progreso Network Climate Resiliency Match Fund. This resulted in some US$650, 000 in leveraged funding invested with 11 producer partners across Latin America to strengthen internal technical support and to invest in projects, such as centralized and improved compost production, field renovation, and technical trainings in regenerative, organic practices. During that same period, CoopCoffees hosted four regional events to support farmer-to-farmer learning and exchange to the benefit of 20 farmer cooperatives across Latin America, representing more than 12, 500 coffee farmer families.

Along the way, we've discovered an incredible capacity within our network of producer partners for innovation, regeneration and the implementation of clear and specific strategies for climate resiliency and adaption. For example in northern Peru, Sol y Cafe is promoting field renovation and systematic pruning practices that have resulted in maintaining extraordinary vitality in their trees and greater climate resiliency in their fields. As we've seen in Honduras, Marcala Organica has developed an entire field curriculum focusing on the 5Ms (Organic Matter, Micro-organisms, Minerals, Living Molecules and Grey Matter) – such as that offered in their Diplomado Organico. Following initial exposure to this kind of innovation, we've seen positive impact for producer partners in every country we work with – as they experiment, adapt and enhance their own local practices to face ever-changing climate and coffee-production landscapes.

It's precisely in this context that we're launching the Carbon, Climate and Coffee Initiative. Following the positive feedback for a programmatic approach to producer support at our Annual General Assembly, we've designed a simple plan for coffee roasters to pay a "voluntary carbon tax" in order to build this environmental-service fund, invested directly with our coffee-producer partners. Our launching priority focuses on project-work that encourages reforestation, soil regeneration, and experimentation and learning about other "carbon-capture enhancing" practices. It also would include complementary actions that contribute towards greater environmental balance in producer communities.

We expect this investment to result in multiple win-win scenarios in terms of: improving our own understanding of climate impact and discovering comparative energy efficiencies between roasters; enhancing climate resiliency and productivity with our producer partners and their cooperatives; achieving more stable supply and, thereby, reducing risk for both producers and roasters; and finally, in achieving our ultimate end-goal of greater social, environmental and economic impact for our producer partner families, communities and organizations.

With this new initiative, we are NOT trying to become "carbon accountants." Nor are we trying to "buy off" our collective, environmental debts. As you'll see in the following posts, CoopCoffees roaster/owners already have a long history of pro-actively pushing the environmentalist envelope. Examples abound, such as the use of alternative energy sources to power their installations, investing in the most "emission-free" possible roasting equipment, insisting on fully recyclable packaging, implementing bio-gas or bicycle delivery of roasted coffee, and supporting local and international environmental projects. So yes, our roasters are already working hard to soften their respective carbon footprints.

But with this new initiative, we want to acknowledge the environmental services that our organic farming partners already provide and encourage them to continue in their efforts. What we haven't been able to reduce in CO2 emissions, we can now attempt to offset through community-based projects with our producer partners. The Carbon, Climate and Coffee Initiative is demonstrative of our most sincere intentions to achieve environmental responsibility through local and global actions.

We hope to illustrate with coffee producers and consumers alike that climate solutions exist – and can be as close as the soil under our feet, and the coffee mug in our hands!

Author: Monika Firl February 2, 2017

3.2.5 Carbon Project

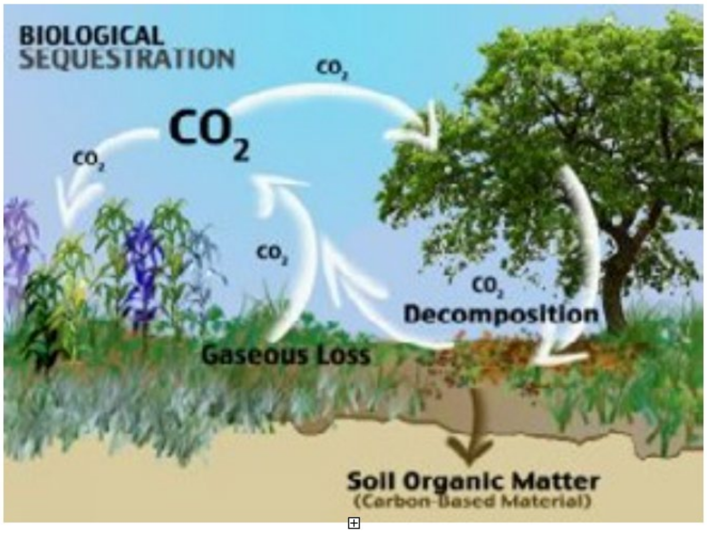
A carbon project refers to a commercial initiative that receives financing because it will result in a reduction in the emission of greenhouse gases (GHG). Two fundamental concepts for the existence of an emission reduction project:

Additionalities: This means that the project only went forward because of the extra financial support provided by the sale of carbon credits. Assuring that each project is additional is integral to the integrity of the CDM. Each business-as-usual (non- additional) CDM project that sells credits under the CDM allows an industrialized country to issue more than their targets without causing the equivalent emissions to be reduced in a developing country. There have been estimates that 20-70% of all CDM projects are non-additional. Very large infrastructure projects, where revenues from carbon credits makes up only a very small fraction of profits, are particularly unlikely to be additional.

Baselines

Every project needs to determine what its emissions would have been if the project was not implemented. These are called the baseline emissions. The number of credits a project receives is then calculated by subtracting the project emissions from the baseline emissions.

3.2.6 Carbon sequestration



Interest in terrestrial carbon sequestration has increased in an effort to explore opportunities for climate change mitigation. Carbon sequestration is the process by which atmospheric carbon dioxide is taken up by trees, grasses, and other plants through photosynthesis and stored as carbon in biomass (trunks, branches, foliage, and roots) and soils. The sink of carbon sequestration in forests and wood products helps to offset sources of carbon dioxide to the atmosphere, such as deforestation, forest fires, and fossil fuel emissions.

Sustainable forestry practices can increase the ability of forests to sequester atmospheric carbon while enhancing other ecosystem services, such as improved soil and water quality. Planting new trees and improving forest health through thinning and prescribed burning are some of the ways to increase forest carbon in the long run. Harvesting and regenerating forests can also result in net carbon sequestration in wood products and new forest growth.

3.2.7 Carbon retirement

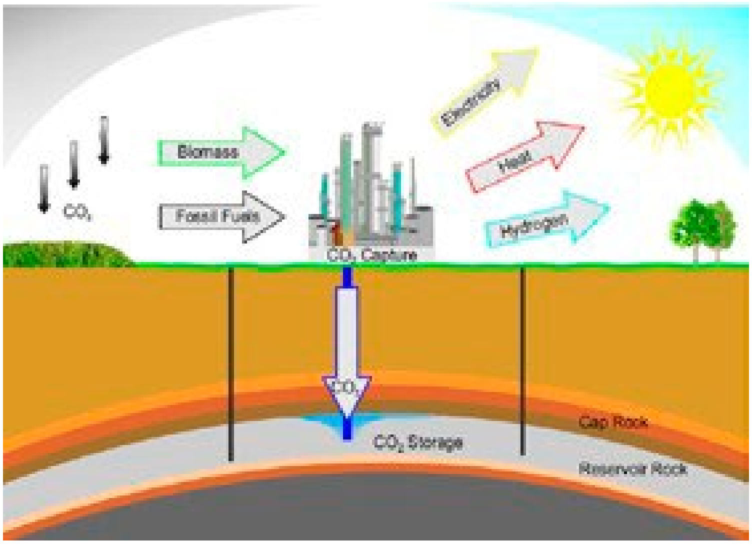
CCS: carbon capture and storage or carbon retirement is a critical CO2 emission abatement technology.

Since pre-industrial times, the atmospheric concentration of several greenhouse gases (notably CO2, methane and nitrous oxides) has increased substantially.

The stability of our climate is directly linked to the atmosphere, so variations in the level, or concentration, of any greenhouse gas will have an impact.

Atmospheric levels of CO2 are now higher than at any time in the past 800, 000 years, reaching 400 parts per million (ppm) in early 2013, compared to a pre-industrial high of 280 ppm. Reducing man-made CO2 emissions, including those produced through the burning of fossil fuels, is a key element in mitigating greenhouse gas emissions and the dangerous effects of climate change.

3.2.8 Carbon tax



A carbon tax is a fee imposed on the burning of carbon- based fuels (coal, oil, gas). More to the point: a carbon tax is the core policy for reducing and eventually eliminating the use of fossil fuels whose combustion is destabilizing and destroying our climate.

Carbon Tax around the world, including in:

- United Kingdom
- Ireland
- Australia
- Chile
- Sweden
- Other Nations (including Finland, and New Zealand)

3.2.9 Carbon Pricing

Carbon pricing is an instrument that captures the external costs of greenhouse gas (GHG) emissions—the costs of emissions that the public pays for, such as damage to crops, health care costs from heat waves and droughts, and loss of property from flooding and sea level rise—and ties them to their sources through a price, usually in the form of a price on the carbon dioxide (CO2) emitted.

A price on carbon helps shift the burden for the damage from GHG emissions back to those who are responsible for it and who can avoid it. Instead of dictating who should reduce emissions where and how, a carbon price provides an economic signal to emitters, and allows them to decide to either transform their activities and lower their emissions, or continue emitting and paying for their emissions.

Placing an adequate price on GHG emissions is of fundamental relevance to internalize the external cost of climate change in the broadest possible range of economic decision making and in setting economic incentives for clean development. It can help to mobilize the financial investments required to stimulate clean technology and market innovation, fueling new, low-carbon drivers of economic growth.

There is a growing consensus among both governments and businesses on the fundamental role of carbon pricing in the transition to a decarbonized economy.

Businesses use internal carbon pricing to evaluate the impact of mandatory carbon prices on their operations and as a tool to identify potential climate risks and revenue opportunities. Finally, long-term investors use carbon pricing to analyze the potential impact of climate change policies on their investment portfolios, allowing them to reassess investment strategies and reallocate capital toward low-carbon or climate- resilient activities.

3.2.9.1 Internal Carbon Pricing

Internal carbon pricing allows companies to assess the financial implications of their carbon emissions and encourage increased energy efficiency.

Major benefits of instituting an internal carbon charge can include:

- Preparing organizations for future regulatory carbon taxes and new environmental laws
- Providing competitive advantages in a future low-carbon economy
- Reducing greenhouse gas emissions when the price of carbon is set properly
- Directing investment towards efficient practices and technologies
- Incentivizing long-term research and development opportunities for new cost-effective and green innovations

- Attracting environmentally aware investors and stakeholders
- Positioning organizations as socially responsible
- Contributing to long-term profits and returns by leading in environmental and social issues

3.2.9.2 PMR

pmr

PARTNERSHIP FOR
MARKET READINESS

The Building Blocks of Market Readiness

Country, Technical, and Policy work streams come together to identify and fill gaps in countries' market "readiness" for mitigation action.

The core work of the PMR is to help countries develop the readiness components such as GHG baselines, systems for MRV, or offset standards – specific to their mitigation goals. For those countries ready to design and implement a carbon pricing instrument, the PMR provides a platform to pilot. Developing readiness and piloting instruments come together in the PMR's Country Work and is embodied in the Market Readiness Proposal (MRP). As the partnership has evolved, two additional work programs have developed to enhance support: Technical Work and Policy Work.

Country Work

PMR Country Work focuses on the readiness activities detailed in countries' the Market Readiness Proposals (MRP). Using a building block approach, countries present their existing mitigation policy contexts, identify readiness components to design or strengthen, target sectors and, if appropriate, select market instruments to pilot. Click here to for a list of final MRPs or here to learn more about the Participant Process.

Technical Work

The Technical Work Program promotes best practices and facilitates efforts to establish common standards and approaches for GHG mitigation. Drawing on country experience, global industry experts, and in-house resources, the PMR generates knowledge products and exchanges on various technical elements related to carbon pricing.

Policy Work

The Policy Work program offers countries targeted, in-depth support to model the costs and benefits of policy options, analyze interactions between policies, and integrates this analysis into low-carbon development plans and strategies. It also provides tools to help countries determine post-2020 mitigation scenarios and build NDCs.

Box 3.2 Microsoft

Implemented in 2013, the internal carbon-pricing scheme used by Microsoft is an innovative quantity based approach. Instead of pricing carbon at the SCC, Microsoft determines its current level of emissions and then calculates the required internal carbon price to make its operations carbon-neutral. However, structural problems are holding back the program.

Microsoft relies on two core formulae in its approach: Cost of environmental initiatives portfolio ($) = Cost of internal initiatives ($) + Cost of green power purchases ($) + Cost of carbon offsets ($)

Internal carbon price (per mtCO2e) = Cost of environmental initiatives portfolio ($; from above)/Total emissions (mtCO2e)

The emphasis of Microsoft's program is on how tax revenues are spent rather than how much the carbon price is or how revenue is collected internally.

In terms of our theoretical framework, this means Microsoft focuses on the secondary benefits of a carbon tax. It takes this approach rather than evaluating the emissions reductions of individual business subunits.

This program is innovative. It would still reap the double effect of emissions reductions if the carbon price is sufficiently high. Because the price of carbon is determined by the total cost of the carbon-fee fund investment strategy, it can change from year to year, although Microsoft has thus far kept its internal carbon price relatively constant.

Unfortunately, Microsoft's current internal carbon price, while not released in official reports, has been mentioned to be between $4-5 USD.12

Hence, we expect minimal reductions in energy consumption and carbon emissions internally. Microsoft's approach to carbon neutrality is to simply buy up carbon credits and reduce carbon emissions else where it is cheaper to do so.

3.2.10 Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)

The International Civil Aviation Organization (ICAO) is a UN specialized agency, established by States in 1944 to manage the administration and governance of the Convention on International Civil Aviation (Chicago Convention).

ICAO works with the Convention's 193 Member States and industry groups to reach consensus on international civil aviation Standards and Recommended Practices (SARPs) and policies in support of a safe, efficient, secure, economically sustainable and environmentally responsible civil aviation sector. These SARPs and policies are used by ICAO Member States to ensure that their local civil aviation operations and regulations conform to global norms, which in turn permits more than 100, 000 daily flights in aviation's global network to operate safely and reliably in every region of the world.

CAO developed model regulations that aim to facilitate the establishment of a regulatory system for the CORSIA monitoring, reporting and verification (MRV) system by ICAO's Member States, in compliance with the Annex 16, Volume IV.

These model regulations are provided for illustrative purposes and do not supersede or replace Annex 16, Volume IV. They are not be prescriptive, mandatory, or construed in any way as to pre-empt individual States' legal structures. The model regulations do not prejudge the form that the legislation takes as such a matter is for each State to decide in light of its domestic legislation.

ICAO Member States may use the model regulations as a reference and are free to adapt them to their own specific needs, legislative style and norms to comply with CORSIA requirements.

3.2.11 Clean Development Mechanism (CDM)

The CDM allows emission-reduction projects in developing countries to earn certified emission reduction (CER) credits, each equivalent to one tonne of CO2. These CERs can be traded and sold, and used by industrialized countries to a meet a part of their emission reduction targets under the Kyoto Protocol.

The mechanism stimulates sustainable development and emission reductions, while giving industrialized countries some flexibility in how they meet their emission reduction limitation targets.

The CDM, defined in Article 12 of the Protocol, was intended to meet two objectives:

- to assist parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the United Nations Framework

Convention on Climate Change (UNFCCC), which is to prevent dangerous climate change; and

- to assist parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments (greenhouse gas (GHG) emission caps).

Any proposed CDM project has to use an approved baseline and monitoring methodology to be validated, approved and registered. Baseline Methodology will set steps to determine the baseline within certain applicability conditions whilst monitoring methodology will set specific steps to determine monitoring parameters, quality assurance, equipment to be used, in order to obtain data to calculate the emission reductions. Those approved methodologies are all coded:

- AM – Approved Methodology
- ACM – Approved Consolidated Methodolog
- AMS – Approved Methodology for Small Scale Projects
- ARAM – Aforestation and Reforestation Approved Methodologies

All baseline methodologies approved by Executive Board are publicly available along with relevant guidance on the UNFCCC CDM website. If a DOE determines that a proposed project activity intends to use a new baseline methodology, it shall, prior to the submission for registration of this project activity, forward the proposed methodology to the EB for review, i.e. consideration and approval, if appropriate.

With costs of emission reduction typically much lower in developing countries than in industrialized countries, industrialized countries can comply with their emission reduction targets at much lower cost by receiving credits for emissions reduced in developing countries as long as administration costs are low.

The IPCC has projected GDP losses for OECD Europe with full use of CDM and Joint Implementation to between 0.13% and 0.81% of GDP versus 0.31% to 1.50% with only domestic action.

3.2.12 Gold Standard (carbon offset standard)

Gold Standard was established in 2003 by WWF and other international NGOs to ensure projects that reduced carbon emissions featured the highest levels of environmental integrity and also contributed to sustainable development. With the adoption of the Paris Climate Agreement and the Sustainable Development Goals, we launched a best practice standard for climate and sustainable development interventions.

Table 5:

Regional distribution of CDM projects	Number of small-scale		Number of full scale		Number of all projects		For all projects kCERs	2020 kCERs		Popu-lation	2020 CER per cap.
Latin America	414	12.3%	697	13.9%	1111	13.3%	144850	957200	11.9%	449	2.13
Asia & Pacific	2809	83.3%	4008	80.1%	6817	81.4%	899161	6504484	81.1%	3418	1.90
Europe and Central Asia	23	0.7%	61	1.2%	84	1.0%	13503	136604	1.7%	143	0.32
Africa	85	2.5%	168	3.4%	253	3.0%	46070	280327	3.5%	891	0.31
Middle East	42	1.2%	70	1.4%	112	1.3%	24602	145956	1.8%	186	0.78
Less developed World	3373	100.0%	5004	100.0%	8377	100%	1134486	8024571	100%	5093	1.58

Gold Standard was founded on the principle that climate action cannot be one-dimensional – climate projects must deliver meaningful sustainable development benefits beyond emission reductions. The success of our approach has influenced both the UN's Clean Development Mechanism (CDM) and other voluntary standards to raise the bar and include sustainable development within some of their climate projects. This all helps deliver on our mission to catalyse more ambitious climate action to achieve the Global Goals.

In total, Gold Standard has issued 110 million carbon credits from projects based in more than 60 different countries around the world.

Case 1: Cambodia National Biodigester Programme

Domestic biodigesters provide a way for individual households with livestock to reduce their dependence on polluting firewood and expensive fossil fuels for cooking and lighting. The project also provides additional benefits with the bio-slurry providing a great means for fertilizing and improving local agricultural production.

The domestic biodigester disseminated in Cambodia is a 'Farmer's Friend', a fixed dome digester, which has a lifespan of over 20 years. The smallest and most popular digester on the market, it can treat the waste from 2-3 bovines or 4-6 pigs and costs around $500 excluding an investment subsidy of $150.

The Cambodian National Biodigester Programme was originally set up in 2006 by the Cambodian Ministry of Agriculture, Forestry and Fisheries (MAFF) and SNV Netherlands Development Organization. In the period March 2006 to December 2018 over 27, 000 biodigesters were constructed through 107 micro-enterprises in 15 provinces. The programme was one of the first large- scale biogas projects certified to Gold Standard with support from HIVOS. Since 2017, MAFF uses money generated from the sale of carbon credits to continue running and expanding this programme.

An important success factor is the special biogas loan that is made available through three nationally operating micro- finance institutions. Since 2010, over 70% of households have used a biogas loan to finance their biodigester. Loans are generally paid back within two years.

The Programme works with a market-based model and has the intention to develop the sector in such a way that it can run without direct involvement of the Programme. The private sector development arm of NBP is therefore establishing independent enterprises in rural areas and building the capacity of those enterprises on marketing and promotion, internal quality control and after sales services.

Project impacts and benefits:

Livelihood and health improvement:

- 27.231 biodigesters constructed from March 2006 to December 2018 / 93.561 direct beneficiaries
- 75.5% of constructed biodigesters still operational; i.e. 20,560 smoke-free kitchens (December 2018)
- Biogas kitchen air pollution reduced with 88% (Particulate Matter 2.5).
- 29,5 averted deaths and 1, 442 averted Disability Adjusted Life Years (ADALYs) realized from 2006 to 2014 with projection of 51 averted deaths and 2,519 ADALYs up to 2020
- 3.028 biodigester connected toilets
- $143 USD saving in expenditures on cookinge fuels per household per year Employment creation:
- 107 private enterprises established of which 53 are active
- 810 trained masons
- 154 trained supervisors Environmental benefits:
- On average 5,05 tCO_2 reduced per digester per year
- 759,000 tCO_2 reduced between May 2009 and December 2018
- 257,300 tonnes of wood saved

3.2.13 Verra

Verra was founded in 2005 by environmental and business leaders who saw the need for greater quality assurance in voluntary carbon markets. We now serve as a secretariat for the various standards we develop and programs we manage, as well as an incubator of new ideas that can generate meaningful environmental and social value at scale.

Standard: Establishes the core rules and requirements that must be met for any project, program or activity to be certified under the framework. Depending on the circumstances, our standards may set out higher-level requirements or, for more complex endeavors, include more detailed rules and procedures.

Independent Assessment: Ensures that projects, programs and activities meet our standards. Where standards require independent auditing or verification, we establish processes for accrediting auditors, overseeing their work, and sanctioning them if they underperform. We provide support and oversight to established accreditation programs to ensure cost-effective and high- quality independent auditing.

Accounting Methodologies: Allow for the determination of baselines (ie, what would have happened in the absence of the project, policy or program) and set out specific parameters for measuring, accounting and monitoring impacts.

Registry: Displays the performance of projects, programs or activities to allow tracking of results or, in some cases, tradable units. The final programmatic component of a typical standards framework and essential to functioning certification markets, registries provide tracking services to account holders and transparent project documentation to the public.

Programs and Initiatives: Currently, Verra manages the following:

VCS Program. The VCS Program allows certified projects to turn their greenhouse gas (GHG) emission reductions and removals into tradable carbon credits. Since its launch in 2006, the VCS Program has grown into the world's largest voluntary GHG program. VCS projects include dozens of technologies and measures which result in GHG emission reductions and removals, including forest and wetland conservation and restoration, agricultural land management, transport efficiency improvements, and many others. There are currently almost 1, 600 registered projects in over 82 countries that have generated more than 450 million carbon credits, the equivalent of 98 million passenger vehicles being taken off the road for one year. (For updated VCS statistics, please click here).

VCS Jurisdictional and Nested REDD+ (JNR) Framework. The JNR Framework is an accounting and crediting system for jurisdictional REDD+ programs and nested projects, designed for market mechanisms. It is a practical framework that provides guidance to national and subnational governments to support development of their REDD+ programs and help nest REDD+ projects within these programs, ensuring environmental integrity and jurisdictional sovereignty. This ensures that these projects support and align with governments' efforts to achieve countries' climate action goals, while driving finance to high impact mitigation. In 2020, Verra plans to release an updated version of the framework which will include more detailed guidance on nesting.

Climate, Community & Biodiversity (CCB) Program. With over one hundred registered projects, the CCB Program is the leading framework for assessing land management projects that create net-positive benefits for climate change mitigation, local communities and biodiversity. The CCB Program can be used in conjunction with a GHG-crediting program, such as the VCS Program, and carbon credits can be labeled with the co-benefits certified under the CCB Program. In total, projects certified to the CCB Program cover almost 11 million hectares.

Sustainable Development Verified Impact Standard (SD VISta). The SD VISta Program is a flexible framework that sets out rules and criteria for the design, implementation and assessment of projects that aim to deliver high-impact sustainable development benefits. SD VISta enables projects to link their social and environmental impacts to the United Nations Sustainable Development Goals (SDGs) through certified claims or tradable assets such as health or water credits. The standard enables donors and investors to identify, support and help drive finance to activities that generate measurable sustainable development outcomes.

Verra California Offset Project Registry (OPR). The California OPR helps the California Air Resources Board (CARB) administer the Compliance Offset Program component of its cap-and-trade system. The OPR facilitates the listing and verification of GHG offset projects that were developed using CARB Offset Protocols and that issue Registry Offset Credits (ROCs). Entities covered by California's cap-and-trade program can use compliance offset credits to satisfy a portion of their regulatory obligations.

Verra is also actively engaged in initiatives that will help to drive more investment in actions designed to protect the environment and promote sustainable development:

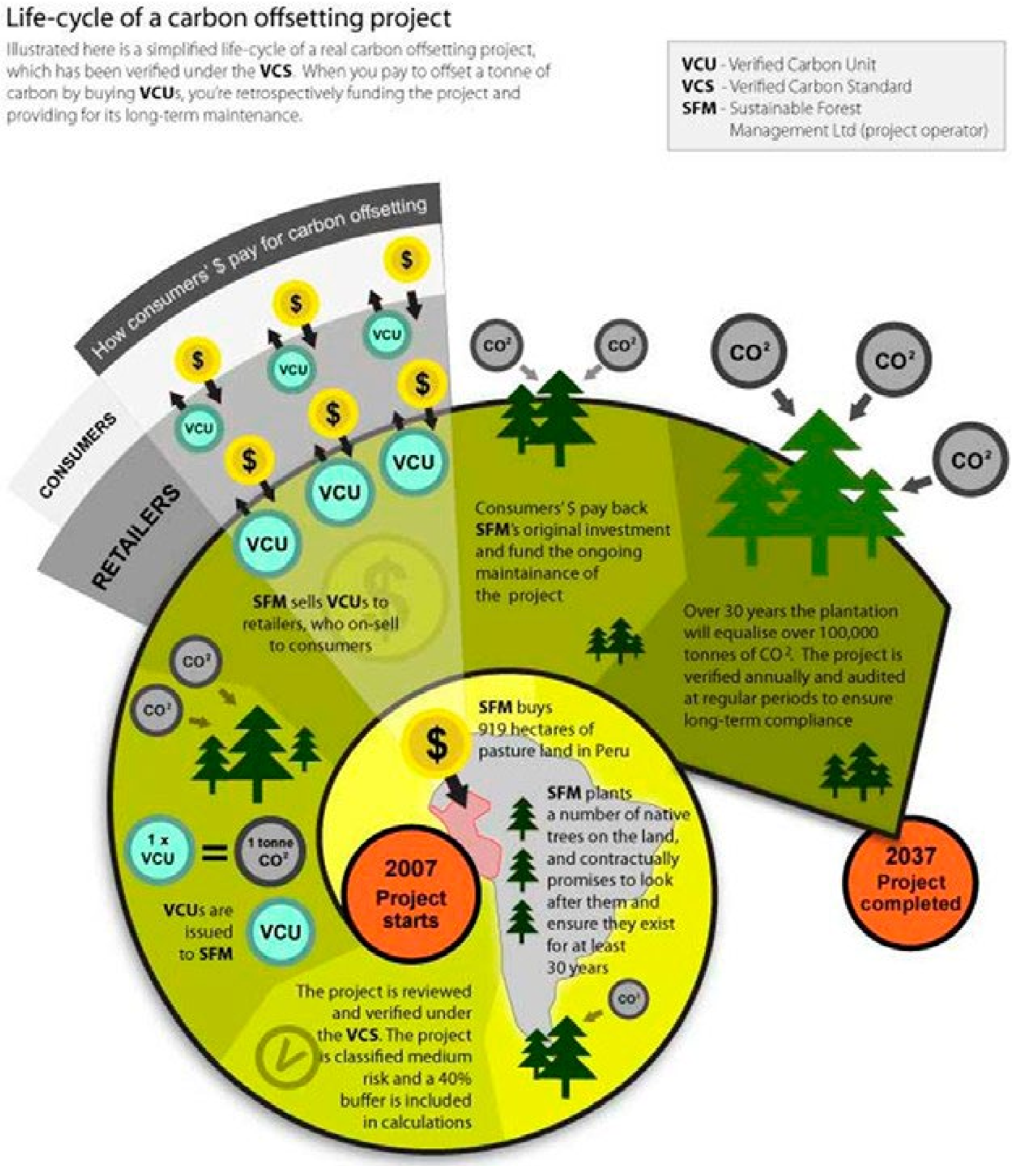
Initiative for Climate Action Transparency. ICAT aims to help countries assess the impacts of their climate actions and to support greater transparency, effectiveness, ambition and trust in climate policies. ICAT integrates methodological guidance, capacity building and knowledge sharing to strengthen the transparency and effectiveness of climate policies and actions worldwide. To this end, the initiative has developed a series of impact assessment guides and is also working with developing countries to strengthen their capacity to assess climate actions in the context of their Nationally Determined Contributions. To date, ICAT is working with 40 countries in four regions.

ICAT is a multi-donor fund that is managed by the United Nations Office for Project Services (UNOPS). UNEP-DTU Partnership, Verra and World Resources Institute were the founding implementing partners. ICAT continues to be implemented by the Italian National Institute for Environmental Protection and Research, UNEP-DTU Partnership, and the World Resources Institute. Verra was a founding member of the Initiative for Climate Action Transparency (ICAT) and led the core team that drafted the series of assessment guides and oversaw their application in the first case studies. Today Verra remains engaged with the initiative in an advisory role.

LandScale (LS). LandScale provides a standardized, yet adaptable, framework to track the outcomes of landscape or jurisdictional sustainability approaches and communicate those outcomes to commodity-buying companies, donors, and other external stakeholders, facilitating multistakeholder, cross-sector collaboration. LandScale enables users to obtain reliable information about the status of ecosystems, human well-being, governance, and productivity in a landscape and to determine the state and trajectory of its sustainability. LandScale assessments will help drive improvements in sustainability performance by informing locally relevant policies and management interventions, guiding sustainable sourcing and investment decisions, and spurring new market incentives for landscape sustainability.

LandScale is co-led by Verra, the Rainforest Alliance and the Climate, Community and Biodiversity Alliance, in collaboration with a growing number of global partners. It is generously supported by the BHP Foundation and the International Climate Initiative of the German Federal Ministry for the Environment, Nature Conservation & Nuclear Safety.

3R Initiative (3RI). To catalyze zero plastic waste corporate leadership, 3RI is developing a market- based approach that will scale up recovery and recycling activities and increase accountability for plastic waste reduction efforts around the world. The 3RI's flexible market mechanism, underpinned by robust standards, will transparently and sustainably increase the value of plastic waste and incentivize new activities that support the circular economy.



3.3 Markets

Carbon markets aim to reduce greenhouse gas (GHG, or "carbon") emissions cost effectively by setting limits on emissions and enabling the trading of emission units, which are instruments representing emission reductions. Trading enables entities that can reduce emissions at lower cost to be paid to do so by highercost emitters, thus lowering the economic cost of reducing emissions.

By putting a price on carbon emissions, carbon market mechanisms, as well as other carbon pricing mechanisms such as carbon taxes, help to internalize the environmental and social costs of carbon pollution, encouraging investors and consumers to choose lowercarbon paths.

There are two main categories of carbon markets: Emissions Trading Systems (ETSs) and a new voluntary scheme defined in the Paris Agreement, article 6.2. In the latter, voluntary cooperation in the implementation of the countries' Nationally Determined Contributions (NDCs) allows for more ambitious mitigation actions. Countries will be able to use Internationally Transferred Mitigation Outcomes (ITMOs) towards their NDCs on a voluntary basis. This entry will focus on the working modalities and establishment of ETSs.

An ETS, also known as a cap and trade mechanism, sets a mandatory limit or cap on GHG emissions on a predefined set of emission sources. Tradable allowances (tradable emissions permits issued, representing the right to generate a metric tonne of carbon dioxide equivalent (CO2e)), are allocated to the emitters covered under the cap.

At the end of a specified reporting period, the covered entities must surrender allowances equivalent to the GHG emissions they produced during the period. Entities whose emissions exceed their allocations may purchase excess allowances or other eligible instruments to fill the gap, or pay a fine. Caps can be tightened over time to promote further emission reductions. ETSs exist at regional, national and subnational levels.

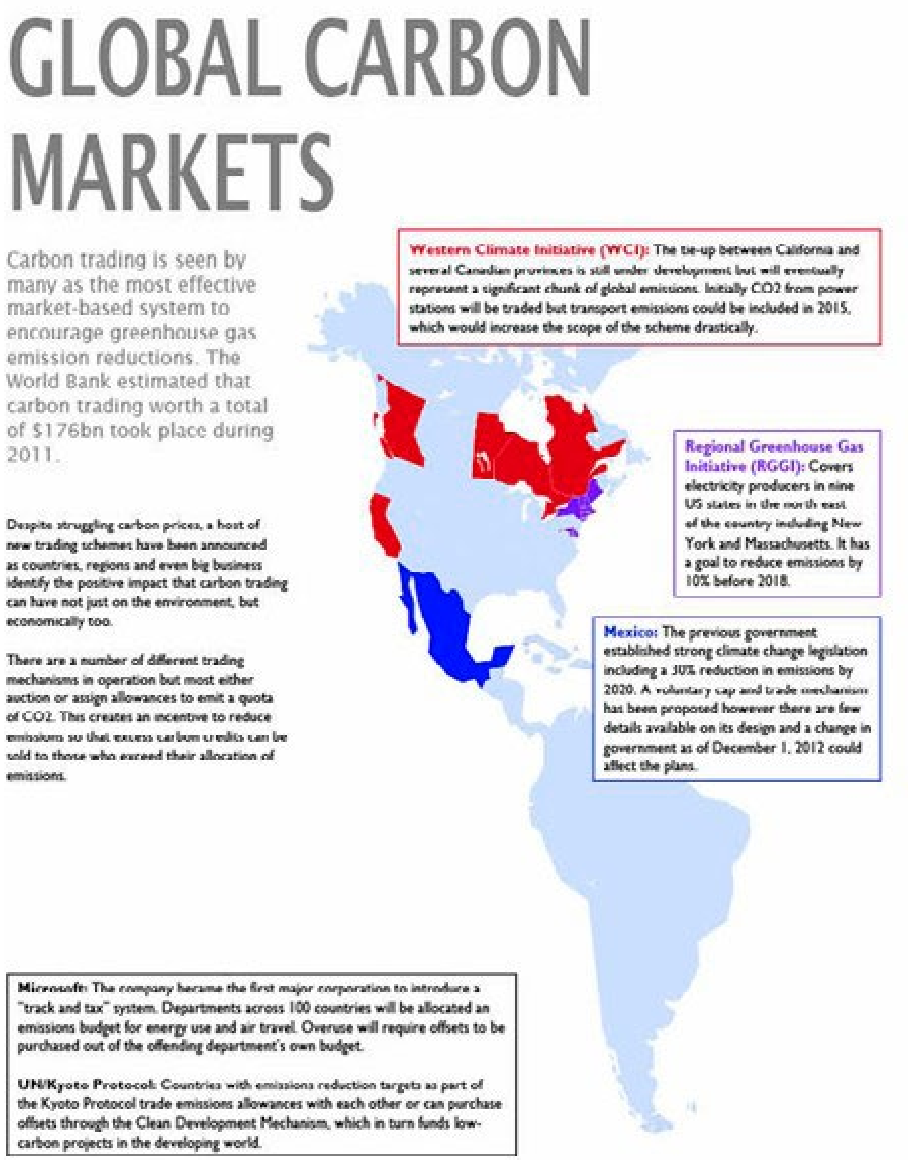
3.3.1 Global Market

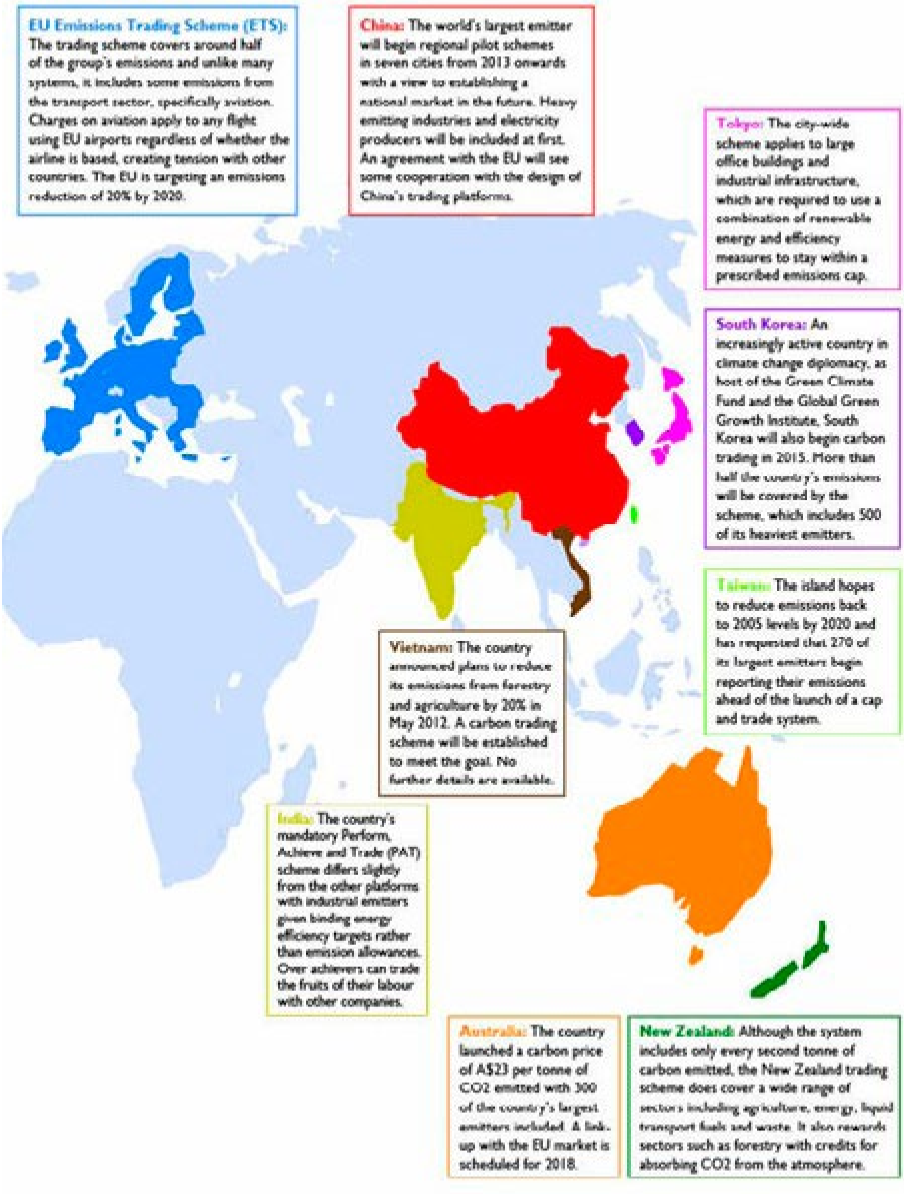
(Reuters) – The turnover in global emissions trading hit a record high last year of $214 billion as prices rose on current or expected stricter regulation, research by Refinitiv showed last month. The turnover was up 34% from a year earlier and marked a third consecutive year of growth.

The world's largest carbon market, the EU's Emissions Trading System (ETS), makes up of almost 80% of traded volume. The average price of carbon permits in the scheme rose by $10 last year to $28 a tonne.

The main reason for the increase in prices was a mechanism which came into effect in January last year, designed to withhold a significant amount of permits and tighten supply. The European Commission's "green deal" policy package, which was announced in December, will commit the European Union to achieve climate neutrality, emitting no more greenhouse gases beyond what can be absorbed, by 2050.

The Commission also intends to propose more ambitious targets to cut emissions by 2030 by the middle of this year. Both of these moves also lent support to EU carbon prices. Emissions trading schemes, or carbon markets, are market-based tools to limit greenhouse gas emissions. They put a cap on the amount countries or companies can emit and if they exceed the limit they can buy permits from others.





While a global carbon market remains elusive, 46 nations and over 30 cities, states and regions now have a price on carbon dioxide emissions (CO_2), overing just over 20% annual global greenhouse gas emissions, according to World Bank data.

3.3.2 E.U. Market

The European Union's Emissions Trading System (EU ETS) was established in 2005 and includes over 11.000 installations across the European Economic Area, covering around 40% of Europe's greenhouse gas (GHG) emissions. The EU ETS is a "cap and trade" system, meaning that a cap determines the total amount of greenhouse gases that companies can emit. Under the annually shrinking cap, companies receive or buy emission allowances which they can trade as needed.

Since the beginning, the EU ETS has suffered from a surplus of emission allowances which has led to a price too low to spur a climate-friendly transformation. The main causes for the insufficient price signal are an unambitious overall target, the economic crisis that started in 2008, and the inflow of international credits.

The situation has improved and prices have recovered since the EU ETS Market Stability Reserve (MSR) began to absorb excess allowances off the market at the beginning of 2019. However, the MSR was designed to handle past oversupply accumulated over the years. It is not fit for purpose to deal with current or future surplus.

In the meantime, EU governments can help strengthen the system by cancelling surplus allowances as power plants are closed down. Furthermore, implementing either national or regional carbon floor prices is an ideal measure to strengthen the EU ETS and provide the necessary incentives to phase out coal.

The EU ETS works on the 'cap and trade' principle

A cap is set on the total amount of certain greenhouse gases that can be emitted by installations covered by the system.

The cap is reduced over time so that total emissions fall.

Within the cap, companies receive or buy emission allowances, which they can trade with one another as needed. They can also buy limited amounts of international credits from emission-saving projects around the world. The limit on the total number of allowances available ensures that they have a value.

After each year a company must surrender enough allowances to cover all its emissions, otherwise heavy fines are imposed. If a company reduces its emissions, it can keep the spare allowances to cover its future needs or else sell them to another company that is short of allowances.

Trading brings flexibility that ensures emissions are cut where it costs least to do so. A robust carbon price also promotes investment in clean, low-carbon technologies.

3.3.3 U.S. Market

US. carbon trading under the Regional Greenhouse Gas Initiative aims to reduce CO2 emissions by another 30 percent over the next decade. But will northeastern states achieve their climate change goals when power plants are no longer the main polluters?

U.S. carbon trading under the Regional Greenhouse Gas Initiative (RGGI) is evolving for the next decade, with new states set to be added to the current nine participants.

States have agreed to reduce the program's CO_2 limit by 30 percent between 2021 and 2030, building on the 47 percent reduction achieved for their power plants since 2008.

U.S. carbon trading under RGGI won't be enough for states to achieve their climate change goals, since power plants are no longer the main emitters in the region.

The oldest U.S. cap-and-trade program for CO_2 emissions is poised to become increasingly active over the next decade as the Regional Greenhouse Gas Initiative (RGGI) grows to cover more states and participants adjust to a new framework governing trading fundamentals.

The RGGI, which started a decade ago, currently involves the states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont in a joint effort to cap and reduce CO_2 emissions from the power sector.

New Jersey will join next year, increasing the range of the program, while Virginia is poised to join in the coming years.

Pennsylvania may one day be the market's largest member.

From 2021-2030, the RGGI states have agreed to reduce the program's CO_2 limit by 30 percent, building on the 47 percent CO_2 reduction the states have already achieved for their power plants since 2008.

The states have also agreed to add a new mechanism, called an emissions containment reserve, to the market in 2021.

The reserve is meant to speed CO_2 reductions by removing allowances from RGGI's quarterly auctions if the clearing price falls below a predetermined threshold, which will start at US$6/st in 2021.

Essentially, this new mechanism reduces supply in the market to better match demand, in the case that CO_2 emissions covered by the program fall faster than anticipated.

Recently, many of the RGGI states have committed or recommitted to ambitious policies to address climate change, such as reducing economy-wide greenhouse gas emissions by 80 percent by 2050.

The framework the states have established for the 2020s ensures that RGGI will remain a key part of that effort.

But RGGI alone will not be enough for the states to achieve their larger climate change goals, since power plants are no longer the main emitters in the region.

Instead, many of the same northeastern U.S. states are considering creating a separate cap-and-trade program for the transportation sector, the largest source of CO_2 in the states and across the country.

That program could work in tandem with RGGI to help the states use markets to drive emissions lower.

The California Air Resources Board

CARB is charged with protecting the public from the harmful effects of air pollution and developing programs and actions to fight climate change. From requirements for clean cars and fuels to adopting innovative solutions to reduce greenhouse gas emissions, California has pioneered a range of effective approaches that have set the standard for effective air and climate programs for the nation, and the world.

Partners for Clean Air

The Board is part of a coordinated three-tiered approach to cleaning up air pollution:

- The United States Environmental Protection Agency sets nationwide air quality and emissions standards and oversees state efforts and enforcement.
- The California Air Resources Board focuses on California's unique air quality challenges by setting the state's own stricter emissions standards for a range of statewide pollution sources including vehicles, fuels and consumer products.
- Thirty-five local air pollution control districts regulate emissions from businesses and stationary facilities, ranging from oil refineries to auto body shops and dry cleaners.

Responsibilities & Work of CARB

Reducing air pollution and protecting public health guide CARB's actions. Our role is to:

- Set the state's air quality standards at levels that protect those at greatest risk – children, older adults and people with lung and heart disease;
- Identify pollutants that pose the greatest health risks, such as diesel exhaust particles, benzene in gasoline and formaldehyde in consumer products;
- Measure our progress in reducing pollutants utilizing the nation's most extensive air monitoring network;
- Verify automakers' emissions compliance at CARB's renowned Haagen-Smit Laboratory in El Monte;
- Research the causes and effects of air pollution problems – and potential solutions – using the best available science and technology;
- Study the costs and benefits of pollution controls, paying particular attention to individuals and communities most at risk; and
- Lead California's efforts to reduce climate-changing emissions through measures that promote a more energy-efficient and resilient economy.

He Cap-and-Trade Program is a key element of California's strategy to reduce greenhouse gas (GHG) emissions. It complements other measures to ensure that California cost-effectively meets its goals for GHG emissions reductions.

The Cap-and-Trade Regulation establishes a declining limit on major sources of GHG emissions throughout California, and it creates a powerful economic incentive for significant investment in cleaner, more efficient technologies.

The Program applies to emissions that cover approximately 80 percent of the State's GHG emissions. CARB creates allowances equal to the total amount of permissible emissions (i.e., the "cap"). One allowance equals one metric ton of carbon dioxide equivalent emissions (using the 100-year global warming potential). Each year, fewer allowances are created and the annual cap declines. An increasing annual auction reserve (or floor) price for allowances and the reduction in annual allowances creates a steady and sustained carbon price signal to prompt action to reduce GHG emissions. All covered entities in the Cap-and- Trade Program are still subject to existing air quality permit limits for criteria and toxic air pollutants.

Program Overview

The Cap-and-Trade Program is a key element of California's climate plan. It sets a statewide limit on sources responsible for 85 percent of California's greenhouse gas emissions, and establishes a price signal needed to drive long-term investment in cleaner fuels and more efficient use of energy. The program is designed to provide covered entities the flexibility to seek out and implement the lowest-cost options to reduce emissions.

Scope

- Program covers about 450 entities
- Starts in 2013 for electricity generators and large industrial facilities emitting 25, 000 MTCO2e or more annually
- Starts in 2015 for distributors of transportation, natural gas, and other fuels
- In 2014, California's program linked with the Canadian province of Québec
- Designed to link with similar trading programs in other states and regions

The Cap

- Set in 2013 at about 2 percent below the emissions level forecast for 2012
- Declines about 2 percent in 2014
- Declines about 3 percent annually from 2015 to 2020

Free Allocation of Allowances

Large industrial facilities

- Focus on free allocation early in the program, transitions to more auction later in program
- Allocation of allowances for most industrial sectors is set at about 90 percent of average emissions, based on benchmarks that reward efficient facilities
- For most industrial sectors, distribution of allowances is updated annually according to the production at each facility

Electrical distribution and natural gas utilities

- Free distribution of allowances, with the requirement that the value of allowances must be used to benefit ratepayers and achieve greenhouse gas emissions reductions
- For electrical distribution utilities, free allocation is set at about 90 percent of average emissions
- For natural gas utilities, free allocation is based on natural gas supplied in 2011 to non-covered entities

Cost Containment and Market Flexibility Mechanisms

- Trading of allowances is allowed to minimize cost of pollution controls
- Banking of allowances is allowed to guard against shortages and price swings
- 4 percent of allowances are held in a strategic reserve to contain costs
- Multi-year compliance periods to buffer annual variations in product output

Offsets

- Allowed for up to 8 percent of a facility's compliance obligation
- Limited to emissions-reduction projects in U.S.
- Restricted to projects in five areas: forestry, urban forestry, dairy digesters, destruction of ozone-depleting substances, and mine methane capture
- Offsets must be independently verified
- Currently analyzing rice cultivation protocol

Emissions Reporting and Verification through the Mandatory Reporting Regulation

- Covered entities must report emissions and additional data annually (as required since 2008)
- Independent third-party verification

Compliance and Enforcement

- Every year, covered entities turn in allowances and offsets for 30 percent of previous year's emissions
- Each compliance period, covered entities turn in allowances and a limited number of offsets covering the remainder of emissions in that compliance period
- If the compliance deadline is missed or there is a shortfall, four allowances must be provided for every ton of emissions that was not covered in time
- The program includes mechanisms to prevent market manipulation
- ARB has a market monitoring group that coordinates with state and federal agencies on market oversight

3.3.4 U.K. Market

The United Kingdom Emissions Trading System (UK ETS) was the first national, multi-sector emissions trading program ever established. The purpose of the UK ETS was to introduce the concept of carbon pricing as na economic incentive for reducing carbon in the UK; the UK's intention was to apply – for greenhouse gases (GHGs) – a similar trading system that successfully reduced SO2 and NO2 emissions in the United States. The UK ETS formed as part of the November 2000 UK Climate Change Programme legislative package, which deployed three interlinked instruments, one of which was the UK ETS, for incentivizing emissions reductions.

The other two instruments were a Climate Change Levy (CCL), which was a tax on fossil fuel users, and the ability to discount the CCL through undertaking a sector-wide Climate Change Agreement (CCA). CCA's set collective, sectoral targets on energy efficiency, and covered entities that overachieve in fulfilling their obligations may access the carbon Market established through the UK ETS.

In April 2001, the emissions trading component of the Climate Change Programme came into effect.

The program intended to provide flexibility for firms to meet their emissions reductions targets, and at the same time establish London's financial markets as the primary location for environmental trading. Direct participants, totaling 34 firms, took on obligatory reduction targets in exchange for government subsidies. In addition, 6, 000 companies that have been part of CCAs have accessed the UK ETS.

The UK ETS was effectively replaced by the mandatory European Union Emissions Trading System (EU ETS), the world's largest carbon market for emissions reductions, in 2007. There was overlap between the UK ETS and the EU ETS during 2005 and 2006, but the UK ETS was voluntary while the EU ETS was mandatory, so the EU ETS took precedence. Direct participants exited the program in 2007, shifting the focus solely towards sectors which had entered into CCA's. The original CCA scheme, which was administered by the Department of Energy & Climate Change (DECC), ended in March 2013. In its place, the Environmental Agency has administered a new CCA scheme spanning April , 2013 through March , 2023.

The UK ETS was a critical incubator for the concept of using trading to lower the cost of reducing emissions, and it helped provide a testing ground to construct the necessary components for a functioning carbon market.

CAP/TARGET: The European Union (EU) negotiated a Kyoto Protocol (KP) commitment to reduce GHG emissions to 8% below the 1990 level by 2008-2012, and the UK's individual KP commitment was 12.5% below 1990 levels. In addition the British government set a unilateral policy goal of reducing emissions to 20% below United Kingdom 1990 levels by 2010. The UK ETS was established as a mechanism to assist UK efforts to achieve these targets. Subsequently, the UK Climate Change Act of 2008 put into statute a binding target for the UK to reduce its emissions by 2050 to 80% lower than in 1990.The UK ETS mandated absolute targets for firms directly covered by the program. However, a number of the CCAs, for which individual sectors constructed obligations based on negotiations with the government, set emissions intensity (tCO2/ unit of output)—not absolute—targets. As a result, these sectors could overachieve in fulfilling their intensity-based targets while their absolute emissions increased. If the excess permits generated from overachieving these intensity targets were sold to companies with absolute emissions targets, then overall emissions could in fact rise. To avoid this outcome, a one-way "traffic light" or valve system was introduced, closing the program to access if the net absolute carbon total would be increased by the transaction.

Scope/Coverage: 34 organizations and facilities agreed voluntarily to take part in the UK Emissions Trading System, undertaking emissions targets that averaged 12% below the baselines measured. This amounted to an aggregate emissions reduction of 12 million tons CO2-equivalent (CO2e) between 2002 and 2006, which is 0.43% of total UK emissions over this period.3 The firms came from across sectors – with bids from non-energy intensive sectors welcomed – rather than from within a single sector as had been the case with Denmark's pilot emissions trading scheme, which focused on the utilities sector only. The program covered emissions from six greenhouse gases, measured by their Global Warming Potential (GWP): Carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofleurocarbons (HFCs), perfleurocarbons (PFCs) and sulphur hexafleuride (SF6).

The Climate Change Agreements are more broadly representative of the UK economy than are the direct participants in the UK ETS. As of 2012, CCAs covered.

Auction Overview: Auctions in the UK ETS have been used to determine the targets undertaken by direct participants. The primary auctioning of targets was only open to direct participants and not those with CCAs, as their targets were pre-determined in the CCA. The government used a pioneering reverse-auction format that featured a descending clock mechanism. The government offered payments to participants to commit towards greenhouse gas emission reductions since, at the time, there was no legal requirement to reduce emissions. For the world's first auction for greenhouse gas reduction, in March 2002, the UK government offered incentive payments of GBP $215 million. The auctions were treated as a procurement auction, with the price descending through the duration of the auction. The government posted a price per unit of emissions reductions, and firms bid the quantity of emission reductions that they were prepared to make at that price. In each new round, a lower price was announced and bidders indicated the quantity of emission reductions that they were prepared to make at the lower price, until the market cleared at the point the budget was able to cover the cost of reductions being offered at the posted price.4 Annex 1 provides an overview for how the auction process occurred under the UK ETS.

Allowance Distribution: Direct participants in the UK ETS entered voluntarily in the auctions that determined their emissions reduction commitments, and they implicitly agreed to the price the government would pay them to secure those reductions. Firms that reduced their emissions below their targets were able to trade the excesso allowances in their compliance account to other firms. This provided additional financial incentive to go beyond their targets, with potential revenues above the government payments for securing an agreed reduction commitment.

Baselines were determined using emissions over the period 1998-2000. Allocation for each year was equal to the baseline emissions minus the annual contracted emissions reductions to which direct participants agreed as part of the auction process described above.

Up to date

The United Kingdom has put forward its own new UK-wide Emissions Trading System (ETS) to replace the European Union's system for trading carbon emissions, which Britain will leave at the end of this year as the Brexit transition period ends.

The UK-wide ETS, which will put a cost on carbon pollution to encourage polluters to reduce the greenhouse gases they emit, includes plans to cut the present emissions cap by 5%, Britain's Department for Business, Energy and Industrial Strategy said in a statement.

The United Kingdom has a target for net zero carbon emissions by 2050.

Emissions trading systems work by setting a cap on the total amount of greenhouse gases that can be emitted from certain sectors, with the cap being reduced over time so that total emissions fall.

After each year, every covered company must surrender enough carbon allowances – each representing tonnes of carbon dioxide – to cover all its emissions, or additional fines of up to £100 per allowance are imposed,

About one-third of UK emissions and nearly 1, 000 UK factories and plants are currently covered by the EU ETS and will continue to be covered by the UK system.

According to the government's draft plans, a minimum auction price would apply during the first phase of the new system, in order to reduce the chances of discrepancies between the new market and the EU ETS.

3.3.5 China Market

Since 2013, China worked on establishing a national carbon trading scheme that would dwarf the prominent EU emissions trading system (EU ETS) market. China is one of the world's largest carbon emitters, much of which is produced from the burning of coal. Although the country has emerged to become a global leader in the renewable energy space, its power sector remains reliant on coal. In 2019, coal accounted for 51.2% and 64.2% of the total capacity installed and power generated in China.

China's environmental policy has for many years encompassed ambitious plans to improve air quality and lower the dependence on coal. A key proponent for the establishment of a carbon market was the provisions laid out in the 12th Five Year plan (2011– 2015). Over the years, several pilot projects were developed and studied with the aim of establishing a national carbon trading market by the end of 2020.

China's greenhouse gas emissions are the highest in the world and are estimated to have risen by around 4% last year, halting several years where they flatlined. It burns more coal than the rest of the globe put together.

Alongside other policies to cut emissions, China has long had plans to create a national carbon market. First floated in the country's 12th Five-Year Plan in 2011, plans to roll out a nationwide scheme in 2017

In January 2016, a notice to industries set out the steps they should take to prepare for the national scheme. This notice was circulated by China's National Development and Reform Commission (NDRC), the state agency tasked with developing the ETS. Draft plans covering three sectors were then set out for consultation with industry and other government departments in May 2017.

On 19 December 2017, China released an initial framework for the first nationwide phase of the ETS, just inside the deadline set by the president's 2015 pledge. This was the first document with final approval by the state council, the country's chief administrative authority.

Initially set to cover more than 3bn tonnes of CO_2 from the power sector, the carbon market will be the largest in the world and close to double the size of the next largest, the EU ETS. Once operational, it will mean around a quarter of global CO_2 emissions are covered by carbon-pricing systems.

Initial Stages

The cornerstone for a nationwide carbon market was the creation of seven regional pilot programmes in 2013. In China, the National Development and Reform Commission (NDRC) is the incumbent government planning authority responsible for climate policy. The NDRC selected five major cities – Beijing, Chongqing, Shanghai, Shenzhen and Tianjin and two provinces Guangdong and Hubei, which have different economic structures and development levels, as part of their pilot programme. Each location covered the primary heavy industries of electricity and steam, petrochemicals, iron and steel, nonferrous metals, pulp and paper, glass and cement, but other industries were included that differed between the locations.

Shenzhen is a major financial and high-tech centre and it included commercial buildings and road transportation in its pilot programme, Shanghai included commercial buildings, railways, ports, airports and aviation, and Beijing included hotels, universities and medical facilities. The diversity among the programmes was to obtain useful information that could help establish a national trading programme for the whole of China and not just the more developed regions of the country. In 2017, the government initiated national rollout, which would take place in phases and be fully implemented by the end of 2020.

National rollout and market structure

A three-step process was outlined for the creation of the nationwide market. The first phase would focus on developing systems for data reporting, registration and trading. The second stage would focus on mock trading of carbon credits to test the effectiveness and reliability of the market. Spot trading would follow in the third and final step. Under the policy, the government gives or sells companies a limited number of carbon credits. Companies that produce less than their allotted emissions can sell the excess to other businesses.

Meanwhile, those that exceed their limits must buy surplus credits from other companies or typically face some kind of penalty. On 30 September 2019, 360 million tonnes of credits have been traded since the markets began with a total value of CNY7.8bn. The nationwide ETS aims to cover eight billion tonnes of carbon dioxide emission a year from approximately 100, 000 industrial plants when the trading scheme is fully launched.

Economic headwinds: Prior to the outbreak, the economy in China suffered as a consequence of a trade war with the US and weakening consumer demand. Now, with the country's economy reeling under the influence of the coronavirus outbreak, the economy is likely to slow down even further. According to the International Monetary Fund (IMF), China is one of the few economies expected to grow in 2020 by 1.2%, which is a sharp drop in economic performance from previous years. Moreover, with global trade expected to slow, China's industrial sector is set for a lean period in the short term. Historically, the growth of China, as an industrial superpower was fuelled largely by state spending and similar support is expected to revive the industrial sector and achieve President Xi Jinping's goal of doubling per capita gross domestic product (GDP) in 2020 from 2010. Much of the spending is facilitated by local provincial governments with the central government supervising proceeding. Provinces such as Beijing, Shanghai, Fujian and Anhui have ratified several infrastructure projects and will accelerate projects under construction i Increased activity is likely to raise the carbon intensity of the respective sectors and, consequently, push back the integration of non- power carbon-intensive sectors into the national carbon market in the short term, delaying the establishment of a comprehensive national market.

Changes in industrial regulations: The government has established several industrial-friendly measures such as relaxing environmental rules for industries and lowering credit costs to spur activity revival. According to the environment ministry, deadlines for companies to meet environmental standards have been extended and some companies have been exempted from on-site checks. Short-term need to shore up the economy could see emission control priorities take a back seat, impacting the pace and timing of the market rollout.

Slowdown in compliance: The MEE's objective for 2020 was to establish spot trading and regulations, covering market allocation, emissions data reporting and data verification. The process to finalise institutional regulations, activate market trading and establish supervisory mechanisms have been affected by the coronavirus epidemic. Earlier in the year, the central government has already ordered companies from eight industrial sectors – oil, chemicals, construction materials, steel, nonferrous metals, papermaking, electric power and shipping to submit their carbon emission data before the end of March, in preparation for the ETS launch. This, in turn, has restricted officials from carrying out their verification process as part of the third phase objectives. In April, the province of Guangdong has pushed back its annual compliance deadline for companies by two months in its emissions trading scheme, giving companies more time to finalise their 2019 data verification. Other pilot markets such as Beijing, Fujian, Shanghai and Shenzhen had already delayed their annual compliance deadlines.

The national carbon market in China could potentially become the largest carbon market in the world and could significantly drive down emissions in the country. Although several institutional delays were witnessed during the implementation phase, *How will China's carbon market work?*

Carbon markets aim to provide incentives for polluters to reduce emissions by allowing firms to trade the right to emit. In the EU and California, this has involved putting an absolute cap on emissions, which is reduced over time.

However, China has generally resisted setting absolute emission caps in its climate pledges, instead opting for intensity-based targets to cut emissions per unit of GDP. While the precise methodology for the cap-setting in China's national carbon market has not yet been released, government sources have indicated it will take a similar approach.

Therefore, it appears China will use a rate-based limit for its ETS. This would see a limit put on the amount of CO2 allowed per unit of output. Each power company would be allocated a certain number of credits, depending on how much electricity it produces. If it emitted less than this set quota, it could then sell that surplus to another firm.

This would reward firms for producing less emissions per unit of output, rather than less emissions overall, which could help alleviate political worry about constraining economic growth. But it would mean that even if power producers become more efficient, emissions could in theory still rise, if power production increases overall.

Who will pay for emissions?

In an initial "simulated" trading period of the ETS, companies will be issued free emissions permits. Under the plan's loose timeline, auctions for permits would begin around 2020.

Once payments begin in the power sector, it is companies that would foot the bill, not consumers. This is because power prices are set by government regulators in China.

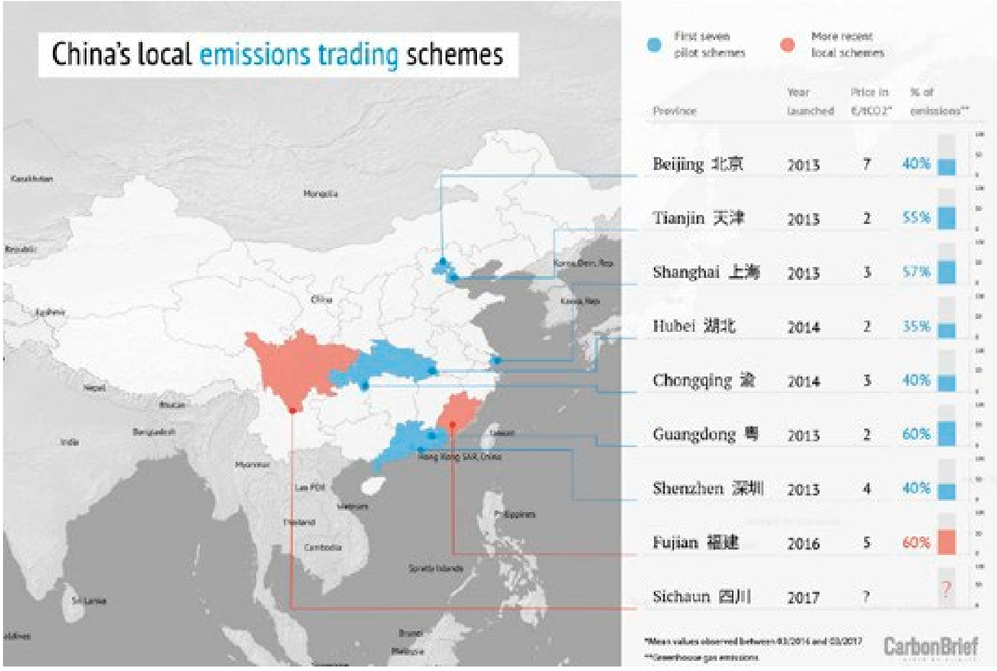
However, a process to reform electricity pricing in China, already underway for several years, could allow the carbon price to be passed on to consumers in future. Dupuy tells Carbon Brief:

"There's still quite a way to go before we can say that the power sector's been reformed and transformed to a model where the true costs, including emissions costs, are really flowing through to end users."

Prices for other industries are set by the market rather than government regulation, so once the ETS expands outside the power sector, it could have an impact on consumers.

China launched regional pilot carbon trading projects in four cities, two provinces and the special economic zone of Shenzhen during 2013 and 2014. Two more local schemes were launched in 2016 and 2017 in Fujian, a southeastern Chinese province near Taiwan, and Sichuan in southwest China, although these are not usually counted as pilot schemes.

The locations of these nine local schemes are shown in the map below.



Location of China's seven pilot local emissions trading projects, set up in 2013 and 2014, and two more recent local schemes, set up in 2016 and 2017. ETS prices are mean values observed between March 2016 and March 2017. Percentages are of total greenhouse gas emissions for the region. Infographic by Rosamund Pearce for Carbon Brief. Data source: I4CE Global panorama of carbon prices in 2017.

When will the ETS start?

The government plan released in December is hazy about the exact timeline for the rollout of the ETS. Instead, it sets out the next few stages of implementation and makes clear that any and all parts of this plan could be adjusted.

In the first stage, over the next year or so, China will focus on the basic infrastructure of the scheme: setting up emissions monitoring, reporting and verification systems, alongside the administrative aspects of the trading system. Companies will be required to monitor and report their emissions to the NDRC and other relevant local regulators.

Power companies will start to receive ETS allowances in this time and the legal basis for the ETS is also likely to be strengthened, according to Energy Foundation China.

The second step will be a year-long "simulated" trial of the market, the plan says, expected to start in 2019. This will see free credits allocated to companies with mock trading, but with no money changing hands. It aims to test and develop the reliability, market risks and management of the trading platform, the plan says.

3.3.6 Voluntary Market

The volume of transactions in voluntary carbon markets hit a seven-year high in 2018, according to "Financing Emissions Reductions for the Future: The State of the Voluntary Carbon Markets 2019, " a new report released today.

The report identifies transactions equivalent to 98.4 million metric tons of carbon dioxide (MtCO2e), with a market value of $295.7 million. This represents a 52.6% increase in volume and a 48.5% increase in value over 2016.

The increase was led by a growing awareness of "nature-based solutions" for climate resilience, which drove a 264% increase in volume of offsets generated through Forestry and Land Use activities and made REDD+ the most popular offset type for the first time since 2015.

This surge in volume continued to accelerate in 2019, according to market experts.

3.3.7 Types of offset projects

The types of carbon offset projects that are implemented are diverse. They range from forestry sequestration projects (in which carbon credits are gained for the CO2 removed from the atmosphere when trees grow) to energy efficiency and renewable ene his set of infosheets focuses on forestry and bioenergy carbon offset projects.

This is because these project types are more abundant than other rural offset project types. Certain types of forestry, biomass energy and methane avoidance projects are also commonly associated with providing benefits to the rural poor compared to other types of offset projects. The reasons for this include:

- These technologies can be implemented by poor people themselves as they are simple and have lower costs;
- These activities directly tackle some of the main sources of emissions of the rural poor, namely deforestation relating to energy production and emissions from agricultural activities such as manure production and burning of agricultural residues; projects (which prevent CO2 emissions into the atmosphere).
- Sequestration activities (where carbon is removed from the atmosphere), particularly through tree planting, do not rely on emissions being avoided, and are therefore also suitable in cases where there are few emissions in the first place. Tree planting is also applicable in rural areas, for obvious reasons.

3.4 Accounting for and verifying reductions

The Verified Carbon Standard (VCS) is one of the leading standards for voluntary carbon offsetting.

It provides a credible but simple set of criteria that will provide integrity to the voluntary carbon market. The VCS will ensure that all project-based voluntary emission reductions that are independently verified to meet its criteria – defined as Voluntary Carbon Units (VCUs) – represent real, quantifiable, additional and permanent project-based emission reductions:

- VCS ensures a project will deliver contracted emissions reductions
- VCS ensures additionality
- VCS prevents double counting
- VCS prevents leakage effects

The VCS has created registries which are used to register, transfer and retire VCU's from the market and therefore prevent double counting.

There are 10 minimum threshold criteria which the emission reduction project must satisfy in order for its reductions to meet the Verified Carbon Standard and be verified and registered.

3.4.1 Criteria for quality offsets

When people talk about the "quality" of a carbon offset credit, they are referring to the level of confidence one can have that the use of the credit will fulfill this basic principle.

The concept sounds straightforward, but it is challenging to guarantee in practice. Quality has two main components. First and foremost, a quality offset credit must represent at least one metric tonne of additional, permanent, and otherwise unclaimed CO2 emission reductions or removals. Second, a quality offset credit should come from activities that do not significantly contribute to social or environmental harms.

The essential elements of carbon offset quality down to five criteria. In short, quality carbon offset credits must be associated with GHG reductions or removals that are:

- Additional
- Not overestimated
- Permanent
- Not claimed by another entity
- Not associated with significant social or environmental harms

3.4.2 Co-benefits

The multiple criteria involved – plus the fact that critical criteria like "additionality" are a matter of confidence rather than absolute truth (see below) – means that quality exists along a continuum. Carbon offset programs, by contrast, are forced to make a binary decision: do they issue an offset credit or not? Most carbon offset programs will say that every credit they issue is equally valid, but buyers should feel justified in questioning this assertion. Think of scoring the quality of an offset on a 100-point scale. A carbon offset program may decide to issue credits for every GHG reduction that exceeds a score of 50. But as a buyer, is a score of 51 really "good enough"?

3.5 Quality assurance schemes

3.5.1 Quality Assurance Standard for Carbon Offsetting

The central idea behind a carbon offset is that it can substitute for GHG emission reductions that an organization would have made on its own. For this to be true, the world must be at least as well off when you use a carbon offset credit as it would have been if you had reduced your own carbon footprint.

When people talk about the "quality" of a carbon offset credit, they are referring to the level of confidence one can have that the use of the credit will fulfil this basic principle.

This concept- frequently referred to as preserving "environmental integrity"- sounds straightforward, but it is challenging to guarantee in practice. Quality has two main components.

First and foremost, a quality offset credit must represent at least one metric tonne of additional, permanent, and otherwise unclaimed CO2 emission reductions or removals. Second, a quality offset credit should come from activities that do not significantly contribute to social or environmental harms.

A variety of terms are frequently used to define quality criteria for carbon offsets, including that associated GHG reductions must be "real, " "quantifiable, " and "verifiable." Most of these terms have their origin in regulatory criteria established for air pollutant credits under the U.S. Clean Air Act (going back to 1977). However, these terms have distinct regulatory meanings under U.S. law that do not always translate meaningfully to carbon offsets. The term "real, " for example, has no commonly agreed definition across carbon offset programs and standards, and is often used as a vague catch-all. 23For this guide, therefore, we have distilled the essential elements of carbon offset quality down to five criteria. In short, quality carbon offset credits must be associated with GHG reductions or removals that are:

- Additional
- Not overestimated
- Permanent

Not claimed by another entity• Not associated with significant social or environmental harmsCarbon offset programs were created with the intention of ensuring the quality of carbon offset credits.

In the remainder of this section, we describe the approaches carbon offset programs use to address the quality criteria listed above. Many observers believe that carbon offset programs have a mixed track record. Part of the challenge is that offset quality is not black and white.

The multiple criteria involved – plus the fact that critical criteria like "additionality" are a matter of confidence rather than absolute truth – means that quality exists along a continuum. Carbon offset programs, by contrast, are forced to make a binary decision: do they issue an offset credit or not? Most carbon offset programs will say that every credit they issue is equally valid, but buyers should feel justified in questioning this assertion. Think of scoring the quality of an offset on a 100-point scale. A carbon offset program may decide to issue credits for every GHG reduction that exceeds a score of 50. But as a buyer, is a score of 51 really "good enough".

Astute buyers will understand this difficulty and actively seek out higher quality offset credits. For each offset quality criterion.

That buyers can ask about specific offset projects to better ascertain their relative quality. Even for sophisticated buyers, however, getting detailed answers to these questions may be difficult.

3.6 Conclusion

Due to the exposed carbon credit market, it is an alternative for companies that seek to offset their impacts in terms of emissions, with the help of the projects that generate these credits. A cycle that generates significant socioenvironmental benefits, especially for developing countries and as we demonstrate the greater the socio-environmental benefits of the projects, they will have lower transaction risks and, consequently, higher pricing in the market.

Brazil is today, without a doubt, one of the biggest bets for this carbon market:

Paris Agreement

The Paris Agreement, at COP 21, was signed by 195 nations that now need alternatives to meet their goals. Many of these alternatives involve replacing fossil fuels with clean energy.

Environmental services

Brazil has the advantage of having, in addition to clean fuel options, also forests, which remove carbon. Most countries have neither, and may need to buy carbon credits from Brazil. Brazil has the chance to enter everything in this market by offering environmental services.

Regulation

The government has already started a process of studying the domestic carbon market and Brazil has great chances of leading the regulation of this service, which today basically works as a voluntary market. If the country is committed to public policies in this sense.

Much is discussed about the legal nature of Certified Reductions, but few conclusions are reached given their complexity, and the need to create security for investors interested in such negotiations. The difficulty is due to its nature that oscillates between intangible goods of economic value with the nature of commodities or securities.

As for being intangible assets, it is important to turn to civilist definitions, characterizing as well everything that necessarily represents something that has economic value and that are subject to legal appropriation by man. While intangibles do not have their physical materiality, they are not subject to the perception of beings on the material plane, and according to the best doctrine they do not have their tangible existence, however they continue to be of paramount importance to the legal world since they entail rights whether it is linked to the intellect, personal relationship or economic value, such as credits.

What needs to be observed at this moment, and will be discussed again at a later opportunity, is that tangible or tangible assets as found in the doctrine are susceptible to purchase and sale while intangible or intangible assets are not suitable for this form of transaction, but rather the assignment, and cannot be the subject of adverse possession or transfer by tradition. This is easily understood by the necessary relationship that is made between the physical non-existence of the good, there is no way to make a purchase and sale if your object does not have a physical or palpable existence, being averse to factual reality. Not to mention the notorious fact that it is about credit or the right to credit that is not simply negotiated through buying and selling.

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4 Overview of Policies and Institutional Frameworks on GHG Emissions in EU, China, Africa, with Special Reference to the Role of Agriculture

Konstantinos Karantininis[1]

4.1 Introduction

In this report we deal with the policies and institutional framework of GHG emissions in the EU, China and Africa with special reference to the role of agriculture.

The key **premise** is a fundamental one for the future of humanity**.** If humans double atmospheric carbon dioxide (CO2) from pre-industrial levels, the planet will eventually warm between 2.6°C and 3.9°C (Sherwood, et. al., 2020). Humanity has already emitted enough CO2 to be halfway to the doubling point of 560 ppm (parts per million), and many emissions scenarios have the planet reaching that threshold by 2060.

Carbon pricing can play a key role in the urgent efforts needed to accelerate the transition toward a low-carbon, climate-resilient future and increase the current level of ambition. Currently there are 57 implemented or scheduled for implementation pricing initiatives around the world (WB, 2019). A shown in Figure 4.1., 46 of these are national, and 28 subnational. These initiatives cover 11 GtCO2e emissions, or 20% of total. The prices range from US$1/t CO2e to US$127/t CO2e. Approximately 57% of the prices are below US$10/t CO2e (WB, 2019).

Climate change (CC) is a global problem, which requires global action. The global policy framework comprises the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol and the Paris Agreement. The EU and all

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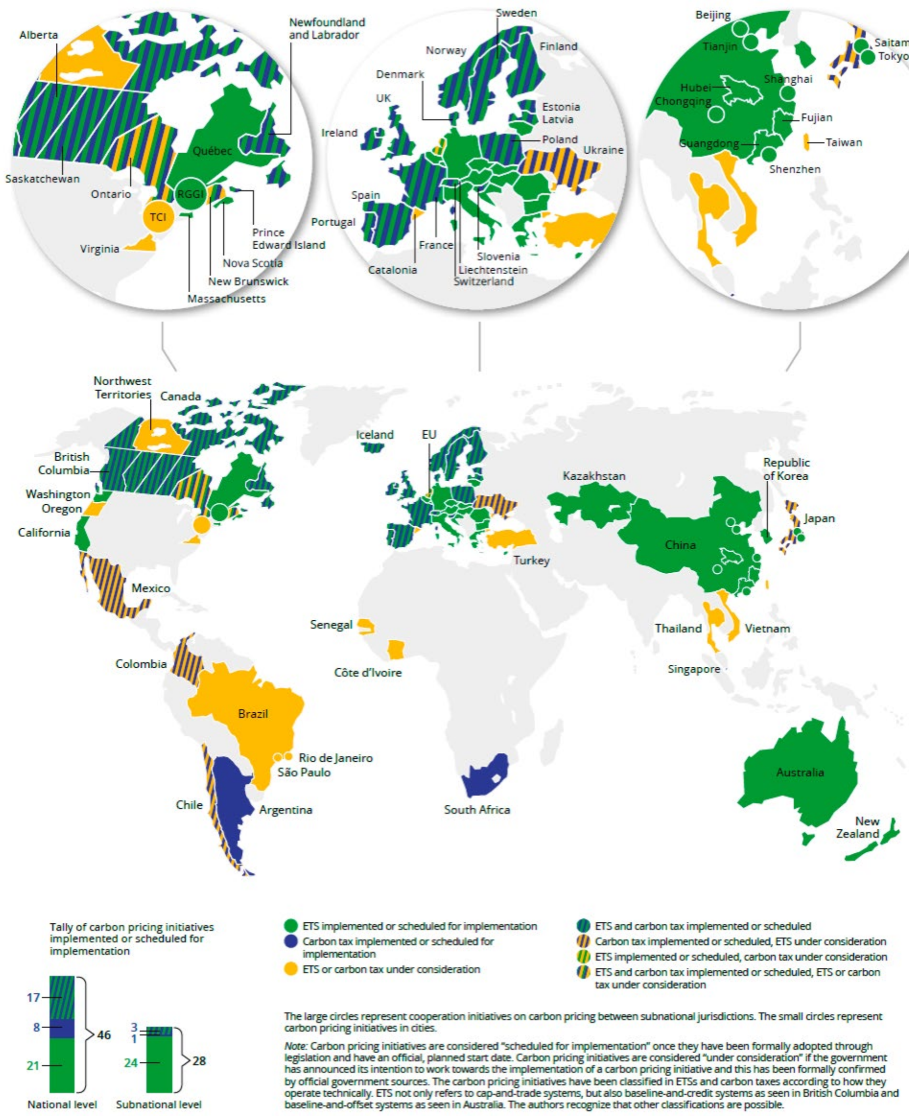
EEA member countries have ratified these international treaties, and they are jointly responsible for their implementation.

The EU as a whole and its individual member-states are key participants in the international effort to combat CC and have signed all the relevant international agreements. The EU was the first region to implemented an emissions trading system (ETS), and still is the largest regional ETS in the world.

Figure 4.1. Summary map of regional, national and subnational carbon pricing initiatives implemented, scheduled for implementation and under consideration (ETS and carbon tax)



Source: WB (2019)

The EU countries employ both mitigation and adaptation strategies. Yet the EU, as most of the world lies behind its targets and commitments to reduce GHG emissions to the 2030 levels. Only 3 (out of 27) have so far met their commitments.

China, one of the world's largest contributors on GHG emissions, has only recently launched a national ETS whereas this country has been running eight pilot ETS schemes. China's performance on CC is evaluated as poor, however China pioneers the world on alternative energy production.

Africa, on the other hand, is going to be affected strongly by CC. Yet, as a continent has very low contribution of industrial GHGs. However, Africa as a whole contributes much on emissions by ***LULUCF*** *(Land Use, Land Use Change and Forestry).*

While agriculture is not part of ETS around the world (with very few exceptions), there is increasing recognition that agriculture can contribute with "negative emissions", i.e. by sinking carbon. Several private negative emissions schemes are discussed here.

4.2 EU Climate Action

The EU and all EEA member countries (EU-27 plus Norway, Iceland, Switzerland, and UK) have signed and ratified the international treaties that comprise the global policy framework:

UNFCC (1992). The United Nations Framework Convention on Climate Change

The **Kyoto** Protocol (1997), and The **Paris Agreement** (2015). The central aim of the Paris Agreement is to keep the rise in global temperature well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C. These global temperature targets correspond directly to remaining carbon budgets, i.e. to the amount of greenhouse gases that human activities can emit without exceeding a given level of warming.

These 31 countries formed the European Environmental Agency (EEA) together with an additional 8 countries (Albania, Liechtenstain, Turkey, Kosovo, Bosnia and Herzegovina, Montenegro, North Macedonia, Serbia).

EU climate action relies on three instrumental strategies:

a. ETS. the EU Emissions Trading System (ETS), a 'cap and trade' mechanism for GHG emissions from nearly 11 000 installations (factories, power stations, etc.) across the EU

b. ESR. the Effort Sharing Regulation, which sets binding annual targets for reducing GHG emissions for 2030 for each Member State in sectors not covered by the ETS (e.g. road transport, waste, agriculture and buildings),

c. LULUCF (Land Use, Land Use Change and Forestry) Regulation committing Member States to ensure that GHG emissions from LULUCF are offset by at least an equivalent removal of CO_2 from the atmosphere in the period 2021-2030.

These commitments are to be considered within the broader perspective of the Energy Union Strategy (EC, 2015b), which addresses environmental and climate dimensions along with issues of security, affordability, market integration, and research, innovation and competitiveness.

The Regulation on the Governance of the Energy Union and Climate Action establishes a unique framework for cooperation between Member States and the EU. It is building on integrated national energy and climate plans, EU and national long-term strategies, and integrated reporting, monitoring and data publication. The online European Climate Adaptation Platform, Climate- ADAPT, plays a central role in improving informed decision-making for climate change adaptation across Europe (EEA and EC, 2019).

4.2.1 EU Mitigation and Adaptation Strategies

Like all countries who signed the Kyoto Protocol and Paris agreement, The EU follows two strands of policies to limit the adversities of climate change (CC): Mitigation and Adaptation. **Mitigation** refers to reducing the emissions of GHGs and increasing their sink. **Adaptation** to climate change refers to policies that make adjustments to minimize the adverse impacts of CC.

Both policies, adaptation and mitigation, can be facilitated by targeted financing. Mitigation and adaptation are both necessary to limit the risks related to climate change. However, the measures and policies are rather different. Adaptation to climate change involves making adjustments to minimise the adverse impacts of climate change or to exploit any opportunities that may arise. Adaptation comprises a wide range of measures, including 'grey adaptation' (e.g. building coastal protection infrastructure in response to rising sea levels), 'green and green-blue adaptation' (e.g. planting trees in cities to reduce the urban heat island effect) and 'soft adaptation' (e.g. improving emergency management to deal with natural disasters). (EEA, 2019, p. 155)

4.2.1.a Mitigation

Mitigation of climate change means reducing the emissions of greenhouse gases and enhancing their sinks. Mitigation of climate change has a quantitative target that was agreed at the global level and is delivered through a set of climate and energy policies with specific targets and objectives for 2020, 2030 and 2050.

The EU has implemented many legislative acts aiming to reduce the emissions of the most important greenhouse gases and to enhance their sinks. The EU's domestic climate legislation has two features:

a. it has the key objective of delivering on the international commitments agreed by heads of state.

b. there exists an internal consistency between the quantified efforts required by Member States and the agreed international objectives binding the EU Member States and the EU as a whole. Specifically, with regard to the provision and use of energy, renewable energy and energy efficiency targets and objectives for 2020 and 2030 were included as headline targets in the Energy Union strategy, along with minimum targets for electricity interconnection (10 % by 2020 and 15 % by 2030), and flanked by objectives in other dimensions. The Energy Union and Climate Action Regulation of 2018 sets out the legislative foundation that is meant to deliver a reliable, inclusive, cost-efficient, transparent and predictable governance of the Energy Union and climate action, for the purpose of ensuring that the 2030 and long-term objectives and targets of the Energy Union, in line with the 2015 Paris Agreement, are achieved.

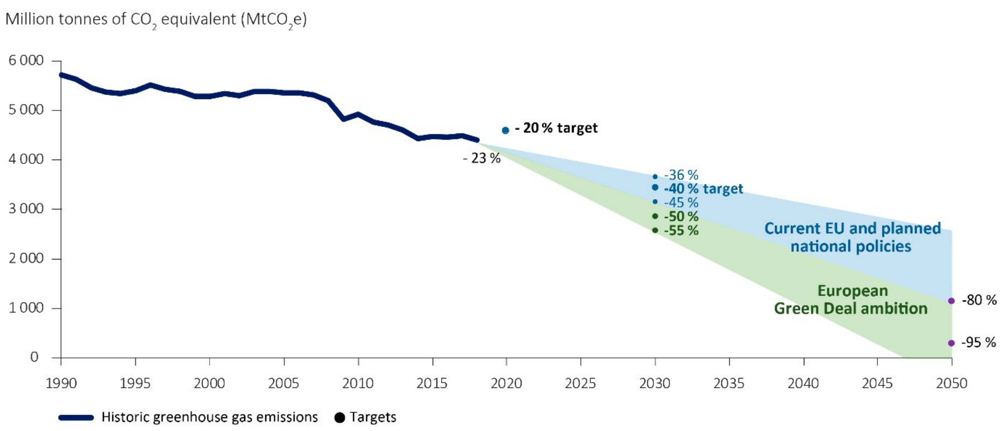
4.2.1.b Adaptation

In contrast to mitigation, there is no single metric for measuring the success of adaptation to climate change. As a result, the policy targets for adaptation at the global and European levels are less quantifiable, and most monitoring activities so far focus on the adaptation process rather than on quantitative outcomes. In addition to the adaptation policies and targets, climate change adaptation also requires 'mainstreaming' — or making part of everyday practice — in many other EU policies addressing climate-sensitive issues. Of particular relevance are policies for disaster risk reduction (e.g. EU Civil Protection Mechanism, EU action plan on the Sendai Framework for Disaster Risk Reduction), the common agricultural policy (CAP), the common fisheries policy, the Floods Directive, the Water Framework Directive, the forest policy, the nature directives, and policies related to public health.

The EU mitigation and adaptation actions are facilitated by a suitable policy framework, earmarked financial resources, and targeted information and knowledge. There are quantified targets for climate change finance at the global and the European levels. Interestingly, none of these targets distinguishes between mitigation and adaptation. Further support for adaptation measures in Europe is provided by, among others, the Copernicus Climate Change Service (C3S) and dedicated research projects (e.g. under Horizon 2020 and JPI Climate).

The EU targets are shown below in Figure 4.2.

Figure 4.2 GHG emission trends and projections in the EU-28, 1990-2050



Source: EEA, 2019

4.2.2 EU climate change performance

On average, EU Member States' past efforts delivered emissions reductions in the order of 46 Mt CO2e per year, or 23% in total between 1990 and 2017. Since 2005, average reductions have risen to 73 Mt CO2e per year. To achieve an overall 40% reduction by 2030, this annual reduction will need to be 81 Mt CO2e per year, on average, from 2017 until the target year of 2030 (Figure 4.2).

The reduction was due to the combined result of policies and measures and economic factors. The carbon and energy intensity of the EU economy is lower now than it was in 1990 because of improvements in energy efficiency and the use of less carbon-intensive fuels, especially renewable energy sources. Transport remains one of the biggest challenges ahead to decarbonising the economy.

Preliminary data from Member States indicate that the EU's total emissions decreased by 2.0% in 2018, bringing the total reductions to 23.2% below 1990 levels (EEA, 2019).

4.2.2.a EU 2030 targets

The 2030 targets for GHG emissions, renewable energy and energy efficiency are: •

1. A binding target of at least a 40 % reduction in the EU's domestic GHG emissions (compared with 1990 levels). A binding emission cap is set for the sectors covered by the EU ETS (EU, 2018b) and binding annual minimum targets for reducing GHG emissions from 2021 to 2030 are set for EU Member States for the sectors not covered by the EU ETS (EU, 2018g). Furthermore, the Land use,

land use change and forestry (LULUCF) Regulation stipulates that 'EU Member States have to ensure that GHG emissions from land use, land use change or forestry are offset by at least an equivalent removal of CO2 from the atmosphere in the period 2021 to 2030'.

2. A binding target to increase the share of energy from renewable sources in the EU to at least 32 % of gross final energy consumption by 2030, including an upwards revision clause by 2023, set in the Renewable Energy Directive.
3. A target of at least a 32.5 % improvement in energy efficiency by 2030 at EU level (compared with the Commission's 2007 energy baseline scenario), with a clause for an upwards revision by 2023, set in the Energy Efficiency Directive.

Several legislative acts renewing or amending the climate and energy policy framework have recently been adopted to achieve the EU's 2030 targets. These include a reform of the EU Emissions Trading System (ETS) to include a more stringent cap reduction after 2020 as well as new, binding annual GHG emission targets for Member States for the period 2021-2030. The latter include emissions that are not covered by the EU ETS (Effort Sharing between Member States), as well as new flexibilities to achieve these targets. Furthermore, the LULUCF Regulation now in place integrates the land use, land use change and forestry (LULUCF) sector into the EU 2030 climate and energy framework and defines new accounting rules for 2012-2030 in these areas.

However, Member States' projections are not yet in line with the target for 2030 of at least a 40 % reduction in GHG emissions. According to the EEA analysis, Member States' current policies can deliver only a 30 % reduction by 2030, while implementing all reported planned policies could bring the total reduction to 36 %.

Based on 2019 reports to the EEA, only **Greece, Portugal and Sweden** expect to reach their 2030 Effort Sharing targets on time with current policies and measures in place. Seven other Member States (Belgium, Croatia, France, Hungary, Italy, Slovakia and Spain) project to achieve their targets with additional policies for 2030 (Figure 4.3).

The EU target of reducing its GHGE by 20 % by 2020, compared with 1990 levels appears to be within reach and EU legislation to meet the 2030 GHG target has been adopted. However, aggregated projections from Member States are not yet in line with the minimum required 40 % reduction target. Together, Member States project that current policies and measures can deliver a 30 % – not 40% – reduction by 2030, while the reported additional policies and measures they intend to launch in the coming years can deliver a 36 % reduction by 2030. While this presents a more positive outlook compared with last year's projections, meeting the 2030 target will demand further efforts (EEA).

Most of the projected reductions until 2030 are expected to occur in the power sector, whereas emissions from other industrial activities are envisaged to remain stable during this period. The emissions from international aviation, which almost doubled between 1990 and 2017, are expected to increase further by 2030.

Member States' most recent projections indicate that total emissions reductions would bring the EU ETS to within 1.3 percentage points of its legislated contribution of a 43 % reduction by 2030, compared with 2005.

Within the sectors covered by the **Effort Sharing Regulation (ESR)**, which establishes annual binding targets until 2030 at Member State level, emissions have fallen at a slower rate than among the ETS sectors. After a period of steady decline, Effort Sharing emissions began to increase in 2014 — a trend that continued until 2017. The most recent data indicate that total Effort Sharing emissions fell again in 2018, by 0.9 % from the previous year.

Figure 4.3. Projected progress of Member States towards 2030 climate targets.

Source: EEA, 2019

4.2.2.b Emissions Trading System

Emissions from activities included in the EU ETS are governed by the EU ETS legislation and subject to an EU-wide cap on emissions. Emissions from large stationary installations, mostly from power and heat production and industrial installations, are covered by the EU ETS (EU, 2003). These currently represent about 40 % of EU GHG emissions, of which a large proportion stem from the power generation sector. Other activities covered by the EU ETS include cement production, iron and steel production, and oil refining. Since 2012, the EU ETS has also covered GHG emissions from aviation

The EU ETS mainly covers CO2 emissions, but it also includes emissions of nitrous oxide (N2O) and perfluorocarbons (PFCs). With these selected emission sources, the system covers sectors and gases that can be measured, reported and verified with a high level of accuracy. The mitigation of ETS emissions is being addressed at EU level through a single ETS-wide emission cap and a 'carbon market' through which emission allowances can be traded. The EU ETS specific targets were set to reduce emissions by 21 % between 2005 and 2020 and by 43 % by 2030 compared with 2005 levels. These EU ETS specific targets were set in line with the EU's overall emission reduction targets of 20 % by 2020 and 40 % by 2030. The most recent inventories and ETS data demonstrate that GHG emissions from the sectors covered by the EU ETS have decreased significantly since 1990 (Figure 4.4). In 2018, EU ETS emissions from EU Member States' stationary installations had already fallen by 29 % since 2005.

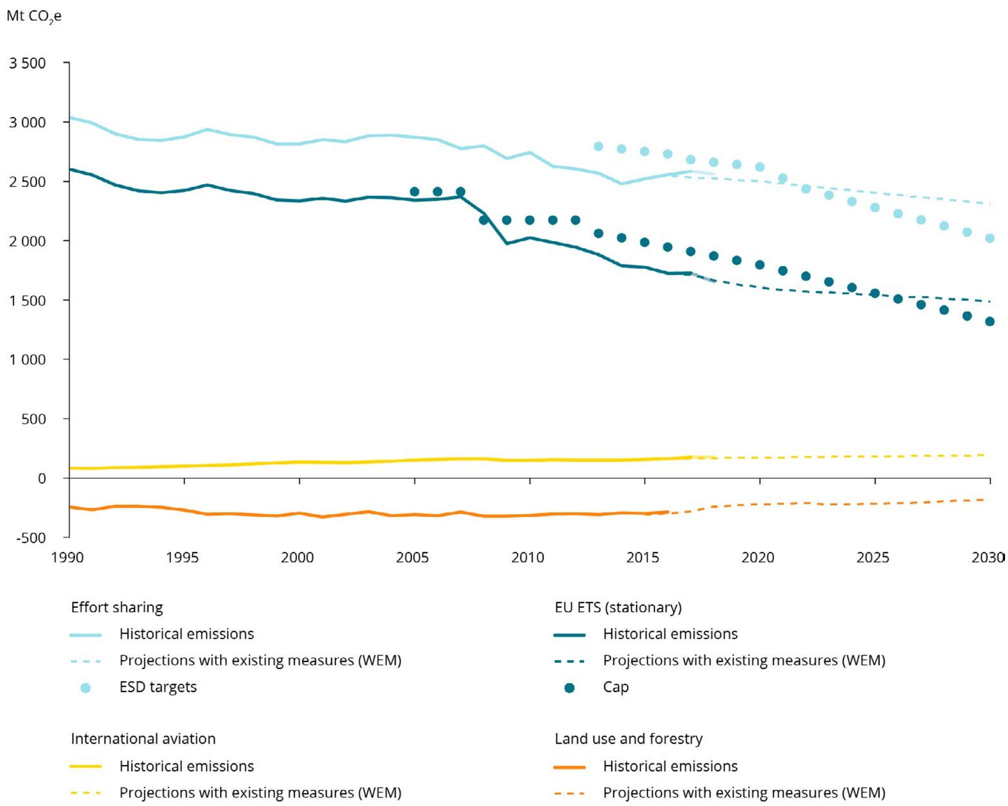
The substantial reductions in ETS emissions since 2005 have been largely driven by reductions in emissions related to power generation. The reduction in emissions was largely the result of changes in the combination of fuels used to produce heat and electricity. In particular, the combination of fuels entailed a decrease in the use of hard coal and lignite fuels, better and more efficient installations, and a substantial increase in electricity generation from renewables, which almost doubled over the period. In addition, reduced production volumes of electricity and heat led to reductions in emissions in that sector. Emissions from other industrial activities covered by the EU ETS have also decreased since 2005. Lower levels of output following the economic recession in 2008 led to reductions in emissions in the second trading period, accompanied by improvements in energy efficiency and increased use of biomass and waste as energy sources in production. Since 2016, emissions have increased alongside improvements in economic conditions and output (Figure 4.4).

According to the projections submitted by Member States in 2019 under the Monitoring Mechanism Regulation (MMR), future cuts in national GHG emissions will mainly take place under the EU ETS. With existing measures in place at the time of the calculation of GHG projections, emissions from stationary installations under the EU ETS are projected to decrease by a further 174 Mt CO2e (10 %) between 2018 and 2030. According to scenarios that consider planned measures, total reductions of 287 Mt CO2e (14 %) are projected between 2018 and 2030.

National MMR projections based on the 'with additional measures' scenario show that the EU ETS emissions could total 1 364 Mt CO2e in 2030. This would be 1.3 percentage points higher than the EU ETS specific target of -43 % for 2030 (in comparison with 2005).

Most of the projected ETS reductions up until 2030 are expected to occur in the energy industries sector, whereas emissions from other activities are envisaged to remain stable during this period. The emissions from international aviation, however, nearly doubled between 1990 and 2017 and are expected to increase further by 2030. In April 2018, important reforms to the ETS entered into force. They establish the rules for the fourth trading period (2021-2030) and include the strengthening of the market stability reserve (MSR). National projections submitted in 2019 reflect national measures in the ETS sectors but do not usually include the effects of these reforms yet. Total EU ETS emissions in 2030 are 3 % higher compared with projections with existing measures submitted earlier and at the same level compared with the most recent projections with additional measures.

Figure 4.4. Effort Sharing, ETS, LULUCF and aviation emission trends and projections in the EU, 1990-2030.



Source: EEA 2019

4.2.2.c LULUCF

Currently, LULUCF represents a net carbon sink at EU level. GHG emissions and removals through LULUCF, which are partly accounted for to assess Member States' compliance with their Kyoto Protocol targets, are not included in the EU's 2020 climate targets. With the rules set in the new LULUCF Regulation (EU, 2018f) and the new ESR (EU, 2018g), this sector will be integrated into the EU 2030 climate and energy framework from 2021 onwards.

The LULUCF Regulation defines harmonised EU-wide accounting rules to measure anthropogenic influence on emissions and removals in the sector. Starting in 2021, national 'no-debit' commitments will be in place with increasing importance related to accounting for reductions in emissions. The ESR establishes limited flexibility for net accounted removals from the LULUCF sector that can be used under certain circumstances to meet Member States' targets. Greater reductions in emissions under the Effort Sharing sectors can also be used to comply with the need to account properly for anthropogenic emissions and removals within the LULUCF sector.

Carbon stock changes in the LULUCF sector take place on managed land and are the result of human interventions that impact the carbon stored in three main terrestrial pools (i.e. living biomass, dead organic matter and soils). Carbon stock changes can result in both emissions of GHGs (source) or removals of CO2 (sink), in the form of terrestrial carbon sequestration.CO2 emissions and removals on agricultural land are attributed to the LULUCF sector and not to the agricultural sector.

In 2017, the EU's LULUCF sector presented a net reported carbon sink of about 258 Mt CO2e. Most EU Member States report a net carbon sink from LULUCF, with the exception of Denmark, Ireland, Malta, the Netherlands and Portugal. Iceland and Liechtenstein also report net emissions from this sector. It is important to note that the LULUCF sector is accounted for as a net aggregate of reported sinks and sources neither for the Kyoto Protocol nor for the LULUCF Regulation.

Although it is a net emission sink, the sector was also a net emission source of CO2 emissions for some land use subcategories, as illustrated in Figure 4.5.

The largest sources are represented by the conversion of forests (i.e. deforestation) to other forms of land use that take up lower levels of GHGs and by organic soils, especially when they are subject to agricultural activities that enhance carbon oxidation. Moreover, natural disturbances such as fires or windthrow play important roles in the overall carbon budget of this sector and its interannual variability.

The main component of the overall carbon sink reported in the LULUCF sector comes from forest land (363 Mt CO2e in 2017), which largely offsets the emissions reported under the other land use categories (see previous Figure). The managed forest land sink is mainly driven by the balance between forest harvest (extraction of carbon from the forest, which is reported as returning to the atmosphere) and forest increment (accumulation of carbon in forest biomass as a result of tree growth, which is reported as an increase in carbon stock) rates.

4.2.2.d Effort Sharing legislation

The Effort Sharing legislation covers emissions that are neither covered under the EU ETS nor related to the LULUCF sector. These emissions are produced by a diverse range of sectors and activities, including road transport, energy consumption in buildings, **agriculture (animals and soils)**, smaller industrial installations, smaller energy generation facilities and waste management. This represents altogether about 58 % of total EU GHG emissions. The legislation sets annual emission trajectories for each Member State for the periods 2013-2020 (ESD) and 2021-2030 (Effort Sharing Regulation, ESR). These are translated into national annual emission allocations (AEAs) by implementing regulations. Member States should stay within the limits of their allocations or can make use of several flexibilities stipulated in the corresponding legislation. Responsibility lies with Member States to implement a combination of national and EU-driven policies and measures in order to meet their commitments under the Effort Sharing legislation. In 2018, a 2030 target and the starting point for the 2021-2030 trajectory were agreed for each Member State in the context of the ESR.

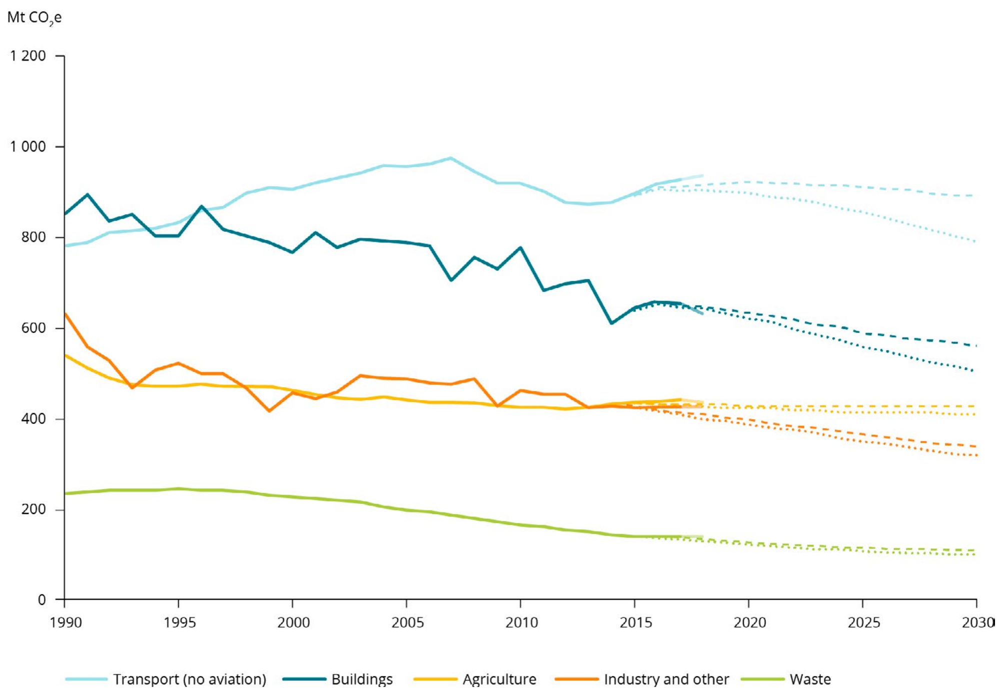
Effort Sharing emissions (i.e. emissions from the sectors covered by the ESD in 2013) have fallen steadily since 1990, albeit at a slower rate than those covered under the EU ETS (Figure 4.5).

This reflects the diversity of the trends in the various sectors covered by the ESD. The building sector has contributed most to absolute reductions in emissions in the sectors covered by the Effort Sharing legislation since 1990, although its emissions have increased since 2015. Emissions from the transport sector, which is the largest contributor to GHG emissions under the Effort Sharing legislation, increased continuously between 1990 and 2007. Following a decline between 2007 and 2013, emissions from this sector have been increasing continuously since 2014.

In 2017, Effort Sharing emissions aggregated at EU level were 10 % below 2005 levels, which is a greater reduction than the average reduction corresponding to achieving all national targets for Effort Sharing emissions by 2020. Yet, the year 2017 was the third year in a row in which total Effort Sharing emissions increased. According to preliminary estimates, Effort Sharing emissions fell by 0.9 % from 2017 to 2018. This decrease is projected to continue and aggregated Member State MMR projections result in a 13 % reduction of Effort Sharing emissions by 2020 compared with 2005 base-year emissions where only existing and adopted policies and measures are considered.

By 2030, aggregated Member State MMR projections would result in a 20% reduction in Effort Sharing emissions, compared with 2005 base-year emissions, where only existing and adopted policies and measures are considered, and a 27 % reduction when additional policies and measures are included. These reductions remain insufficient compared with the 30 % reduction that the Effort Sharing sectors should achieve by2030. The 2030 targets thus require efforts from Member States that go beyond the measures currently implemented and planned.

Figure 4.5 Greenhouse gas emission trends and projections under the scope of the Effort Sharing legislation, i.e. Emissions from land use, land use change and forestry (LULUCF)



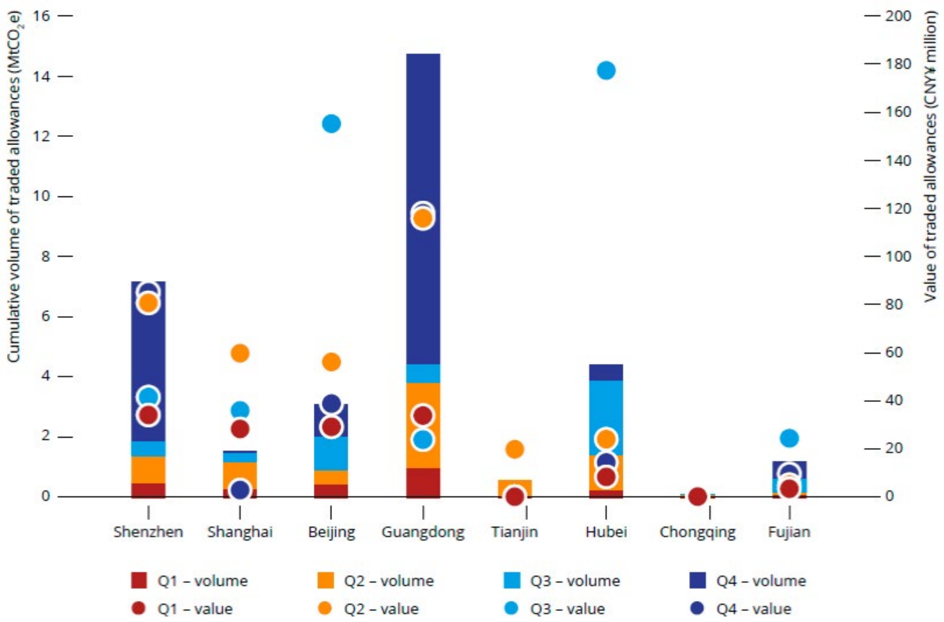
Source: EEA, 2019

4.3 China Climate Action

With a delay compared to the rest of the industrialised world, China launched officially its national ETS in December 2017. On March 2018, at the National People's Congress of China, approved the restructuring of the government and the establishment of a new Ministry of Ecology and Environment, to replace the Ministry of Environmental Protection. The new Ministry will be in charge of climate action and the development of the national ETS. On June 25, 2018 the State Council (China's Cabinet) released a three-year action plan – so called "Winning the Blue Sky War" – for tackling air pollution, which sets up targets for improving the air quality of the country by 2020 (LOC, 2020).

In preparation for the national ETS, China developed several regional pilot ETSs, with various measures including decreasing free allocation shares in some pilots, as well as transitioning free allocation methods from grandfathering to benchmarking (WB, 2019). As we see in Figure 4.6 the volumes and prices vary between the pilot schemes.

Figure 4.6. Cummulative trading volume and value of the Chinese ETS pilots in 2018.



Source: WB, 2019

In March 2018, Taiwan, China, also published the GHG Reduction Action Plan. The plan proposes to implement a **cap-and-trade** system, calculate baseline emissions, and set up regulations but without a precise timeline. Interestingly enough, agriculture is included among the six major industries which will participate in the program (the other five being: energy, manufacturing, residential and commercial transportation, and environment). The emissions situation and projections for China are shown in Figure 4.7.

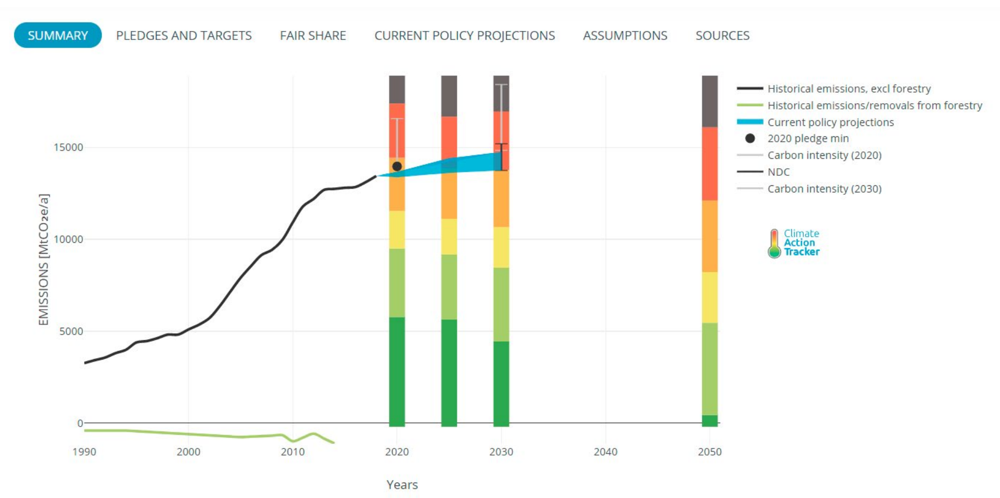
The Climate Action Tracker (CAT) ranks China's climate effort as "highly insufficient:

We rate China's climate commitments in 2030 "Highly Insufficient." We base our rating of China's NDC on its commitment to having 10% gas and 20% non-fossil fuels in its primary energy mix by 2030. Were we to base the NDC rating on the carbon intensity target only, it would also be "Highly Insufficient, " but the absolute emissions level of this element of the NDC is highly uncertain as it depends on GDP growth.

The "Highly Insufficient" rating indicates that China's post-2020 climate commitment is not consistent with holding warming to below 2°C, let alone limiting it to 1.5°C as required under the Paris Agreement. It is instead consistent with warming between 3°C and 4°C: if all countries were to follow China's approach, warming could reach over 3°C and up to 4°C. This means China's climate commitment is not in line with any interpretation of a "fair" approach to the former 2°C goal, let alone the Paris Agreement's 1.5°C limit.

If the CAT were to rate China's projected emissions levels in 2030 under current policies, China would also be rated "Highly Insufficient."

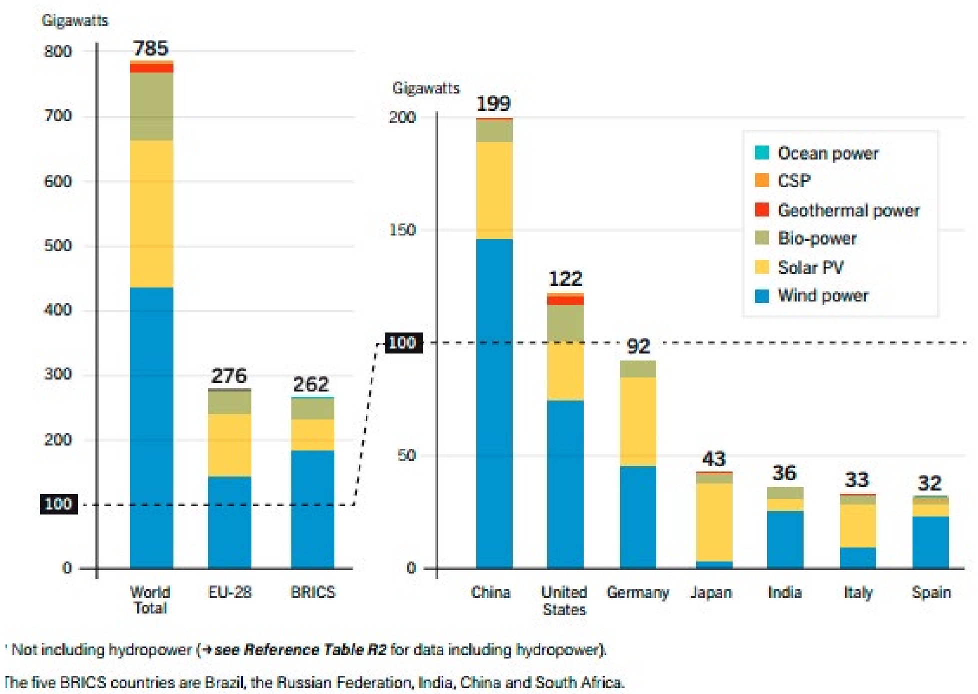
Figure 4.7. Emissions in China. Source: https://climateactiontracker.org/countries/china/



The characteristic of China is that it is the world's manufacturing hub. Worldwide, in most industrial sectors, 75% of greenhouse-gas emissions are produced from the supply chains. This means China's emissions are generated to meet more than just its own rising demand. Research conducted by the Carbon Trust found that China is the world's largest emitter in the apparel sector, but 72% of those emissions are essentially the responsibility of companies overseas where the products are exported and sold (Ma, 2019)

China, however, is investing highly in renewable sources of energy. Figures 4.8, 4.9 and 4.10, show China's leadership in alternative energy production.

Figure 4.8. Green energy capacity in the world.

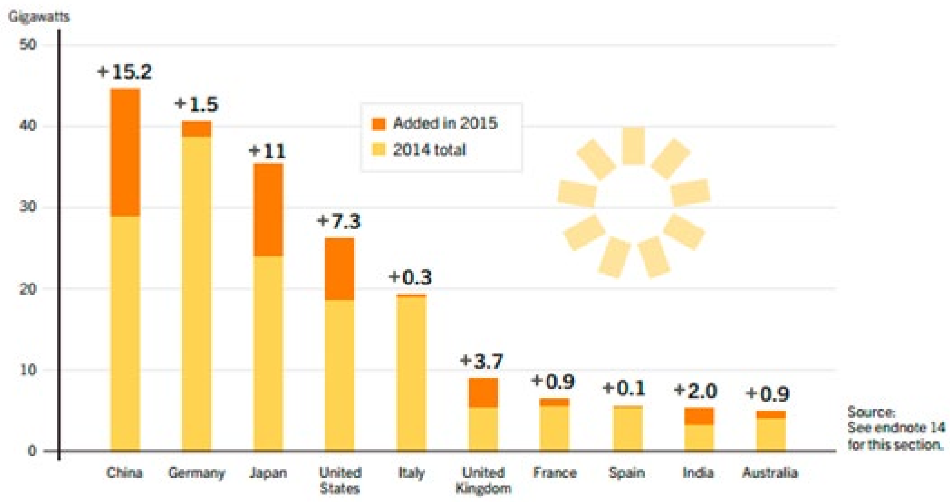


Source: https://www.weforum.org/agenda/2016/06/china-green-energy-superpower-charts

Figure 4.9: Wind power capacity and additions in top 10 countries in 2015

Source: https://www.weforum.org/agenda/2016/06/china-green-energy-superpower-charts

Figure 4.10. Solar PV Capacity and additions, top 10 countries, 2015



Source: https://www.weforum.org/agenda/2016/06/china-green-energy-superpower-charts

4.4 Climate change and emissions Africa

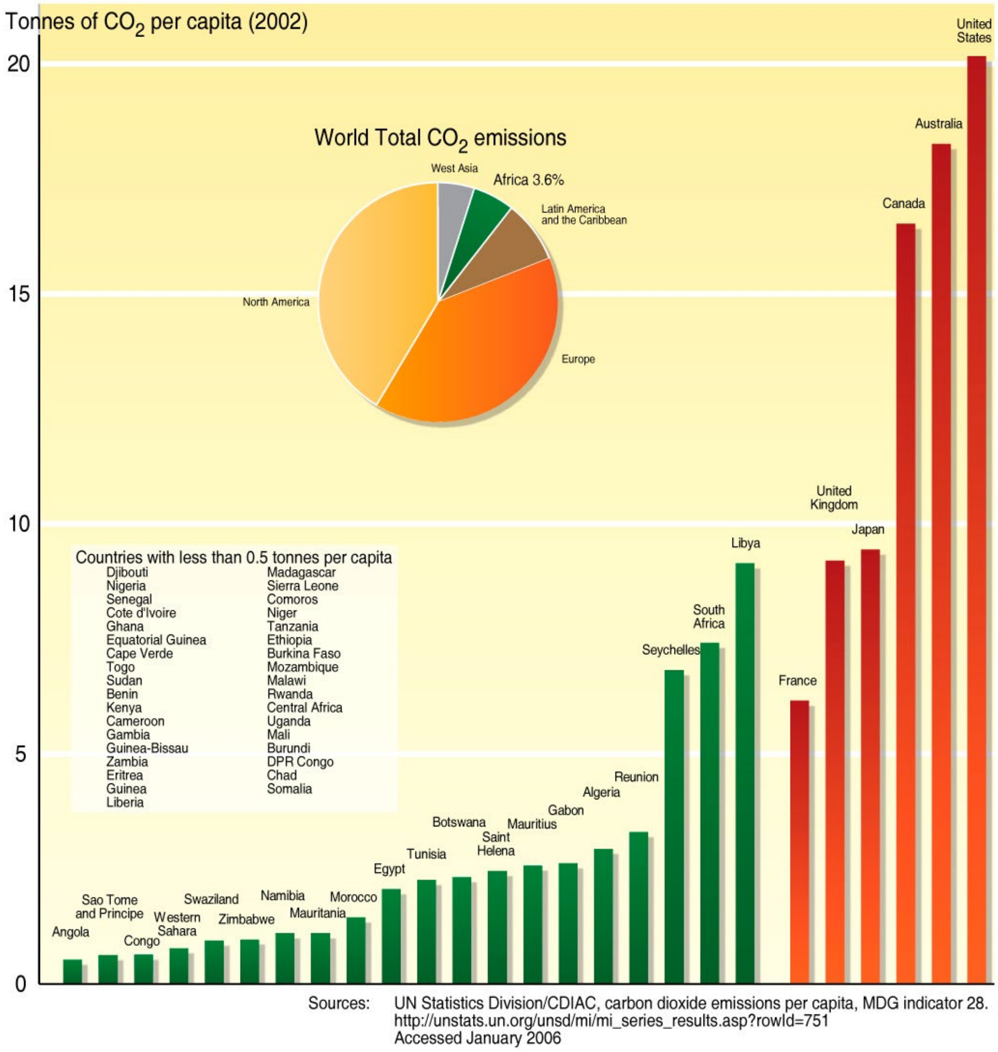
Africa is the continent that contributes to climate change the least, and yet is this continent which will be impacted severely by CC. This is mainly because of high dependency on agriculture and limited capacity to adapt (Collier, Conway and Venables, 2008). Crop yields will be adversely affected and the frequency of extreme weather events will increase. Expected is large migration of people, changes in the sectoral structure of production, and changes in crop patterns. Adaptation to CC will be impeded by Africa's fragmentation into small countries and ethnic groups, and by poor business environments. Mitigation undertaken in other parts of the world will impact Africa, both positive (eg new technologies) and negative (eg commodity price changes arising from biofuel policies) (Collier, Conway and Venables, 2008).

Historically and to the present day Africa has made little contribution to the stock of greenhouse gases in the atmosphere. Africa represents only a small fraction, 3.6%, out of the total carbon dioxide (CO2) emissions per year, although 14% of the population of the world lives here / and this is increasing. The emissions per inhabitant in Libya, the Seychelles and South Africa are on the level of the lowest among OECD countries with the other African countries trailing lower behind them. Regionally, emissions (both per capita and in total) are at their highest in North Africa and in the country of South Africa (Figure 4.11).

Although the anthropogenic emissions out of Africa due to industrial production are extremely low, compared to the rest of the world, its main contribution to CC is due to emissions from LULUF. In particular Africa due to deforestation accounts for 20 per cent of world emissions (Figure 4.12)

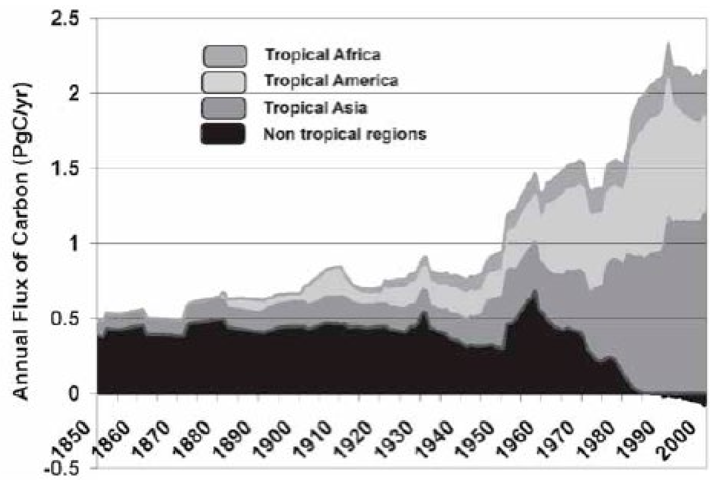
South Africa became the first African nation to launch a carbon tax after Parliament passed the Carbon Tax Bill on February 19, 2019 (WB, 2019). The South Africa carbon tax is one of its key instruments to meet its NDC pledge. Senegal and Cote d'Ivoire are also considering to implement ETS.

Figure 4.11. CO2 emissions per capita, 2002 (tonnes)



Source: https://www.grida.no/resources/7865

Figure 4.12 . Annual emissions of carbon from changes in land use over the period 1850 to 2000.



Source: Houghton, 2005

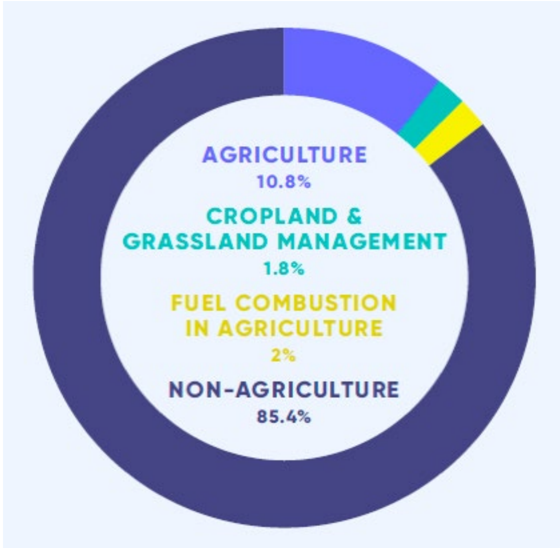
4.5 Emissions and agriculture

Humans practice agriculture for approximately 12000 years. It is estimated that this activity through twelve millennia, has taxed the top one meter of the globe's soil 133 billion tonnes, or 8%, of total global soil carbon stocks (Sanderman, 2017). It is unclear how much of this has been released into the atmosphere and how much has been runoff. Still, the top one meter of earth's soil contains three times more carbon than the atmosphere (Batjes, 1997).

"Considering humans have emitted about 450bn tonnes of carbon since the industrial revolution, soil carbon losses to the atmosphere may represent 10 to 20% of this number. But it has hard to calculate exactly how much of this has ended up in the atmosphere versus how much has been transported due to erosion." (Carbon Brief, 2017).

However, a portion of carbon is returned to soil through plants. Every year, 30% of the atmosphere's carbon dioxide (CO2) is absorbed by plants through the photosynthesis process. Part of this carbon returns to the soil when those plants die and decompose, the living organisms of the soil, such as bacteria, fungi or earthworms, transform them into organic matter. This carbon-rich organic material is essential for human nutrition because it retains water, nitrogen and phosphorus, essential for growing plants.

Figure 4.13. GHGE by sector



Source: Carbon Brief

GHG emissions arising from agricultural production appear under multiple categories in national GHG inventory reports, which EU Member States and the EU as a whole are required to submit annually to the United Nations Framework Convention on Climate Change (UNFCCC). The "agriculture" category covers mainly non-CO2 emissions linked to enteric fermentation (from cattle, sheep and goats), fertiliser application and manure management. CO2 emissions arising from on-farm energy use for machinery, buildings and other activities are accounted for under the "energy" category. Changes in carbon stored in soils and biomass due to cropland and grazing land management practices are reported under the Land use, land use change, and forestry (LULUCF) category. Emissions arising from on-farm energy use for buildings and machinery are also accounted under other sectors. (Lóránt A & Allen B, 2019, p. 13)

It has been proposed that this natural carbon sequestration into soil can be enhanced through appropriate agricultural practices through eco system services schemes. These practices include: Increased productivity and residue retention; Cover crops; No-tillage and other conservation tillage; Manure and compost addition; Conversion to perennial grasses and legumes; Agroforestry; Rewetting organic (i.e., peat and muck) soils; Improved grazing land management (Paustian, et al, 2019). These agronomic practices can be considered as negative emissions technologies (NETs) and can be viewed as a component of the mitigation portfolio (NAS, 2017). It is estimated that these practices can return up to 3 billion tons of carbon into the soil (NAS, 2017).

Governance of such NETs schemes in agriculture, is important since measurement uncertainties, missing markets, incomplete property rights, may cause market failures. "Appropriate governance of NETs and sequestration is critical because overly lax oversight would lead to ineffective CO2 removal and loss of public confidence, while overly strict oversight would limit deployment" (NAS, 2017, p. 12). In addition in order for the schemes to function properly and deliver carbon sequestration, they need to engage and incentivise many participants, such as farmers, certification agencies, as well as a market to buy and sell carbon certificates.

New efforts on the part of companies to incentivize producers as part of sustainable or "low carbon" supply chain initiatives are at present much more fragmented, with the potential for double-counting and low transparency in the carbon removal activities actually undertaken. Hence institution building and development of governance structures to better engage the private sector in pursing demand-side carbon removal activities is a future need. One way to maintain public confidence during rapid deployment of NETs is to invest in a substantial effort to educate the public during the research and development stage. (NAS, 2017, p. 133)

4.5.1 NETs schemes

There are several attempts to organise schemes where NETs are used in agriculture. These exhibit interesting organisational forms, complex governance structures and incentive systems. We can see the engagement of large multinational corporations, such as Bayer, Cargill, cooperatives, such as Land O Lakes, or producer-based organisations. The common characteristic of these schemes is that are founded in order to produce an artificial product, "carbon certificate", and often they involve multitudes of private-private or public-private partnerships, alliances, or contractual relationships. We present very briefly a number of these schemes, so as to exhibit the multitude and innovativeness of the organizational and governance structures.

4.5.1.a Bayer in USA and Brazil

Bayer launched a pilot program on July 21/2020, in Brazil and the US, that will pay farmers for capturing carbon in croplands. Eventually, it plans to expand the program to other countries.

Over the next three years, Bayer expects to invest $5.76 million (5 million euros) through the program in Brazil. However, the company refuses to disclose the total cost of the initiative in both countries.

The program follows several recent environmental initiatives by agriculture companies, which were criticized for not trying hard enough to stop deforestation in Brazil and for using harmful chemicals.

If growers want to participate in Bayer's carbon program, they are required to enroll in its Climate FieldView digital farming platform (https://climate.com/). From the platform, farmers would log data about their eco-friendly agricultural practices, including no-till farming or planting cover crops. Satellite imagery could then verify those claims.

Farmers would be compensated for sequestering carbon. Bayer will give them the option of either getting paid in credits to buy products from its Bayer Plus rewards platform or in cash.

Bayer explains that market would dictate the value of the carbon sequestration. "At the end of the day, we have to have a clear line of sight that this has to contribute to Bayer's bottom line and benefit our shareowners as well, ".

The company chose around 500 farmers in 14 states of Brazil to participate in the pilot program for the 2020/2021 crop season, with roughly 60, 000 hectares of mostly corn and soy farms. So far these are plans that will be interesting to observe how they materialise in the near future.

4.5.1.b Land O' Lakes and Microsoft

On July 15, 2020, Land O'Lakes Inc. and Microsoft Corp announced a multiyear strategic alliance to pioneer new innovations in agriculture and enhance the supply chain, expand sustainability practices for farmers and the food system, and close the rural broadband gap. Land O'Lakes Inc. is one of the nation's largest farmer-owned cooperatives with 150 million acres of productive cropland in its network.

Initially, the two companies will focus on developing a connected AgTech platform, built on Microsoft Azure, that will bring together Land O'Lakes' portfolio of innovative AgTech tools, such as WinField United's R7 Suite, Data Silo and Truterra Insights Engine under one unified architecture. By standardizing on Azure and harnessing the power of Azure FarmBeats, Land O'Lakes will be able to derive insights that enable intelligent agriculture solutions for farmers to be more productive with their time and resources. This includes early mitigation of plant stress to guide precisely where and when farmers should take action on their field for ideal growth conditions, maximization of yield potential by planting the right seed varieties and nutrients, optimizing fertilizer investments, and ensuring accurate output ratio to meet demand properly, all while lowering the farm carbon footprint.

Built on top of the AgTech platform, the companies will collaborate to advance an aggregator of data with Data Silo, as well as leverage Microsoft Azure and its AI capabilities and insights from WinField United Answer Plot® test fields, to support more predictable decisions for placement of crop inputs such as seeds and treatments, with the goal of increasing return on investment with the entire acre.

The Land O'Lakes – Microsoft alliance will develop capabilities to quickly and effectively predict the carbon benefits of regenerative practices like no-till, precision nutrient management and planting of cover crops. They will combine this with the real-time transparency from remote sensing and satellite data. The companies will explore integrating these new capabilities into Microsoft's Truterra Insights Engine. We still need to look closely as to how this initiative will materialise.

4.5.1.c Iowa SoyBean Association

This is a much complicated structure.

i. The Iowa Soybean Association (ISA) (https://www.iasoybeans.com/), a farmer-based organisation funded mainly by levies paid by farmers, together with Quantified Ventures (QV) (https://www.quantifiedventures.com/), an investment firm, established the Soil and Water Outcomes Fund (SWOF) (https://www.theoutcomesfund.com/). The SWOF is a program intended to support farmers who design and implement initiatives aimed at improving water quality and mitigating flooding and runoff, increasing carbon sequestration, reducing emissions from on-farm operations, and creating or protecting habitat. These include practices such as planting cover crops, reducing tillage and preserving edge-of-field wilderness buffers or wetland.

ii. The program is administered by ISA, promoting the idea with members and advising them on best practices. QV is helping with cost-benefit analyses and other operational aspects including fundraising.

iii. The Progress against a farm's individual carbon removal or water stewardship efforts will be measured using COMET-FARM, a carbon reporting and accounting system developed by the United States Department of Agriculture's Natural Resources Conservation Division and Colorado State University.

iv. Cargill will buy carbon credits through the fund on an annual basis. Cargill is encouraging farmers to participate as way of helping address its Scope 3 emissions targets.

v. Ecosystem Services Market Consortium (ESMC) of which Cargill is a founding member, is an organisation that seeks to create a national marketplace for carbon credits by 2020.

vi. There exist other similar initiatives. Startup Indigo Ag, backed by companies including investor FedEx, for example, is planning to pay farmers based on how much carbon they have stored in their soil — it collects soil samples to that end. Software company Nori, another rising player, is using blockchain to manage the transactions.

We need to keep a close eye on how these initiatives will take shape, their viability and potential success in sinking carbon in effective ways.

4.5.1.d 4 per 1000

The French National Low Carbon Strategy, first published in 2015, has been reviewed recently in order to better align its objectives with the Paris Agreement. Between October 2017 and June 2018, five workshops were organized, addressing mitigation ambition in the agriculture sector. More specifically, participants, including representatives from the farming sector, technical institutes, environmental NGOs and local agricultural chambers, explored how emissions from the sector could be halved by 2050 compared to 1990 levels. The ClimAgri calculator was used to assess the mitigation potential of various measures going beyond a business as usual scenario. Input variables to the calculator, such as land use, yields, livestock population, had been initially defined based on the review of relevant literature (e.g. foresight exercises) but they were reassessed and changed if needed to reflect the feedback received from stakeholders. There are currently three scenarios on the table, the first one focusing on agroecology, the second on precision agriculture and the last one targeting the demand side (the main levers are listed below). Further engagement with stakeholders will aim at combining the above mentioned three approaches into one scenario leading to a 50% reduction in agricultural emissions by 2050 compared to 1990.

Table 4.14. The 4 per 1000 scheme

PRODUCTION SIDE	DEMAND SIDE
An expansion of organic farming reaching 44% of cropland by 2050	A move towards healthy diets
An expansion of protein crops (mainly for feed)	No major changes in the size of area used for biofuel production
An expansion of agroforestry and hedges	Decreasing import of animal feed reaching 5% of the volumes imported in 2015
A more widespread use of anaerobic digesters	Export patterns of agricultural products remain unchanged
Decrease of cattle population by approximately one third	

If the carbon level increased by 0.4%, or 4 ‰ per year, in the first 30-40 cm of soil, the annual increase of carbon dioxide (CO2) in the atmosphere would be significantly reduced. This is what the 4 per 1000 Initiative proposes.

The international initiative "4 per 1000", was launched by France on 1 December 2015 at the COP 21, consists of federating all voluntary stakeholders of the public and private sectors (national governments, local and regional governments, companies, trade organisations, NGOs, research facilities, etc.) under the framework of the Lima-Paris Action Plan (LPAP).

The aim of the initiative is to demonstrate that agriculture, and in particular agricultural soils can play a crucial role where food security and climate change are concerned.

Supported by solid scientific documentation, this initiative invites all partners to state or implement some practical actions on soil carbon storage and the type of practices to achieve this (e.g. agroecology, agroforestry, conservation agriculture, landscape management, etc.).

The ambition of the initiative is to encourage stakeholders to transition towards a productive, highly resilient agriculture, based on the appropriate management of lands and soils, creating jobs and incomes hence ensuring sustainable development. The Executive Secretariat of the "4 per 1000" initiative is hosted by the CGIAR System Organization, an international organization based in Montpellier.

The 4 per 1000 is a very ambitious global initiative with over 500 participants from around the world. We are yet to observe when it will be applied.

Similar programs are initiated by Australia and the Canadian provinces of Alberta and Saskatchewan which have paid farmers for soil carbon sequestration.

4.6 Conclusions

There is variety of efforts around the globe to mitigate and adapt to climate change. Pricing schemes, most notable emission trading schemes (ETS) with cap-and-trade instruments, offer the most preferred policy instrument. The EU was the first, and still is the largest block that offers an effective ETS scheme. However, still the EU lags behind its ambitious targets.

Many countries are entering into emission trading systems, most notable is China. Africa on the other hand is the largest victim in the climate change game, since due to its dependence on agriculture and institutional ineffectiveness is going to be severely affected. Africa contributes to GHG emissions mainly through deforestration, which besides contributing to global CC has further impacts biodiversity and the local microclimates, soil loss, etc.

Agriculture raises as a main contributor of GHG emissions (more than 10%), however, agriculture has the capacity to sink carbon. This offers great potential for income for farmers, if the technological and institutional requirements are met. Various initiatives designed to pay farmers that sink carbon (negative emissions) have sprung around the world. They are yet to be actually applied. One likely key factor for their delay is that carbon emissions from agriculture and forestry (as well as from the LULUCF) are not included into the emission trading systems (ETS). There are proposals to create separate such systems for agriculture. As the argument goes, a ton of carbon emitted into the atmosphere should be priced differently from a ton of carbon removed from the atmosphere (EURACTIVE, 2020).

In this report we did not deal with the impact of COVID19 on climate change. It will be very interesting to observe the impact of the current COVID19 pandemic on the global emissions sphere.

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5 State of Art about Methods of Measuring Soil Carbon Stocks: Agriculture in general and coffee production

Carlos Eduardo Cerri[1]

5.1 Initial considerations

There has been growing worldwide concern about global climate change, mainly due to the increased emissions of carbon dioxide (CO_2) and other gases, such as methane (CH_4) and nitrous oxide (N_2O). In principle, these gases are responsible for maintaining the average temperature of 16-18ºC on Earth, promoting the so-called "greenhouse effect", essential for the existence of life on the planet.

Studies reveal that in the last 200 years the concentration of these gases in the atmosphere, mainly CO_2, has been increasing gradually, and more significantly, in the last decades (IPCC, 2019). One of the main consequences is what is called "increase in the greenhouse effect" or "anthropic greenhouse effect", due to the greater reflection of the infrared rays to the Earth, promoting an energy imbalance (Figure 5.1).

According to the latest report by the Intergovernmental Panel on Climate Change (IPCC, 2019), from 1850-1900 to 2006-2015, the mean air temperature on the earth's surface increased 1.53° C, while the average global temperature (land and ocean) increased by 0.87 ° C. This warming resulted in an increase in the frequency, intensity and duration of heat-related events, including heat waves in most land regions. The frequency and intensity of droughts has increased in some regions (including the Med-

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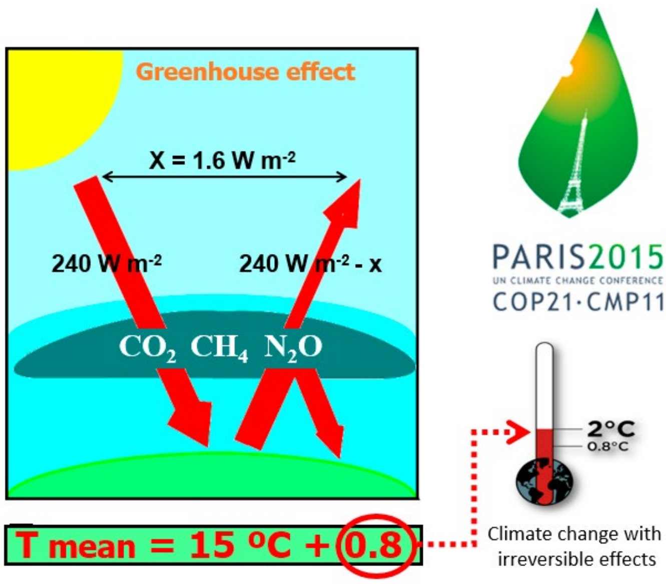
iterranean, West Asia, many parts of South America, much of Africa and Northeast Asia), and there has been an increase in the intensity of heavy rain events at scale global (IPCC, 2019).

The Agriculture, Forestry and Other Land Use (AFOLU) sector is responsible for about 25% (approximately 10 to 12 $GtCO_2eq$ $year^{-1}$) of global anthropogenic greenhouse gas (GHG) emissions – which are mainly from the deforestation and emissions from livestock and use of nitrogen fertilizers. Between 2000 and 2010, annual GHG emissions from agricultural production were estimated between 5.0 and 5.8 $GtCO_2eq$ $year^{-1}$, while the annual flow of GHG resulting from land use activities and land use change of approximately 4.3 to 5.5 $GtCO_2eq$ $year^{-1}$ (IPCC, 2014).

However, it is estimated that the global implementation of best agricultural and livestock production practices could provide 20 to 40% of the mitigation of GHG emissions to meet the Paris Agreement objective – which is to limit global warming to 1.5°C and 2°C until the end of the next century (IPCC, 2019).

In its Nationally Determined Contributions (NDC), a package of commitments and contributions from countries to comply with the Paris Agreement (UNFCCC, 2015), Brazil has proposed to reduce its GHG emissions by 43% in 2030, based on 2005 levels. The agricultural sector would come through the strengthening of the Low Carbon Agriculture Plan, called "Plano ABC", which promotes the introduction of sustainable practices in agriculture (Brasil, 2015).

Figure 5.1. Schematic representation of the "anthropic greenhouse effect" and its impacts in relation to the average temperature of the Earth



These practices focus on the recovery of degraded pastures, the adoption of the no-tillage system and the implementation of integrated systems such as the crop-livestock-forest integration on approximately 20 million hectares. The implementation of such practices are capable of increasing the efficiency of agricultural production and reducing GHG emissions mainly through the removal of part of the carbon (C) currently in the atmosphere, in the form of CO_2, and fixation into the soil, a process called "soil carbon sequestration".

However, despite the fact that Brazil has already invested more than R$16 billion directly through the ABC Plan between 2010 and 2019 and already includes countless producers who have implemented and conduct good production practices on their rural properties, the country still cannot prove the soil C sequestration derived from these actions. One of the largest obstacles is the lack of knowledge about the assessment of soil C stocks for the assessment of C sequestration. As a consequence, the country is unable to give transparency to the implementation of its NCD in the sector. Additionally, this has prevented the country leverage green financing, the adhesion of new producers to more efficient production practices and the valorization of their producers in the national and international market.

The aim of the present study is to describe the state of art of research methods related to measurements of soil C stocks (both quantity and quality). It brings relevant information for decision making for the monitoring of public policies, programs and initiatives for enhancing soil C squestation strategies.

5.2 Soil carbon stocks: basic concepts

Carbon (C) is a vital element, because together with oxygen (O_2) forms CO_2, it participates in the process of photosynthesis, which is the beginning of the trophic chain. Thus, C transits in all spheres: atmosphere, biosphere, pedosphere (humosphere), lithosphere and hydrosphere. Their participation occurs in both the form of very simple inorganic compounds (CO_2) to complex compounds of plant tissue (cellulose, lignin) and animals and even more condensed compounds such as humus, coal, oil, among others.

Considering only the atmosphere and terrestrial ecosystems, the estimates made by the IPCC show that there are approximately 730-750 PgC in the atmosphere (with 1 Pg = 10^{15} g or 1 billion tons of C), 470-655 PgC in vegetation and 1500-2000 PgC in the soil at 1 meter deep in the soil (about 800 Pg C are stored only in the first 30 cm of depth). These values indicate that there are two to three times more C in soils in relation to that stored in vegetation and about twice as much compared to the atmosphere (Figure 5.2).

Figure 5.2. Global carbon pools in terrestrial ecosystems

Global Carbon Pool	Pg C
Atmosphere	760
Vegetation	560
Soil (0-30cm)	800
Soil (0-100cm)	1550

1 Pg C = 10^{15} g C or 1 billion tons of C

In the pedosphere, C is in organic and inorganic forms. The organic form is related to the constituents of soil organic matter (SOM), where humic substances are the most abundant components, but it is also present in organisms and their metabolites, plant and animal remains in various stages of decomposition. C in mineral form can be present in the form of carbonated minerals in different phases of alteration, as well as inputs and residues normally applied in agriculture, such as limestone.

Admittedly, the soil is composed of 4 main components: air, water, mineral matter and SOM. The main source of SOM are plant and animal remains that are deposited on the soil surface, as well as products of exudation from the root system or itself when in the stage of decomposition. The entry of these plant and animal remains is a source of energy for soil organisms (both macro and mesofauna as well as microbial biomass). From this interaction between organisms and SOM sources, usually defined as a decomposition process, the formation of humic substances and non-humic substances and other products in mineral form and gases occurs. Although it represents only 1-5%, SOM is one of the main components of the soil because it strongly influences plant productivity and environmental aspects, as it provides nutrients for plants, in addition to influencing the physical, chemical and biological properties of the soil, promoting conditions favorable to plant growth.

SOM is a very important soil constituent in the sustainability of plant production. Although in small amounts, it is important, when mineralized, in the supply of nutrients to plants, in addition to influencing soil physical properties (for example in reducing soil density and consequent increase in soil porosity and increased water retention), soil chemical (such as the generation of negative charges increasing the cation exchange capacity) and soil biological properties (mainly associated with nutrient cycling for plant nutrition). Therefore, SOM (expressed by soil C) is key to maintaining and even increasing soil quality ("soil health") and directly helps to promote favorable conditions for plant growth. However, SOM products do not stay in the soil infinitely and the time that they remain in the soil is called the Mean Residence Time (MRT). Using this concept, SOM can be categorized into active pool (MRT of days-months), slow pool (years-decades) and passive pool (centuries-millennia). Therefore, there is a constant flow of C entering and leaving the soil.

In this context, there are at least two metrics of expression of this element in the soil: soil C content (examples of units: % C or milligram of C per gram of soil) and soil C stock (that is, an amount of C in a given layer of soil per unit area). Clearly the second form of expression, by soil C stock, is the most technically correct, with the most used units for a given soil layer (examples: 0-10cm or 0-30cm or 0-100cm deep) it has been kilogram per square meter (kg m^{-2}) or even tons per hectare (t ha^{-1}).

5.3 Soil carbon stocks and best management practices in agriculture

Mitigating climate change requires clean energy and the removal of atmospheric C. In this sense, soil C build-up is an appealing nature-based solution to deal with climate issues in a global scale (Bossio et al. 2020; Seddon et al. 2020). Globally, soils hold three times more carbon than the atmosphere (Sanderman et al. 2017), and the role of soil C as a regulator of climate is fully accepted by scientist, policy makers and general society. Soil C represents 25% of the potential of natural-based solutions, accounting 9% of the mitigation potential of forests, 72% for wetlands and 47% for agriculture and pastures (Bossio et al., 2020). Moreover, there are important additional benefits, such as increase soil fertility, maintain or increase resilience to climate change, reduce soil erosion, besides its effects on land sparing, all in line with the United Nations Sustainable Development Goals. Accordingly, soil C can be enhanced to the adoption of best management practices, and therefore, is a key component to any policy regarding climate change mitigation and sustainable development. Nevertheless, there is probably a finite potential for accumulating carbon in the soil. This concept of soil carbon saturation is still in discussion in the scientific literature, but the majority of the experts believe soils have a limited capacity to store carbon until an equilibrium ("steady-state") is achieved. However, it is still unclear when the carbon saturation is reached (years/decades/centuries) and how much carbon can be stored into the soil. This is a complex equation to be solved, considering that many factors directly influence it, including soil type, climatic conditions, quantity and quality of organic inputs, diversity of microorganisms associated to decomposition and stabilization processes, land use, agricultural management practices among many other factors.

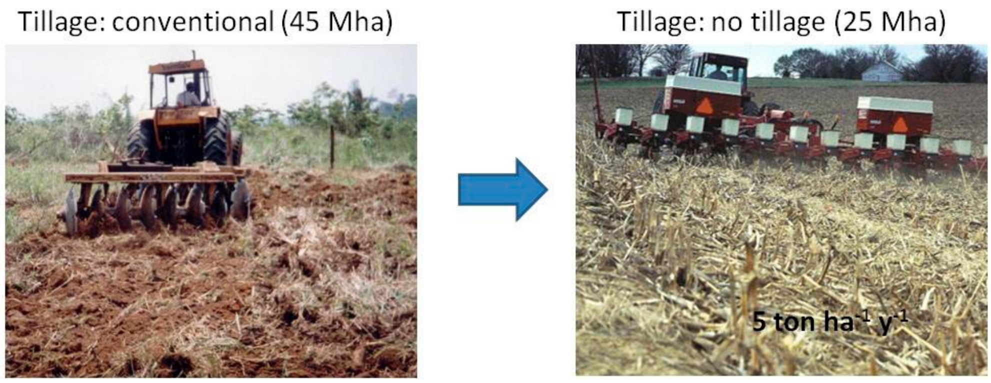
The concepts of best management practices must be viewed in a broad form that includes the needs for increasing agronomic productivity, improving resource conservation, and enhancing environmental quality. This view unquestionably highlights the role that soil C plays as an important component of the agroecosystem to promote agricultural sustainability (IPCC, 2019). According to Lal (2019), sustainable land use must be assessed in terms of its impact on soil C stocks. A nonnegative trend in soil C stock would imply a sustainable land use/soil management system. All other factors remaining the same, a sustainable system would enhance C content. Because soil C stocks can have tremendous effect on the capacity of a soil to function, it has been recommended as a basic component in every minimum data set for assessing soil quality. The aim of this section is to assemble available information on the main management practice that potentially contributes to the enhancement soil C stocks.

5.3.1 Soil carbon stocks in conventional versus no-tillage systems under tropical conditions

No-tillage is presumed to be the oldest soil management system in agriculture and, in some parts of the tropics, NT is still practiced in slash-and-burn agriculture, where after forest clearing by controlled burning, seeds are directly placed into the soil without any tillage operation. As mankind developed more systematic agricultural systems, cultivation of the soil became an accepted practice as a mean of preparing a more suitable seedbed and environment for plant growth. Indeed, tillage as symbolized by the mouldboard plough became almost synonymous with agriculture (Dick & Durkalski 1997; Blanco-Canqui & Wortmann 2020). No-tillage can be defined as a crop production system where soil is left continuously undisturbed, except in a narrow strip where seed and fertilizer are placed, as show in comparison with conventional tillage practices in Figure 5.3a and b, respectively. In Latin America, no till practices haves gain but a long way is still to go as in Brazil, for instance, annual crops are still managed in majority by using conventional tillage practices (around 45 million hectares, Figure 5.3a) while no till with directly seedling is practices in around 25 million hectares, and results also in a good amount of crop residues left on soil surface (Figure 5.3b).

Conversion of native vegetation to cultivated cropland under conventional tillage (CT) system has resulted in a significant decline in SOM content (Paustian et al. 2000; Lal 2002; Zach et al., 2006). Farming methods that use mechanical tillage, such as the mouldboard plough for seedbed preparation or disking for weed control, can promote soil C loss by several mechanisms: (i) they disrupt soil aggregates that protect SOM from decomposition (Six et al. 2002; Soares et al. 2005), (ii) they stimulate short-term microbial activity through enhanced aeration, resulting in increased levels of CO_2 and other gases released to the atmosphere (Bayer et al. 2000a, b; Kladivko 2001), and (iii) they mix fresh residues into the soil where conditions for decomposition are often more favorable than on the surface (Plataforma Plantio Direto 2020). Furthermore, tillage can leave soils more prone to erosion, resulting in further loss of soil C (Bertol et al. 2005; Lal 2006; Lal 2019).

Figure 5.3. Conventional versus no till practices where annual crop residues is left on soil surface instead of incorporated in the soil.



No-tillage farming, however, due to less soil disturbance often results in significant accumulation of SOC (Bayer et al. 2000b; Sá et al. 2001; Schuman et al. 2002; Blanco-Canqui & Wortmann 2020) and in consequent reductions of greenhouse gas emissions to the atmosphere, especially CO_2 (Lal 1998; Paustian et al. 2000), compared to CT. There is considerable evidence that the main effect on SOC is in the topsoil layers (Six et al. 2002; Abril et al, 2005; Noellemeyer et al., 2008), but significant increments in SOC have also been reported for layers below 30-cm depth in NT soils with high input cropping systems (Sisti et al. 2004; Dieckow et al. 2005; Lal 2019).

Worldwide approximately 63 million ha are currently being managed under NT farming, with USA having the largest area (Lal 2006), followed by Brazil and Argentina. In Brazil, NT farming began in the southern states in the 1970s as an alternative to the misuse of land that was leading to unacceptable levels of soil losses by water erosion (Denardin and Kochhann, 1993). Similarly, in Argentina NT began to be used in the central rolling Pampas, where water erosion also had become a major problem when soybean-wheat double cropping was introduced (Alvarez and Steinbach, 2009), and NT was shown to effectively reduce run-off velocity and sediment load (Castiglioni et al., 2006). The underlying land management principles that led to the development of NT systems were prevention of surface sealing caused by rainfall impact on soil surface, achievement and maintenance of an open soil structure and reduction of the volume and velocity of surface runoff. Consequently, NT was based on two essential farm practices: (i) not tilling and (ii) keeping soil covered all time. This alternative strategy quickly expanded and the cropped area under NT has since then increased exponentially.

In the early 1990s, the NT area in Brazil was about 1 million ha, increased 10 times by 1997, and currently is approximately 24 million ha. This expansion includes the conversion from CT in the southern region (72%) and expansion of the agricultural frontier clearing natural savannah in central-western area (28%). Recently, due to the high profits, ranchers in the Amazon region are converting old pastures to soybean/millet under NT.

Changes in soil C stocks under NT have been estimated in earlier studies for temperate and tropical regions. Reicosky et al. (1995) reviewed various publications and found that organic matter increased under conservation management systems with rates ranging from 0 to 1.15 t C ha^{-1} yr^{-1}, with highest accumulation rates generally occurring in temperate conditions. In the tropics, specifically in Brazil, the rate of C accumulation has been estimated in the two main regions under NT systems (south and central-western regions). In the southern region Sá (2001) and Sá et al. (2001) estimated sequestration rates of 0.8 t C ha^{-1} yr^{-1} in the 0-20 cm layer and 1.0 t C ha^{-1} yr^{-1} in the 0-40 cm soil depth after 22 years under NT compared to the same period under CT. The authors mentioned that the accumulated C was generally greater in the coarse fraction (> 20 mm) indicating that most of this additional C is relatively labile.

Bayer et al. (2000a, b) found a C accumulation rate of 1.6 t ha^{-1} yr^{-1} for a 9 year NT system compared with 0.10 t ha^{-1} yr^{-1} for the CT system in the first 30 cm layer of an Acrisol in the southern part of Brazil. Corazza et al. (1999) reported an additional accumulation of approximately 0.75 t C ha^{-1} yr^{-1} in the 0-40 cm soil layer due to NT in the savannah region located in the center-west. Estimates by Amado et al. (1998) and Amado et al. (1999) indicated an accumulation rate of 2.2 t ha^{-1} yr^{-1} of soil organic C in the first 10 cm layer. Other studies considering NT system carried out in the center-west region of Brazil (Lima et al. 1994; Castro-Filho et al. 1998; Riezebos and Loerts 1998; Vasconcellos 1998; Peixoto et al. 1999; Spagnollo et al. 1999; Resck et al. 2000) reported soil C sequestration rates due to NT varying from 0 up to 1.2 t C ha^{-1} yr^{-1} for the 0-10 cm layer. Bernoux et al. (2006) reported that most studies of Brazilian soils give annual rates of carbon storage in the top 40 cm of the soil varying from 0.4 to 1.7 t C ha^{-1}, with the highest rates in the Cerrado region. However, the authors stressed that caution must be taken when analyzing NT systems in term of carbon sequestration. Comparisons should include changes in trace gas fluxes and should not be limited to a consideration of carbon storage in the soil alone if the full implications for global warming are to be assessed. The adoption of NT management in subtropical Brazilian soils has led to SOC accumulation rates of 0.19–0.81 Mg ha^{-1} $year^{-1}$ in the 0–20 cm layer (Bayer et al. 2006a), due to the less oxidative environment and the physical protection mechanism imparted by the stable aggregates in NT soils (Eiza et al., 2005; Blanco-Canqui & Wortmann 2020).

5.3.2 The importance of cover crops for sustainable carbon management in tropical and subtropical agroecosystems

Soils in tropical and subtropical environments are often exposed to strong rain and long term drought events during the year. Hence, either in sugarcane or annual crops any management that leaves more crop residues covering the soil surface is beneficial for soil protection and C sequestration. The importance of residue cover to avoid soil erosion or food web respiration, and for maintaining soil organic matter in annual crops through grass-legume rotations has been discussed by many authors (Magdoff and Weil 2004; Lal et al. 1998). In southern Brazil many experiments showed SOC accumulation due to the conversion of systems based on intensive tillage to NT with crop rotation, with topsoil SOC gains up to 91% (Zanatta et al., 2007).

Dieckow et al (2005) evaluated soil organic C and N losses during a period of conventional cultivation (1969-1983) that followed native grassland and the potential of four long-term (17 years) no-till cereal- and legume-based cropping systems with different N fertilization levels to increase the C and N stocks of a southern Brazilian Acrisol. The C content in the 0-17.5 cm soil layer decreased by 22 % (8.6 Mg C ha^{-1}) and N decreased by 14 % (0.44 Mg N ha^{-1}) during the period of conventional cultivation. Legume-based cropping systems increased C and N stocks due to the higher residue input. Although the major soil management effects were found in the 0-17.5 cm layer, up to 24 % of the overall C losses and 63 % of the gains of the whole 0-107.5 cm soil profile occurred below the 17.5 cm depth, reinforcing the importance of subsoil as a C source or sink. The average C sequestration rate of legume based cropping systems (with N) were 0.83 Mg C ha^{-1} yr^{-1} in the top 0-17.5 cm layer and 1.42 Mg C ha^{-1} yr^{-1} in the profile, indicating the remarkable potential of legume cover crops and N fertilization under no-tillage to improve soil carbon stocks and thus soil and environmental quality in humid subtropical regions.

The adoption of NT and soil cover also brings about favorable soil physical conditions that improve water infiltration and storage (Fernandez et al., 2008) and prevent water and wind erosion (Hevia et al., 2007), which is very important in semiarid regions. For temperate environments in eastern Argentina, NT combined with pasture rotations showed to be a sustainable agricultural practice that combines high yields with carbon storage in the soils (Studdert and Echeverria, 2000; Studdert et al., 1997). Similar results were also obtained in Uruguay when NT was incorporated into crop-pasture rotations (Garciaprechac, 2004). Other benefits of NT include higher biological activity of the soil ecosystem (Quiroga et al., 2009; Fernández et al., 2010a), which also promotes the diversity of soil organisms, as confirmed by studies on Chilean and Argentinean NT soils (Borie et al., 2006, Abril et al., 1995). Crops cultivated under NT are usually more efficient in water use and produce higher yields (Noellemeyer et al., 2013). Especially when cover crops are used to improve soil cover and residue biomass input to the soil all of the mentioned benefits were enhanced (Fernández et al., 2010b; Mohammadi, 2010; Santos et al., 2011; Restovich et al., 2012) without negative impacts on crop yields. Cover crops or double cropping can also help to retain more water in the soils of a region compared to single crops under conventional tillage (Nosetto et al., 2012), by reducing losses through deep-drainage and surface run-off. Cover crops and NT technology has been widely adopted both in Brazil and Argentina, and is also applied in important areas of Chile, Paraguay, Bolivia and Uruguay, resulting in manifold benefits. Generally crop yields are higher under NT resulting in improved provision of goods, but also many ecosystem services such as water filtration and storage, erosion prevention, soil formation, biodiversity conservation are enhanced.

Ferreira et al (2020) reported that no-till management affected not only the dynamics of soil aggregation but also the organic carbon fractions. Over the years, no-till farming increased soil particulate organic carbon (POC), mineral-associated organic matter (MAOM) and humin contents because of the constant input of crop residues to surface layers.

Therefore, crop residues management is a key point of NT systems and includes selecting crops that produce sufficient quantities of residues (e.g., corn, sorghum etc) and introduction of cover crops in rotation schemes that provide an effective ground cover. Rather than turning under plant materials or crop residues following harvest, the residues are left on the soil surface to protect soil against the erosive forces of rainfall and wind. Crop residues management is also a key point for enhancing SOC on energy crops like sugarcane. Here there is room to improve the management simply by changing the tillage system during the reform of the sugarcane fields (Cherubin et al., 2018).

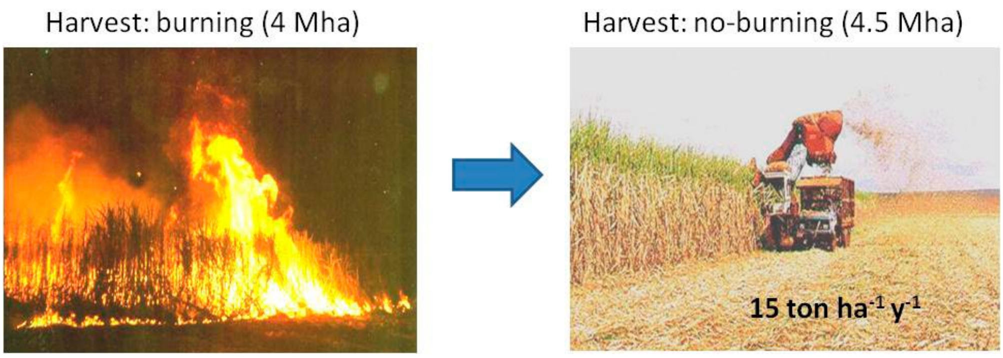
5.3.3 Burned versus green harvested sugarcane

Brazil is the main sugarcane producer in the world; with nearly twice the harvested area and almost 2.5 times more production than India that ranks second (FAOSTAT, 2020). In 2020, the sugarcane harvested area in Brazil was more than 9 million hectares. Around 54% of sugarcane produced in Brazil is for ethanol production (CONAB, 2020).

Figure 5.4 exemplifies a common conversion which took place in Brazil in terms of harvest practices in sugarcane areas. Residue deposition in no-burning harvest areas is equivalent to 15% of the dry matter productivity of sugarcane, with a mean value of 13.9 Mg of dry matter per hectare per year (Cherubin et al., 2018). No-burning harvest systems have several benefits, for instance higher crop longevity, and lower costs for renewing areas; recycling and gradual release of nutrients by straw decomposition; decrease in gas emissions; and less nutrient losses (Canellas et al., 2003). There is also improvement of physical soil conditions, like moisture retention, which is especially important during drought periods (Resende et al., 2006), increase in soil aggregate stability (Luca et al., 2008; Szakács, 2007), and improvement in soil structure, mainly in sandy soils with an original low level of soil C (Luca et al., 2008; Cherubin et al., 2018).

Higher organic matter levels in soils improve chemical and physical soil properties, as discussed above, and also contribute to mitigate global warming due to higher soil C stocks. Sugarcane crops without burning accumulate more organic C in the soil than those harvested with fire (20% more C in 0-5 cm and 15% more in 0-10 cm soil depth). The main difference in organic carbon levels between the two systems occurs in the 0-2 μm fraction, where there is 35% more C under the no-burning management (Razafimbelo et al., 2006), indicating the stabilization of the accumulated C. This was also shown by higher humification indexes of soil organic matter (Panosso et al., 2011) in no-burn sugarcane. Soil organic matter under this management has up to four times more C of aromatic compounds and less C of carboxylic groups (Canellas et al., 2003, 2007). However, the effect of harvest management system on the quality of soil C seems to occur slowly. The results reported by Canellas et al. (2003) occurred 55 years after adoption of green harvest, while Czycza (2009), considering a period without burning of 12 years, did not observe differences in carboxylic and phenolic group concentrations of humic acids due to sugarcane harvest management. Czycza (2009) also compared 12 and 19 year old areas and verified higher aromatic group concentration of humic acids in the superficial layer (0-10 cm depth) of older areas, while in the subsuperficial layer (10-20 cm depth), there was no differences due to time of system adoption.

Figure 5.4. Burning practice and mechanized harvest, where large amount of crop residues is left on soil surface in sugarcane areas



About 50% of total sugarcane in Brazil, (approximately 4 million hectares) is still burnt prior to harvest (Canasat, 2012). Once those areas are converted from burning to mechanized harvest, a huge amount of crop residues is left on soil surface, in some places close to 15 ton per hectare, which is equivalent to 6 ton of C. Several studies were conducted on sugarcane areas converted from burned to green harvest, showing an important enhancement of soil carbon stocks due to this conversion (Cerri et al., 2011). The increases in soil carbon stocks reported in those field studies, at least in the first years of green harvest adoption, would be enough compensate all emissions associated to other sources associated to agricultural practices. Recent estimations of the amount of greenhouse gases emitted to atmosphere associated to all sources in agricultural management of sugarcane fields in southern Brazil mention about 3t CO_2 equivalents per hectare per year (De Figueiredo amd La Scala 2011). Soil carbon accumulation rate of 1 ton per hectare per year, which has been observed in many field studies (Cerri et al., 2011; La Scala et al., 2012), would be enough to compensate emissions associated to crop production, and the ethanol derived from this agricultural management would have close to a "zero emission" footprint.

Renovation operations with intensive soil tillage promote mineralization of soil organic matter (Silva-Olaya et al., 2013) and attenuate differences between burning and no-burning harvest systems (Resende et al., 2006). To better understand the carbon balance and the system potential to increase C stocks in no-burning sugarcane areas, it is important to take into account the tillage system during the renovation period (De Figueiredo and La Scala Jr., 2011). La Scala et al. (2006) evaluated the effects of conventional tillage (moldboard plowing followed by two passes of offset disk harrows), reduced tillage (chisel plowing) and no-till on CO_2 emissions from sugarcane soils. The CO_2 emissions during one month after soil tillage were increased by 160% and 71% when soils were prepared with conventional and reduced tillage as compared to no-till, respectively. The results suggest that in a 1-month period after tillage, 30% of soil carbon input in sugarcane crop residues could be lost after plowing tropical soils, when compared to the no-till plot emissions.

The same set of studies has also pointed to another important aspect: once the sugarcane fields are reformed and tillage is applied a large amount of CO_2 is emitted from soil and soil carbon stocks are dramatically depleted (Cerri et al., 2011). Hence, the adoption of green harvest in sugarcane fields, with the input of large amounts of residues on soil surface should desirably be combined with a reduced or even no-till practice. This would be an ideal production scenario, a win-win situation where less fossil fuel and synthetic fertilizer use would result in higher soil carbon stocks.

In addition to reducing the dependence on fossil fuels, another objective of ethanol use is to mitigate greenhouse gases (GHG) emissions (Cerri et al., 2007; Goldemberg et al., 2008). Brazilian sugarcane ethanol presents a mean decrease of 85% in GHG emissions compared to fossil fuels, while American corn ethanol presents a reduction of only 25% (Borjesson, 2009). Galdos et al. (2010) presented data for Brazilian ethanol production showing that most of ethanol GHG emissions occur in the field, during the sugarcane production. De Figueiredo et al. (2010) quantified the carbon footprint of sugar production in two Brazilian mills and observed that 241 kg of CO_2 equivalent are emitted to produce one ton of sugar, 44% of this from burning, 20% due to mineral fertilizers use and about 18% derived from fossil fuel combustion, confirming the information reported by Galdos et al. (2010). Brazilian ethanol has another advantage: lower production cost per liter in relation to fossil fuels extraction and refinement (Luo et al., 2009; Cherubin et al., 2018).

5.3.4 Integration agriculture-livestock-forestry

The integration agriculture-livestock-forestry (ILPF) is a sustainable production strategy, which integrates agricultural activities, livestock and forestry, carried out in the same area, in intercropped, sequential cultivation or rotated, and seeks synergistic effects between the components of the production system, contemplating the environmental adequacy and the economic viability of the agricultural activity (Balbino et al., 2011; Bieluczyk et al. 2020). Thus, it covers diversified production systems for the production of food, fibers, energy, wood and non-wood products, either whether of vegetable or animal origin, in order to optimize the biological cycles of plants and animals, as well as inputs and their respective residues (Garrett et al. 2020).

The ILPF has shown considerable potential for C accumulation in the soil. Carvalho et al (2010), when assessing changes in soil C stocks in the main change processes land use in the Amazon and Cerrado biomes, comparing them with the implementation of ILPF systems, observed that the conversion of areas of succession of crops, with soy as main culture, for ILPF systems (both under no-tillage system), results in accumulation of C in the soil; accumulation rates ranged from 0.82 to 2.85 t ha^{-1} $year^{-1}$. However, the magnitude of accumulation of C in the soil depends on the implanted crops, the edaphoclimatic conditions and still the time of implantation of the ILPF system. Studies carried out in the Cerrado region have shown an increase in soil C stocks in ILPF systems under no-tillage, when compared to areas under no-tillage system without the presence of forage in the rotation or succession of crops (Carvalho et al., 2010; Salton et al., 2011). Salton, (2005) when evaluating the accumulation rates of C in different land use and management systems in the Cerrado, observed accumulations of C 0.60 and 0.43 t ha^{-1} $year^{-1}$ in areas of nine and 10 years of implantation of ILPF systems, respectively.

Because of the recognized role of trees and the growth to sequester C and, consequently, to mitigate GHG emissions, ILPF systems are considered relevant to sustainable production. In the ILPF system, the cultivation of forest species with increased spacing between lines, enabling the implantation a culture of commercial interest in the region, such as soybeans, corn, beans, sorghum, sunflower, cassava etc., between the lines for two to three years (Garrett et al. 2020). Then, the culture is implanted forage intercropped with maize or sorghum. After harvesting the grain crop, you will have pasture formed between the lines of the cultivated forest, allowing the implantation of the activity of livestock and their exploitation until the wood cutting.

Studies with different arrangements of ILPF systems have shown that the component forestry provides numerous benefits that reflect improved use efficiency land (Carvalho et al., 2010; Macedo, 2009). However, it is the positive impacts on microclimate variables and C sequestration that expand the possibilities of its use in climate change scenarios. However, studies evaluating the C balance in these systems are still scarce in Brazil. The potential for greenhouse gas mitigation in ILPF systems with fast-moving trees growth (> 2.2 cm in diameter per year) in Brazil is approximately 5.0 t ha^{-1} $year^{-1}$ Ceq (average for 11 years) fixed in the wood (trunk) of the trees, according to results by Tsukamoto Filho (2003). This is equivalent to the neutralization per year of the issue of 13 oxen adults (450 kg of live weight of the animal). ILPF systems in addition to being a technology to mitigate greenhouse gas emissions, meets the need for animal welfare by providing protection against thermal stress, promotes biodiversity in productive systems and increases the efficient use of land with added value and income for the areas of pastures (Leite et al., 2010, Bieluczyk et al. 2020).

In the last two decades, eucalyptus has been established in the Cerrado, in combination with rice and soy crops in the first two years, followed by pastures (*Brachiaria*) and beef cattle, from the third year. Tsukamoto Filho et al. (2004), when evaluate the fixation of C in different land use and management systems in the Cerrado region, observed that the agrosilvopastoral system, with eucalyptus, rice, soybean and *Brachiaria*, greater amount of C than in traditional systems, being considered an option for Clean Development Mechanism projects in Brazil. Studies indicate that ILPF systems store more C than the unique cropping of species and grazing systems, on the surface and subsurface (Nair et al., 2011). The increase in soil C stocks and the improvement of the physical quality of the soil with the introduction of the tree component to the crop and pasture components indicate that the ILPF system has the potential to reduce the environmental impact of activities productive, by reducing greenhouse gas emissions, with a consequent increase in the stability of crop production and improved use of water and nutrients (Franchini et al., 2010; Bieluczyk et al. 2020).

The results for the ILPF show that this is an economically viable alternative, environmentally friendly and socially just to increase food security, fibers and agroenergy, enabling the diversification of activities on the property, reducing climate and market risks, improving income and quality of life in the contributing to mitigating deforestation, reducing erosion, sequestering C and the reduction of greenhouse gas emissions, finally enabling sustainable production (Garrett et al. 2020).

5.3.5 Biochar application in soil for carbon accumulation and potential greenhouse gas emission reduction

Biochar is the product of biomass pyrolysis and has been applied to the soil with the purpose of improving soil quality and increasing soil C stocks, especially in tropical regions. Biochar may not only increase soil C content but may also have the potential to decrease greenhouse gas (GHG) emissions, especially N_2O. However, an increase or no effect on N_2O efflux have also been reported (Spokas and Reicosky, 2009; Scheer et al., 2011). These variable responses of soil N_2O efflux to biochar amendments have been attributed to different mechanisms. Biochar addition may affect N_2O emissions by changing soil ammonium and nitrate concentration (Cheng et al., 2008; Liang et al., 2006), decreasing soil bulk density (Karhu et al., 2011), facilitating N_2O consumption in the terminal step of denitrification (Cayuela et al., 2013) and adding labile carbon and nitrogen compounds to the soil (Spokas and Reicosky, 2009). These mechanisms may be to some extent affected directly or indirectly not only by biochar addition rate, but also by temperature.7

It is relevant to mention that biochar produced from different feedstock type may, however, have varied concentrations of nutrients of agricultural interest. In this sense, animal manure derived biochar is shown to accumulate important elements, such as phosphorus (P), calcium (Ca) and magnesium (Enders et al. 2012; Cantrell et al. 2012). Thus, animal manure derived biochar has higher potential to be used as a nutrient source in agricultural systems (Azargohar et al., 2014). Macronutrients concentration in biochar increase during the pyrolysis process while volatile matter and water is released from biochar structure. These latter compounds are represented by organic acids, and as pyrolysis temperature increases, the release of such molecules and the accumulation of basic elements such as Ca and Mg are the drivers of high pH in biochars. These properties support the use of biochar as soil amendment, as liming agent and nutriente source (Ippolito et al., 2015).

Higher soil aggregation was also observed for fine-textured soil where wood and animal derived biochar was added (Wang et al., 2017), improving soil physical structure, aeration and moisture ratio, consequently an improved environment for root development. These mechanisms are often related to increased agricultural production; however, results vary due to biochar properties and its interaction with different environmental conditions (Lorenz and Lal, 2014).

It is clear that the use of the biochar can vary according to its properties, which are defined as a function of the origin/type of biomass used and the variables related to the pyrolysis process, such as time and temperature. Several outcomes are observed from the interaction of biochar and soil particles (Joseph et al., 2010). These contrasting effects are caused by the various physicochemical properties of biochar combined with environmental conditions. Thus, elucidation of the effect of pyrolysis conditions and feedstock type on biochar structure and chemical properties provide basic information to support the understanding of the resultant interactions of biochar with soil. Moreover, this knowledge also enables the selection of feedstock type and production conditions according to the environmental conditions and desired amendments for particular situations.

Recent review studies showed that N_2O production is reduced with biochar application rates of 1–2% by weight (Cayuela et al., 2014; Kammann et al., 2017). Stewart et al. (2013) reported a decrease between 21-92 % in N_2O emissions with the increase of biochar addition (1-20% by weight) in four contrasting soils. An 80–88% reduction of N_2O efflux was also found when 5, 10 and 20 g kg^{-1} of biochar was applied in soil with and without added manure (Rogovska et al., 2011). Contrary to these results, Scheer et al. (2011) did not find any decrease in N_2O emissions from a fertilized pastured when applying 10 Mg ha^{-1} of feedlot biochar and Spokas and Reicosky (2009) found an increase on N_2O emissions when applying biochar rich in nitrogen compounds. Some of the variable responses found in these studies may be attributed to the different characteristics of the biochar, soil type and prevailing environmental conditions (Kammann et al., 2017).

Warming may modify soil properties and directly influence N_2O fluxes. In a two-year field study, Bamminger et al. (2017) reported that biochar-warming interactions led to higher total N_2O emissions than the control. According to the authors, increased N_2O emissions in warmed biochar plots may be due to the: (i) mobilization of the nitrate sorption in the biochar by soil warming; (ii) stimulation of soil organic matter mineralization under warming, increasing the amount of available C in the soil, and at the same time decreasing oxygen concentration in the soil due to respiratory consumption, thereby creating anaerobic zones for denitrification; (iii) Increases in soil moisture by biochar application, especially under dry conditions; (iv) changes in the microbial community because of soil warming and biochar application.

Considering the potential of biochar application for mitigating GHG emissions in tropical areas (Rittl et al., 2015), the influence of increased temperature on the N_2O emissions of biochar-amended soils requires investigation. Little information is available for the interactive response of tropical soil on soil C sequestration and N_2O emissions changes and biochar addition rates (Bamminger et al., 2017). Therefore, results for tropical soil conditions are still inconclusive and display variations and the underlying mechanisms explaining the effect of biochar-soil interaction include biochar properties and soil biotic and abiotic conditions.

Box 5.1 Study cases for the coffee production systems

Despite its recognize importance as one of the most important commodities, information is still lacking in regard to the impact of best management practices on soil C stocks in coffee production systems. Nevertheless, this section briefly presents some studies available in the literature that address the impact of land use change and/or management practices on soil C quantity and quality.

For instance, during the land use change process, the accumulation or loss of soil C depends on the edaphoclimatic characteristics of the place where the coffee culture is installed and the initial soil C stock. When the coffee culture was implanted for 11 years in an area under native vegetation in the southern region of Minas Gerais, Brazil, Rangel et al. (2007) observed an average loss rate of 1.28 Mg of C ha^{-1} $year^{-1}$. This fact is predictable since the implantation of crop systems, such as coffee culture, modify the inputs and outputs soil C and increase soil C losses. However, despite not being found many studies in the literature that prove this hypothesis, the implantation of coffee production in degraded pasture and agricultural areas (with a low annual contribution of C) should result in significant increases in soil C stocks.

In coffee production areas there are several factors that interfere with the entry of C in coffee culture, such as crop spacing and the presence of plants (cultivated or invasive) between the lines. According to Pavan & Chaves (1996), in a study carried out in Brazil, the reduction spacing in coffee plantations increases soil C stocks, due to the greater contribution of plant residues from leaves and branches of the coffee tree deposited naturally or shed during harvest and the organic compounds released by the roots (exudates, mucilages and dead cells). On the other hand, Rangel et al. (2007) observed higher soil C stocks between the lines of the coffee crop when compared to the coffee canopy projection region. These authors attribute the greatest accumulation of C between the lines to the presence of weeds and also to the large contribution of plant material in that location, as a result of weeding, plowing and crop pruning.

Marchiori Junior & Melo (2000) reported a reduction between 10 and 33% in soil C stocks, for the first 20cm soil depth, when coffee was cultivated in Brazil for 12 years in areas previously covered with Cerrado native vegetation. Moreover, in Brazil, the vast majority of coffee crops are grown under a monoculture, not using crop rotation. The implantation of coffee plantations in crop rotation systems or agroforestry systems exhibit a greater potential for store C in soil and vegetation. In a study carried out in the state of Rondônia, it was the accumulation of carbon in areas of coffee monoculture and coffee areas intercropped with tree species (Rodrigues et al., 2000). The authors found that the systems agroforestry with coffee + bandarra and coffee + rubber, the C stock in aerial biomass was 97.2 and 64.5 Mg C ha^{-1}, equivalent to 65.7% and 43.6% of the C contained in the forest. At the monoculture coffee system (7 years) the maximum C stored in the aerial part was 16.6 Mg C ha^{-1} (11.2% of the forest C stock), while in the fallow area with natural capoeira (5 years), the C stock was 11.2 Mg C ha^{-1} (7.6% of the forest).

Estimates made in Indonesia indicate that after deforestation and burning native vegetation, the area part of coffee in monoculture, shaded coffee and regeneration in native vegetation, they result in a C accumulation rate of 1.0; 2.0 and 3.5 Mg ha^{-1} year^{-1} (Van Noordwijk et al., 2002). In the 0-30 cm layer of soil, C stocks in the area under regeneration, shaded and monoculture coffee represented 79%, 60% and 45% of the total obtained in the area under native vegetation.

Another important point in the assessment of C accumulation in coffee culture is associated is the application of organic fertilizers and or the use of green fertilizers. In study carried out in the south of Minas Gerais, Brazil, Oliveira Junior et al. (2008) evaluated the impacts of organic management and the application of synthetic fertilizers in the coffee crop. The authors observed higher levels of C in the soil under forest, followed by organic coffee and coffee conventional with application of synthetic fertilizers. The highest C content in soil under coffee organic is associated with the use of green manures (*Crotalaria juncea* and *Cajanus cajan*), the which resulted in a greater amount of C added by the roots of these plants. Compared the area under native vegetation, it was observed that the cultivation of organic coffee, with greater of C, via organic / green fertilizers, showed a reduction of only 10%, in relation to the original C content, compared to the 20% reduction observed in conventional cultivation. Thus, the authors conclude that the introduction of coffee crops causes losses in the of C and the adoption of organic management provides recovery and / or minimization of these losses of carbon.

Youkhana & Idol (2009) studied the decay of tree pruning mulch and effects on soil C and N in a shaded coffee agroecosystem in Hawaii. Chipped tree pruning residues (mulch) were added to coffee plots shaded with the *Leucaena hybrid KX2* over three years. The authors reported that mulch additions significantly increased soil C and N in the top 20 cm by 10.8 and 2.12 Mg ha^{-1}, respectively. In the no-mulch treatment, there was no significant change in soil C or N concentration, but a decline in soil bulk density led to a significant decline in soil C stocks. Leucaena mulch can provide an important source of organic C and N to coffee agroecosystems and can help sequester C lost as plant biomass during shade tree management.

In Guatemala, Schmitt-Harsh et al (2012) examined the carbon pools of smallholder coffee agroforests (CAFs) as they compare to a mixed dry forest (MDF) system. Data from 61 plots, covering a total area of 2.24 ha, was used to assess the aboveground, coarse root, and soil C stocks of the two land-use systems. Results of this research demonstrate the total carbon stocks of CAFs to range from 74.0 to 259.0 Mg C ha^{-1} with a mean of 127.6 ± 6.6 (SE) Mg C ha^{-1}. The average C stocks of CAFs was significantly lower than estimated for the MDF (198.7 ± 32.1 Mg C ha^{-1}); however, individual tree and soil C stocks were not significantly different suggesting that agroforest shade trees play an important role in facilitating carbon sequestration and soil conservation. This research demonstrates the need for conservation-based initiatives which recognize the carbon sequestration benefits of coffee agroforests alongside natural forest systems.

Soil C stocks were assessed in Costa Rica by Hergoualc'h et al (2012) in two adjacent coffee plantations, both highly fertilized (250 kg N ha^{-1} $year^{-1}$): a monoculture (CM) and a culture shaded by the N_2-fixing legume tree species Inga densiflora (CIn). During a 3-year period (6–9 years after the establishment of the systems), soil C in the upper 10 cm remained constant in the CIn plantation (+0.09 ± 0.58 Mg C ha^{-1} $year^{-1}$) and decreased slightly but not significantly in the CM plantation (−0.43 ± 0.53 Mg C ha^{-1} $year^{-1}$).

Cogo et al. (2013) evaluated soil C stocks on a clayey Oxisol cultivated with coffee and subject to different weed control systems in southern Minas Gerais, Brazil. The experimental design was in randomized blocks, and weed control systems were: no weeding, manual weeding, pre-emergence herbicide, post-emergence herbicide, rotary tiller, rotary mowers and disk harrow. Undisturbed soil samples were collected at two positions in the coffee plantation (tire tracks and planting line), at depths of 0-3, 10-13, and 25-28 cm. A nearby native forest was sampled as a reference. A higher bulk density of soils under coffee plantations occurred compared to soil under the forest. There was little difference between soil C concentrations in the plating line in relation to the native forest, but for the tire track position, the amount of soil C was generally lower. After correction for soil compaction, it was estimated a loss of ca. 20% in soil C stock for the 0-30 cm depth for herbicide post-emergence, rotary tiller, manual weeding and disk harrow, and a 35% loss when using herbicide pre-emergence. Soil C stocks under no weeding and rotary mowers did not differ from native forest (37 Mg C ha^{-1}), indicating that the rotary mower, which allows temporary growth of weeds and does not disrupt soil structure, is the most appropriate weed control for the preservation of soil C in coffee plantations.

Belizário (2013) assessed soil C stocks and greenhouse gas (GHG) emissions due to the conversion of Cerrado vegetation to coffee cultivation in Patrocínio, Minas Gerais state, Brazil. Soil C stocks were determined for the original Cerrado and in areas converted 37, 15 and 8 years, and also two areas who received addition of 22.684 e 16.845 kg ha^{-1} organic compound in 2006 and 2010, respectively. The author reported that after the land conversion for coffee production, there is a considerable increase in soil C stock, but over time this value tends to decrease, probably due to the adopted management practices.

Data from two long-term coffee agroforestry experiments in Costa Rica and Nicaragua was used by Noponen et al. (2013) to assess the effect on soil C stocks of (i) organic versus conventional management, (ii) higher versus moderate agronomic inputs, (iii) tree shade types. During the first nine years of coffee establishment total 0–40 cm depth soil C stocks decreased by 12.4% in Costa Rica and 0.13% in Nicaragua. Change in soil C stocks differed consistently amongst soil layers: at 0–10 cm soil C stocks increased by 2.14 and 1.26 Mg C ha^{-1} in Costa Rica and Nicaragua respectively; however much greater reduction occurred at 20–40 cm (9.65 and 2.85 Mg C ha^{-1} respectively). Organic management caused a greater increase in 0–10 cm soil C but did not influence its reduction at depth. Effects of shade type were smaller, though heavily pruned legume shade trees produced a greater increase in 0–10 cm soil C than unpruned timber trees. No significant differences in soil C stocks were found between shaded and unshaded systems at any depth and soil C was poorly correlated with above-ground biomass stocks highlighting poor validity of "expansion factors" currently used to estimate soil C. Soil C stock changes were significantly negatively correlated with initial stock per plot, providing evidence that during establishment of these woody-plant-dominated agricultural systems soil C stocks tend to converge towards a new equilibrium as a function of the change in the quantity and distribution of organic inputs. Therefore it cannot be assumed that tree-based agricultural systems necessarily lead to increases in soil C stocks. While high inputs of organic fertilizer/tree pruning mulch increased surface-layer soil C stocks, this did not affect stocks in deeper soil, where decreases generally exceeded any gains in surface soil. Therefore site- and system-specific sampling is essential to draw meaningful conclusions for climate change mitigation strategies.

Silva et al. (2015) evaluated the effect of organic fertilization on soil C and N stocks in a Conilon coffee agrosystem in Linhares, Espírito Santo state, Brazil. The authors assessed two organic composts; presence and absence of the jackbean legume between the rows; and five different proportions of each organic compost (0, 25, 50, 75, and 100 %) to substitute the recommended mineral fertilization. The organic composts were compound 1, prepared from elephant grass and coffee straw in a 1:1 ratio (v:v); and compound 2, prepared from elephant grass, coffee straw, and chicken litter in a 2:1:1 ratio (v:v:v). The use of organic compounds to fertilize coffee led to a decrease in soil bulk density of approximately 13 %. The increase in the proportion of organic compounds in fertilization increased the content and stock of C and N in the soil at 30 days after fertilization in the 2^{nd} crop year. There were increases of 11 and 0.4 Mg ha^{-1} for the stock of C and N, respectively, for coffee plants fertilized with 100 % of compound 1, in relation to mineral fertilization. According to the authors, fertilization with organic compounds is an alternative for increasing C and N stocks in agrosystems of conilon coffee.

Tumwebaze & Byakagaba (2016) conducted a study to quantify and compare the soil C stocks among *Coffea arabica L.* (Arabica coffee), *Coffee canephora Pierre ex Froehn* (Robusta coffee) agroforestry systems and Coffee monoculture (coffee monocrops) in Uganda. Soil samples were collected at 0–15 cm and 15–30 cm and tested using routine soil testing procedures. The authors found that there was higher soil C under CAS than coffee monocrops. When intercropped with non- fruit tree species, Robusta CAS produced higher soil C stocks (57.564 t C ha^{-1}) compared to the Arabica CAS (54.543 t C ha^{-1}). In contrast, Arabica CAS stored more soil C (54.01 t C ha^{-1}) compared to Robusta CAS (49.635 t C kg^{-1}) when intercropped with fruit trees like *Artocarpus heterophyllus Lam.* and *Mangifera indica L.* Under the coffee monocrop systems, Robusta coffee sequestered 4.86 t C ha^{-1} more soil C than Arabica coffee. The study showed that a farmer growing Robusta coffee intercropped with non-fruit trees is likely to benefit more from soil carbon credits than a farmer growing Arabica coffee with the same trees. Farmers growing Arabica coffee would sequester more carbon if intercropped with fruit trees. There is need for policy incentives that encourage the planting and maintenance of shade trees in coffee plantations for the benefit of carbon sequestration.

The type of previous land use to the coffee cultivation and the adopted management practices of coffee pruning may affect the dynamics of soil carbon (C) and nitrogen (N). Thus, Cerri et al (2017) quantified soil C and N stocks in the three main coffee production regions of Minas Gerais State, Brazil, evaluating different management systems and coffee cultivation time compared to cultivated pastures. For the calculation of C and N stocks, soil samples were collected to determine the content of C and N, in addition to soil density at different depths. Evaluated situations included management of coffee areas with and without pruning, and the type of previous land use to the coffee crop currently in the areas (i.e. pasture or coffee). The results indicated that coffee cultivation under grazing areas along with the adoption of good agricultural practices such as proper management of pruning and good weed control led to the maintenance of soil C and N stocks over time. The authors pointed out that the three sources of carbon input associated with coffee cultivation (roots and shoots of grasses present between the lines of cultivation, leaves and branches of coffee plantations and trunks pruning) in the three largest producing regions of Minas Gerais contributed to the maintenance of the soil C stock in coffee areas in relation to pasture.

Finally, Chatterjee et al. (2020) assessed SOC stock at various depths (0-10, 10-30, 30-60, and 60-100 cm) in shaded perennial coffee (*Coffea arabica L.*) agroforestry systems in a 17-year-old experimental field at the Centro Agronómico Tropical de Investigación y Enseñanza, Turrialba, Costa Rica. The authors evaluated the treatments including coffee (Coffea arabica L.) grown conventionally (with chemical fertilizers) and organically (without chemical fertilizers) under two shade trees, *Erythrina poeppigiana* and *Terminalia Amazonia*, Sun Coffee (*Coffea arabica L.*) (sole stand of coffee without shade), and Native Forest. The authors found that soil carbon stocks were highest under forest (146.6 Mg C ha^{-1}) and lowest under sun coffee (92.5 Mg C ha^{-1}). No significant differences were noted in soil carbon stock within coffee agroforestry systems and sun coffee across fraction sizes and depth classes. Organic management of coffee under heavily pruned *E. poeppigiana*, with pruned litter returned to soil, increased soil carbon stocks for 0-10 cm depth soil only. High input of organic materials including pruned litter did not improve soil carbon stocks in deeper soil, whereas variations in silt and clay percentages had a significant effect on soil carbon stocks. The authors suggested that high amounts of aboveground biomass alone are not a good indicator of increased soil carbon storage in agroforestry systems, particularly for soils of sites with historical characteristics and management similar to this study.

5.4 Approaches for estimating soil carbon stocks

In a given native system, the soil C stock is in "steady-state", that is, the inputs and outputs of C are offset. When the native system is altered by anthropic activities, the dynamic balance is disrupted and normally, the inputs are smaller than the outputs, leading to a reduction in the amount of C and modifying the quality of the organo-mineral compounds.

The C stock in the soil is also influenced by a number of factors, such as: soil type (mainly relative to mineral fraction), vegetation type (aerial part contribution and root system), climate (dry / cold versus wet / hot), relief (topography may favor, for example, accumulation of C in lowland regions), organisms (quantity and functional diversity), management practices (for example conservation practices such as well-managed pasture, no-tillage system and integration crop-livestock-forests tend to increase soil C, while degraded pastures, excessive use of plowing / harrowing tend to reduce soil C).

Therefore, considering the various factors that directly influence soil C stocks, its adequate assessment is a complex activity with varying uncertainty associated with the results obtained. In this context, several approaches have been proposed in an attempt to assess changes in soil C stocks, mainly due to the change in land use and / or the adoption of management practices.

Among the main existing approaches for estimating the variation of C stocks, using tools or spreadsheets, one can mention the system proposed by the “Carbon Benefits Project” (CBP), the “EX-ACT” tool proposed by FAO. In addition, there are the calculation methods based on the Tier 1, Tier 2 and Tier 3 of the IPCC. These approaches are useful for obtaining general information, but they do not replace a more specific assessment based on field sampling and determination of soil C levels using an elementary analyzer (dry combustion method).

The Carbon Benefits Project (CBP) provides tools for projects aimed at agriculture and forestry to estimate the impact of its activities in mitigating climate change, covering both changes in C stocks and greenhouse gas emissions. The tools can be used at all stages of a project, they are free and relatively easy to use. The tools are divided into a “simple” and a “detailed” module and were developed by Colorado State University and partners as part of a project co-financed by the Global Environment Facility (GEF), led by the UNDP United Nations Environment Program. The simplified module uses standard values (“default”) extracted from the literature to estimate C stocks and gas emissions. In the detailed module, the user needs to insert more specific information about changes in land use and / or agricultural management practices such as the amount of fertilizer applied, types of crops, ways of preparing the soil, etc. Both CBP modules generate, as a result, general information about the situation assessed and provide the respective uncertainties associated with the estimates. Such tools are useful for the general assessment of projects that directly or indirectly aim to assess, roughly, the impacts of their activities on C stocks and gas emissions. CBP itself suggests that more accurate and monitoring-based assessments should be carried out with data directly obtained in field conditions and measured more specifically for each situation assessed (https://banr.nrel.colostate.edu/CBP/).

The EX-ACT tool (Ex-Ante Carbon-balance Tool) was developed by FAO in order to provide ex-ante estimates of the impact of agricultural and forestry development projects on greenhouse gas emissions and C sequestration, showing its C balance effects. For this purpose, the tool uses the standard values extracted from the IPCC reports (Tier 1) and / or more specific coefficients obtained from the literature for some situations associated with agroforestry systems (Tier 2). The user has access to a set of interconnected Excel spreadsheets to estimate the potential accumulations or losses of soil C and the emission of greenhouse gases. There is information that allows to know the uncertainties associated with such estimates. Similarly to the CBP tools, the EX-ACT was not designed to provide detailed or even specific information for a given situation. These are useful tools for general knowledge of the magnitudes of the values of C stocks and gas emissions from activities associated with agriculture and forestry systems (http://www.fao.org/tc/exact/ex-act-inicio/en/).

The IPCC classified the methodological approaches for national estimation of greenhouse gas emissions and C stocks into three different tiers (levels), according to the amount of information needed and the degree of analytical complexity (IPCC, 2003, 2006). Tier 1 uses the standard emission factors ("default") provided by the IPCC, which is of general scope. In this sense, according to the IPCC document (IPCC 2003, 2006) the stock change assessment method is not applicable in the context of tier 1 due to the more specific data requirements of the situation to be assessed. Tier 2 is based on the same methodological approach as Tier 1, but uses emission factors and other country-specific parameters. Country-specific emission factors and parameters are most appropriate for that country's forests, climatic regions and land use systems. More highly stratified activity data may be needed for the tier 2 approach to match country-specific emission factors and parameters for specific regions and specialized categories of land use. In tier 3, simulation models are used, which must be adapted to meet national circumstances. Properly implemented, the simulation models can be combined with geographic information systems to cover greater territorial extensions. Progress from tier 1 to tier 3 may represent a potential reduction in the uncertainty in estimates of greenhouse gas emissions and variation in C stocks, but the reduced uncertainties associated with the procedure that calls for the collection of samples in the field, analysis in specialized laboratories and calculation of C stocks; as will be discussed in the following items.

It can be said that the approaches presented here are useful for the general knowledge of the values of C stocks, usually accompanied by high associated uncertainty, since the purpose of such tools is to provide generic / coarse information and usually more applicable to contexts broader inventories and estimates before a given project / action has actually been implemented (ie "ex-ante"). Therefore, for the quantification of specific situations of land use change and / or agricultural management practices and adequate monitoring of changes in C stocks in the soil, it is highly recommended that the evaluation be based on data obtained from samples collected in real conditions of field, as proposed by IPCC (2006). For that, it is necessary to collect soil samples in the field, properly prepare the collected samples, determine the C content of the soil in a specialized laboratory and correctly express the results in the form of "C stocks", as will be presented in the items to follow.

5.5 Calculation of soil carbon stocks

Assessments with greater precision and accuracy on soil C stocks should be based on the collection of soil samples, preparation of collected samples, determination of C levels in specialized laboratories and correct expression of analytical results by calculating C stocks for a given evaluated soil layer. The calculation of the C stock is based on the following equation:

$$\text{Soil C stock} = \text{soil C content} \times \text{soil bulk density} \times \text{soil layer}$$

Therefore, there is a need to determine not only the C content of the soil, but also the density of the soil and the thickness of the evaluated soil layer. The following will present important information for an adequate assessment of soil C stocks.

5.5.1 Soil sampling to determine carbon content

In characterizing the C content of soil in an area, it is generally not possible to examine the entire soil and therefore it is necessary to collect samples. The collected soil samples must be as representative as possible of the entire area to be evaluated. Pre-selection of the area where the samples will be collected can be done using soil maps, land use maps, aerial photographs, satellite images and interviews on the history of land use. In addition to office work, site visits can be used to assess the exact location of sampling points. Ideally, the location to be sampled should be as homogeneous as possible and representative of the land use or management practice adopted. Whenever possible, select the flattest part of the relief and pay attention to the type of soil in which the samples will be collected, especially with regard to soil texture, that is, comparisons between land uses or management practices should be carried out on soils under the same texture (ideally with a difference of less than 5-10% in the clay contents of the evaluated soils).

The grid sampling scheme provides good coverage of the sampled area, allowing for future identification of the area for resampling purposes. Each sampling area must be geo-referenced using a GPS device, and the sampling points must be plotted on a map of the area. A 3 × 3 grid, totaling 9 trenches, 50 m apart (Figure 5.5), covering an area of one hectare, is suitable for assessments in areas under native vegetation and altered by anthropogenic activities (agriculture, livestock, forestry etc.) .

The IPCC suggests that at least the 0.3m surface of the soil profile be considered. However, several authors have emphasized the need to investigate soil C stocks in deeper layers when assessing the impact of changes in land use and management practices, preferably up to 1.0m deep. Therefore, samples should be collected in stratified soil layers, since the C in the soil does not have linear behavior along the profile. The samples must be sampled in layers from 0.1 m to 1 m deep in 3 of the 9 trenches, that is, in the 3 deepest trenches samples must be collected in the following soil layers: 0-0.1; 0.1-0.2; 0.2-0.3; 0.3-0.4; 0.4-0.5; 0.5-0.6; 0.6-0.7; 0.7-0.8; 0.8-0.9 and 0.9-1.0 m and in the remaining 6 trenches samples can be collected only in the superficial layers (0.0-0.1; 0.1-0.2 and 0.2-0.3m) as suggested by Cerri et al. 2013 and illustrated in Figure 5.5.

Once the sampling grid has been established and marked in the field, soil sampling will consist of two steps: i) gain access to the sampling point (remove any plant material from the soil surface and dig the trenches to the desired sampling depth); and ii) carry out the collection of soil samples. Most of the vegetable remains that may be on the surface must be removed by hand carefully. The deepest trenches must measure 1.5m (depth) × 1.5m (length) × 1.0m (width), and the smaller trenches must measure 0.4m

× 0.4m × 0.4m. After the trenches are excavated, soil samples will be collected in 0.1 m increments, using a knife, spatula or other tool that allows a volume of soil to be removed from the sampled layer (Figure 5.6).

Figure 5.5. Sampling scheme for soil C and soil bulk density determinations. The nine trenches cover an area of 1 hectare. In six trenches, soil samples are taken at depths 0.0-0.1; 0.1-0.2 and 0.2-0.3 m. In the remaining three trenches, the soil is sampled every 0.1m to a depth of 1.0m.

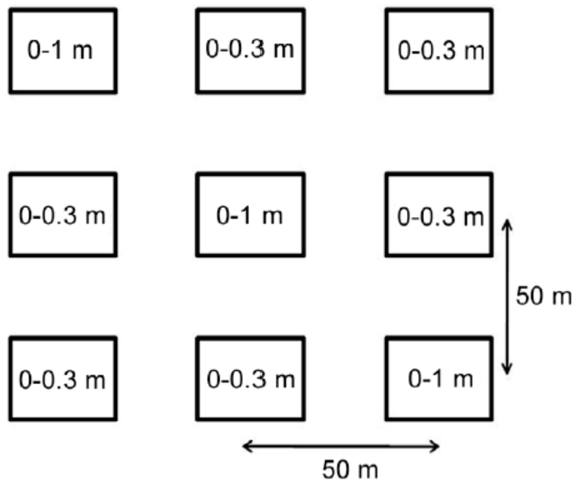


Figure 5.6. Collection of soil samples in trenches 1.5 m deep for sampling up to the 90-100 cm layer.

When sampling in agricultural areas, samples should be collected both on the lines and between the lines, in order to detect possible spatial differences related to machine traffic, soil preparation operations and other effects of management practices.

5.5.2 Preparation of collected samples

After collected, soil samples must be prepared to be analyzed in the laboratory. For this purpose, the collected samples must be air dried, homogenized and sieved in a 2 mm sieve, obtaining two fractions: air-dried fine earth less than 2 mm (TFSA) and fraction greater than 2 mm, consisting of roots and small rocks.

For the determination of the C content by the dry combustion method, the most recommended method due to its high precision and accuracy, a subsample with about 6 g of air-dried fine soil must be ground enough to pass through the 60 meshes sieve, or that is, mesh with a diameter less than 0.250 mm. Subsequently, approximately 20 to 30 mg of the ground earth is weighed in an analytical balance of 5 decimal places, this amount being placed in tin capsules with a dimension of 8 x 5 mm for the determination of the C content in the elemental analyzer (dry combustion method)) (Figure 5.7).

Figure 5.7. Steps for preparing the collected samples (sieving and grinding), weighing and elementary analyzer equipment to determine the C content of the sample.

5.5.3 Analyses of soil carbon content by wet oxidation or dry combustion

The general principle of the dry method (also known as the combustion method or determination via an elementary analyzer) is the oxidation of C and thermal decomposition of carbonated minerals by heating a soil-catalyst mixture in a resistance furnace or with a circulation of oxygen (temperature around 1, 000 to 1, 500 ° C). For this, an equipment called an elementary analyzer is used. The principle of most devices used for analysis is related to the measurement of soil C based on the measurement of CO_2 by medium infrared, where CO_2 is formed by the oxidation of the organic and inorganic constituents of the sample.

An important aspect to be mentioned is that at the time of soil sampling, one should analyze the possible presence of carbonated minerals, such as rock fragments or secondary minerals (carbonate nodules), or in agricultural areas by the recent application of limestone as a corrective or nitrogen fertilizers. As the procedure does not discriminate against origin of the elements, knowledge of the sample history is important in the evaluation and interpretation of results.

The great advantage of this method is the high accuracy and precision of the analytical results. However, it is an expensive method and requires sophisticated equipment (elementary analyzer) and trained technician for its correct operation. Some considerations about determining the C content via the combustion method:

i) If the interest is in determining the C content (when in the presence of limestone), one should: 1) Acidify the sample to eliminate the C from the limestone (CO_2) and 2) Analyze the sample containing C in organic form.

ii) If the interest is in determining the C content (when in the presence of coal), one must: 1) Eliminate the coal by flotation with inorganic liquids with high density and 2) Analyze the sample without coal;

iii) If the interest is in determining the content of organic and mineral C, when the sample is known to contain organic C + limestone (inorganic C), the following steps must be carried out: 1) proceed with total C determination, 2) Acidify (usually with HCl) the sample for carbonate removal (inorganic fraction), 3) Quantify the C of the sample devoid of carbonate (ie, containing only C in organic form) and 4) Calculate the difference between total C – organic C.

It should be mentioned that there are other methods for determining the C content of the soil, the best known of which is "Walkley & Black" also called "wet oxidation" or "potassium dichromate". This method is more suitable for use in routine analyzes for the purpose of assessing soil fertility and has less precision and accuracy than the determination of the C content obtained by the elementary analyzer (or also called the dry method). More information on the method for determining the C content of the soil for purposes of assessing soil fertility can be found in the Box 5.2 below.

Box 5.2 Method of determining soil carbon content for soil fertility purpose (expression in soil organic matter)

The general principle of the wet oxidation method (also called oxidation with dichromate or Walkley & Black) is based on the oxidation of C in organic form with dichromate ions in an acid medium and determination of the easily oxidizable material. This method is more appropriate for assessing soil fertility in routine analysis laboratories. Potassium dichromate, in the presence of H_2SO_4 and hot, transforms into CO_2 all easily oxidizable forms of soil C. The reaction associated with determining the C content of the soil sample is shown below:

$$2\ Cr_2O_7^{-2} + 3C + 16H^+ \rightarrow 4\ Cr^{+3} + 3CO_2 + 8H_2O$$

The excess dichromate is titrated with a Mohr salt solution $[(NH_4)_2\ Fe(SO_4)_2 \ldots 6H_2O]$. In addition, there is a recovery factor of 77% (60-86%) for conversion from easily oxidizable organic C to total organic C. Standardization is done with 25 and 50 mg EDTA. More details on this method can be found in Walkley (1947).

Some observations and criticisms related to the present method are: 1) it is the most used method in routine laboratories in Brazil, as it does not require the use of specific equipment; 2) Only C in the organic form is determined (only organic C that is easily oxidizable, therefore the need to use the recovery factor). Therefore, it is not a suitable method for soils with significant presence of inorganic C and 3) It is not a method considered clean, as it generates residues containing, for example, chromium and sulfuric acid.

Some laboratories that perform routine analyzes for the purpose of evaluating soil fertility, present the total SOM content of a soil in their routine analyzes. This total SOM value is obtained by multiplying % C by a factor with a constant value of approximately 1.73. This factor is derived from works mainly by the Russian researcher Kononova, who in the 50s and 60s, determined that the average C content of humic acids extracted from different soils was approximately 58. As researchers at the time considered humus as a synonym for MOS, this factor of 1.73 (100/58) was introduced to estimate the SOM. Although humic substances represent the highest percentage of SOM, currently this index is no longer used in research, because other constituents in addition to humic acids, with different levels of C are also considered as SOM.

5.5.4 Determination of soil bulk density

Soil density is defined as the mass of the volume unit. Two main types of density are considered: the real or particle density and the apparent or bulk density, or even soil density. Actual or particle density is not affected by the arrangement of soil solids, nor by texture and porosity. It depends only on the mineralogical nature and the content of organic matter. In the apparent or bulk density, the total volume of the soil, including porosity, is taken into account. For the calculation of soil C stocks, the bulk density is used.

The overall density has been determined by the volumetric ring and the paraffin or clod method: the first is more used in assessments related to C stocks in the soil. The procedure recommends the introduction of the ring in the layer to be evaluated (coinciding with the soil layer sampled to determine the C content), being careful not to compact the soil at the end of the beater (Figure 5.8). Remove the ring, trimming the excess soil on both sides with a knife. Place in an aluminum box, close it tightly with masking tape and, in the laboratory, dry in a study at 105-110ºC for 24 hours and weigh (evaluate the humidity, if you want). The calculation of the ring volume takes into account the equation $V = \pi r^2 h$ and usually the unit of expression of the bulk density is g cm^{-3} (or t m^{-3}).

Figure 5.8. Collector auger for undisturbed samples (using volumetric ring) to determine soil bulk density.

Box 5.3 Estimation of soil bulk density via pedotransfer equation

Pedotransfer equations represent a strategy increasingly used for the estimation of soil attributes with the purpose of supplying the absence of information about certain soil properties. Thus, this approach has been used in order to estimate soil attributes that require a long time of execution and / or are expensive to obtain. In this context, regression models or pedotransfer functions can be used to estimate, for example, the soil density of layers that have not been sampled.

The estimation of soil bulk density is one of the biggest sources of uncertainty for calculating C stocks. Although the determination of soil bulk density comes from a relationship between land mass and occupied volume, variables that are theoretically easy obtaining, it is a fact that there is difficulty in obtaining safe and accurate information about the density of the soil (Barros & Fearnside, 2015). This has stimulated the creation of many predictions of soil bulk density that explore the relationships between this parameter and other variables most commonly available in pedological inventories, in order to guarantee reliability on carbon stocks and reduce assessment costs (Bernoux et al ., 1998).

Pedotransfer equations built based on common parameters in pedological inventories, such as carbon content and clay content, show great potential to represent direct measures of soil bulk density when these are difficult to access or are unavailable (Benites et al., 2007).

However, it should be mentioned that the measurement of the soil bulk density values under field conditions is always more reliable and reflects less uncertainty than the use of estimated values from pedotransfer equations elaborated from such or more complex attributes. and that can present high spatial variability.

5.5.5 Expression of soil carbon stocks: comparison based on equivalent soil mass

As soil samples are always collected in the field in fixed layers, errors can be made in calculating C stocks, due to the variation in soil bulk density due to change in vegetation or management practice. Therefore, considering that the C stock is also a function of soil bulk density, factors such as machine traffic and soil tillage, which affect soil density, can influence the results. Correcting the density of all locations for a reference area, the stock comparison will be made considering the same soil mass (Ellert and Bettany, 1996). The C stocks in the evaluated areas must be calculated at an equivalent depth, that is, considering the depth that contains the same soil mass as the corresponding layer of the reference area. The reference areas are generally a location under native vegetation or a previous land use (eg, pasture), depending on the land use history of the assessed area.

Box 5.4 Diachronic and synchronic approaches

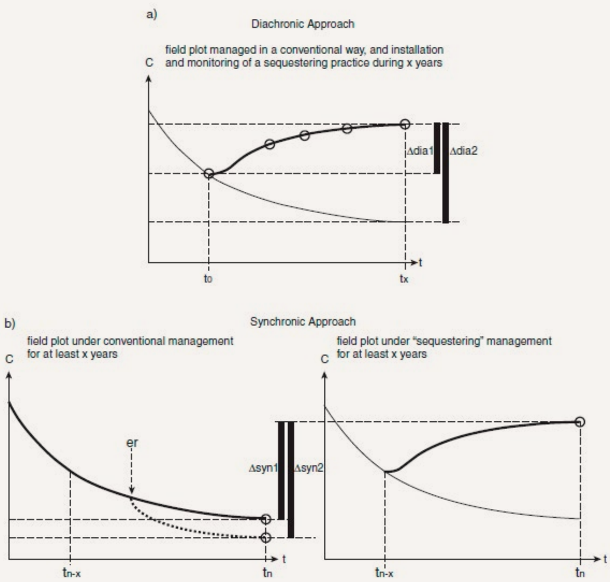
There are two different approaches to soil sampling to assess soil C stocks: diachronic and synchronic (Figure 5.9, Source: Bernoux et al. 2006).

In the first, soil C stocks are measured over time in the same location (field plots) with different land use or management treatments (example: experiment in field conditions). This is expensive and usually has an evaluation time limitation, since soil carbon can take a long time to show significant differences.

In the second approach (synchronous or chronosequence), samples are collected at the same time in plots in the field under different land use or management systems. In this approach, the soil C stocks in the area to be evaluated are compared to the soil stocks under initial reference state (usually under native vegetation). The main premise with the synchronous or chronosequence approach, where space replaces time, is that soil conditions, topography, climate etc. are similar to each other, with the only variable being the time of land use adoption or management (Costa Junior et al., 2013).

In theory, the diachronic and synchronic approaches should provide approximately the same results for soil C stocks. However, in practice in the synchronic approach, it is practically impossible to eliminate all the environmental factors that influence soil C stocks due to the high spatial variability, especially of soil properties.

Figure 5.9. Comparison of the diachronic (a) and synchronic (b) approaches. Black circles correspond to the determination of carbon stocks. "Er" means erosion.



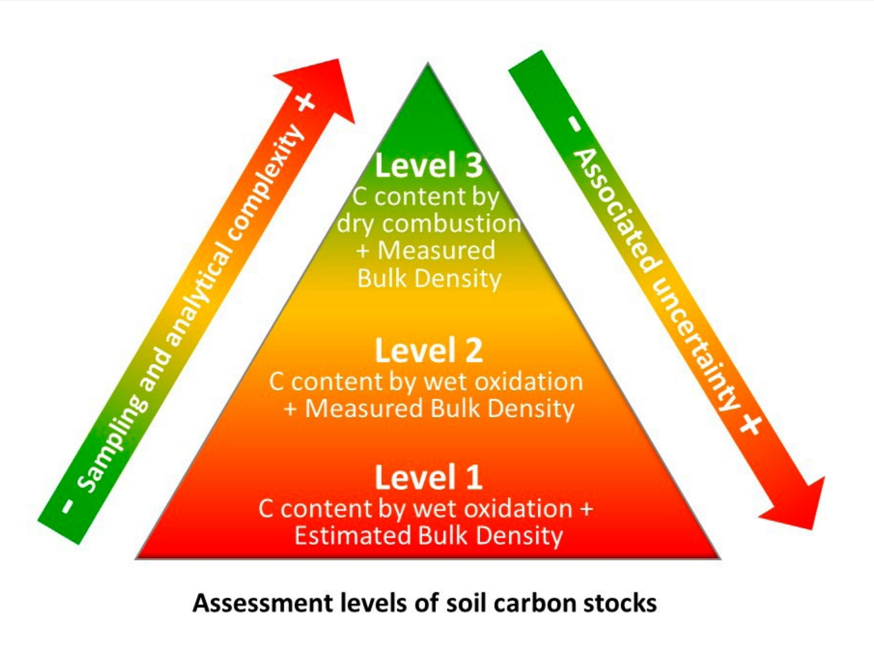
Source: Bernoux et al. (2006).

Box 5.5 Uncertainty associated with the measurement of soil carbon stocks

As already mentioned in this document, there are several methods for determining soil C content (such as the wet oxidation method also called Walkley & Blach and the dry method or elemental analyzer) and ways of estimating soil bulk density (for example, by pedotransfer equations), both of which are essential information for the calculation of soil C stocks.

Although it is possible to use the results from the C determination by the wet oxidation method and estimates of soil bulk density using pedotransfer equations, these options usually provide a high uncertainty associated with calculations of soil C stocks. Figure 5.10 illustrates a gradient with three levels of determination of the C content and density of the soil and its associated uncertainties.

Figure 5.10. Schematic illustration of the levels of assessment of soil carbon stocks.



In this context, level 3 (Figure 5.10) is recommended to obtain less uncertainty associated with the calculation of the soil C stock, that is, collection of samples under field conditions to determine the soil C content by the method via dry combustion (also called "determination by elemental analyzer"), measurement of soil bulk density in field conditions (that is, use of pedotransfer equations in very specific cases for which direct measurement with samples collected in the field is not possible) and remembering the possible need for adjustments to the calculations so that equivalent masses of soil are compared to the situations for which it is intended to compare C stocks (see more details in previous BOX). Levels 1 and 2 in Figure 5.10 are useful to give a general idea about trends and estimate the magnitude of the stock values, but have greater associated uncertainty, generally not consistent with the requirements required by institutions directly linked to the topic of soil C measurement.

5.6 Final considerations

Carbon is a commonly occurring element but it has an uncommon role in nature and human history, due to the fact that C is key component in the vital energy transfers that enable live of all plants and animals. For organisms other than people, the exchange of C with the atmosphere and among organisms involves the manufacture of food through photosynthesis, the transfer of food energy in food chains, and respiration. As a result, part of this C is allocated into the soil. Soil C in the form of organic matter is a key component of the soil ecosystem structure. Thus, the soil C content is an important contributing factor in the many flows and transformations of matter, energy and biodiversity – the essential soil functions that provide ecosystem services and life-sustaining benefits from soil. Soil C content and soil functions are under threat worldwide due to resource demands and the increasing intensification of land use. The agricultural use of the soil with conventional cultivation techniques has been pointed out as one of the main causes of greenhouse gas emissions to the atmosphere, potentiating global warming, whose adverse consequences may influence agricultural productivity itself. More recently, the adoption of conservationist management systems has changed this paradigm. Research results show that these practices can, on the one hand, reduce emissions of gases into the atmosphere and, on the other hand, incorporate and store C in the soil ("carbon sequestration"), which was previously found in the atmosphere in the form of CO_2.

Thus, conservation management systems, in addition to reducing production costs without changing productivity, also have the function of mitigating global climate changes. However, despite the clear environmental benefits they produce, they are not necessarily recognized yet to apply for C credits under the United Nations Framework Convention on Climate Change. Thus, immediate political actions are needed to make this reduction in gas emissions, and the increase in C sequestration by the soil due to the adoption of land uses and conservation systems, widely recognized as eligible activities. In this context, one of the obstacles for the broader inclusion of the soil C stocks into the scope of the global carbon market is the lack of knowledge about the assessment of soil C stocks for the analysis of C sequestration. The subject is considerably complex due to interconnection of several factors including the difficulty to assess soil

C stock changes under field conditions due to the large heterogeneity of soil, topography and vegetation types with implications for rates of C stock changes; the relatively high cost of direct measuring soil C stock changes; the need for a baseline scenario to determine additional soil C stocks; the non-permanence of soil C stock gained; the potential leakage of C stock gained within the primary project boundary; the need for estimating the net additional or incremental soil C stock gain over the baseline stock gain or loss; the scale of the project with implications for heterogeneity of land-use systems; among other issues.

Despite current knowledge on soil C stocks and changes, there are still multiple uncertainties and challenges for the management of soil C that call for an action global program. Uncertainties include, but are not limited to the quantification of synergies between the different benefits of soil C, defining critical thresholds for achieving gains by individual and multiple benefits, and establishing the time frame needed to reach the level required for significant impact on an environmental service. In addition, the significance of change in soil C towards a social benefit is not well understood. This material helps to elucidate important aspects associated with the proper assessment of soil C stocks, and the consequent approach on the potential for C sequestration in systems under native vegetation and also in those altered by human activities. We should take advantage of current scientific knowledge on soil C characteristics, its dynamics and complexity, and managements that affect it, to direct efforts towards key missing areas and to improve knowledge and practices towards the long-term goals of increasing soil C. It seems that, in addition to the issues already pointed out, another significant underlying reasons for lack of investment in soil C is the mismatch between short- and long-term objectives in land management. It follows that irrespective of the favorable long-term economic case for investment in soil carbon, such investments are unlikely to come about without policy intervention. Soil C could be promoted not only through global carbon markets but also through the payment of ecosystem services and schemes to reduce the intertemporal trade-offs between short- and long-term objectives. Ultimately, we suggest that any of these priorities cannot be attained without extensive education efforts on the benefits of soil C to increase public understanding of the need to protect soils around the world. Thus, there is an urgent need for overcoming the barriers to the adoption of practices that enhance soil C through appropriate policies, investment and land-use planning at various scales.

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6 Final Considerations

6.1 Virtuous Agriculture. What is? Where are we?

There are many international movements inclined to return to the ideas of soil and food health that began in the early 20th century. These ideas were propagated by attracting followers from various categories, which included, scientists, religious, lay-people, and ordinary people interested in having healthy food, coming from healthy soils, and the environment as a whole. The movements spread across different continents with different orientations. These differences, when compared in an organization chart, show that some movements were concomitant, and practically all of them valued the health of the soil to produce healthy food. Thus, under different denominations in different places, movements with this common nature emerged.

Due to the pandemic of the new coronavirus-19 many initiatives with organics that had been doing well in terms of marketing and sales, suffered an impact. There have been some distribution chains that have been disrupted by the fact that their physical sales outlets could no longer be frequented by consumers. On the other hand, new start-ups in the food segment have emerged. They envisioned reaching the consumer with their logistical means and this included raw and processed organic products, as well as ready to consume food in their product baskets.

In the huge nomenclature of healthy methods and ways of producing an idea of regenerative agriculture arises, which can be considered as the combination of all healthy ways of producing. A clear and consistent definition of virtuous agriculture is still in gestation. At the moment we can say that it constitutes a sum of methods that, at the same time that they manage the environment through friendly practices, they produce healthy food from healthy soil.

We are in a period of major changes in the ways of operating in agribusiness segments. Consumers who kept the flux of money going on in the agrisystem of organics disappeared physically from the markets for more than 90 days. And the initiatives to supply these consumers by making delivery systems not always closed the gap left by the pandemic. Many consumers are not able to manage information technology systems to make their shopping causing these impacts. With the cloudy horizon of a new wave of covid-19, businesses established at physical points of sale may suffer greater impacts. However, many alternatives remain, which are increasingly creative in making new forms of commercialization so that products can reach consumers. On the production side, operations have not changed much, as there are not many different alternatives.

Some variations in the way of operating and mechanizing all operations with vegetables, from planting to harvest, have been introduced in the European Community and the United States. These systems provide for intense machine connectivity with software, 4G internet, and higher, traceability, certifications, and guarantees to the consumer that the product to be consumed meets all the requirements of hygiene, health, purity, nutrition, sustainability in production, and respect for natural resources and to the man who operates these functions. The workforce tends to be increasingly reduced and specialized, as well as the high-performance technical assistance that these disruptive technologies call for. It is no different in coffee, nor other crops.

6.2 The mother of all market failures. The global warming

Market failure is a situation in which the allocation of goods and services by a free market is not efficient. It often leads to a net loss of social welfare. The following examples show some of the market failures:

a) Rent-seeking

It is an economic concept that occurs when an organization or entity seeks to gain wealth using its influence with the government to obtain advantages, at the expense of other agents of society without any reciprocal contribution to productivity. It generally involves government social services and social service programs.

b) Asymmetry of information

Among the information, asymmetries are **adverse selection** and **moral risk**. **Adverse selection** occurs when it is not possible to differentiate between good and bad products. For example, in a used car sale, there are used cars in good condition and those in poor condition. However, only salespeople know the real state of the vehicles. Buyers don't know it. What happens then is that the selling price of the vehicle will be an average price. That is, above the value of the bad car and below the value of the good car. This, over time, will drive out sellers of good cars, making the price lower for sellers of bad cars. A solution to this problem is to offer guarantees proving that one product is better than the other. Good quality products tend to offer longer warranty periods, eventually eliminating the problem of asymmetric information.

Moral risk occurs when people change their attitude during an economic transaction. An example is a new car purchased without insurance. The driver will drive very carefully. However, after taking out insurance, he may feel more comfortable and drive less carefully. This is the moral hazard (age, gender, the existence of garages, going to college at night, number of claims in the past, etc.) that the insurer runs and needs to estimate when making the contract.

c) Externalities generated by climate change. The mother of all market failure

When market results affect other agents, the effects generated are called externalities for those who do not participate directly, as buyers and sellers.

The fact is that there is an environmental cost associated with the effect of CO2 emissions. This cost is dispersed and falls on the entire society.

There are benefits to the production sector because the costs of producing rural goods are not internalized.

What are the ways to internalize environmental costs and why is it done? We are looking for ways to internalize costs because it is known that if the market failure is corrected, there will be a social gain. In the case of CO2, global warming may be reduced and this is desirable.

It can be believed that all participants in the production system will act in a socially responsible manner. This is unlikely to work, as each agent makes isolated decisions. There will always be those who will increase their margin without adopting the appropriate technologies or practices.

The market can reward those who are socially responsible, but it doesn't always work. There may even be some markets that reward agents by paying a higher price. It can work if certifications are well done and brands capture these margins. In general, it is not a solution for the entire market, but only for part of it. For example, perhaps consumers of a particular brand of coffee will accept to pay a premium for quality, plus care for the environment. But what about the other companies?

6.3 The 20th century, the green revolution and the challenge of carbon balance

The State can legislate and institutionalize conservationist practices. This is the path followed by the European Union. In other words, institutions improve themselves by creating sanctions/incentives for those who work within or outside the law.

The paths to be taken to face climate change are often not resultant of the instantaneous politics that assumed the power for a certain mandate. They are policies of the long term. Some Blocks like the European Community, have more stable institutions and more lasting rules. Other blocks are guided by total market liberalization or export interests for their products.

In the 20th century, there was the Green Revolution, whose purpose was to guarantee, through genetic improvement and synthetic inputs, the supply of food to the world, avoiding the wars eventually generated by hunger. A great effort has been made by the world community in this regard. Genetic improvement programs have been carried out in international research centers in several countries and large numbers of cultivars of basic products such as cereals and others have been produced. This was a momentary solution to alleviate the acute shortage of food at the time.

With the advancing years and the continuous emission of CO2 and equivalent greenhouse gases, given the maintenance of the *status quo* and *modus vivendi* of the most affluent social classes of the planet, an impasse raised by scientists has reached: things as they were, the land and its inhabitants would not have longevity and would be seriously threatened in their survival until the year 2, 100. From the Rio1992 conference and summit on the environment, regulatory measures that could mitigate these warming effects agreed at International Summit Conferences, began to be outlined. The sustainability of the planet and, in the case we studied, of agricultural production, came to be pressured and influenced by civil society, which was no longer inclined to consume products that had not been produced within standards of respect for the environment and its natural resources. , social respect for workers who participated in production and respect for agricultural and livestock products, which should be free from chemical and biological contamination.

6.4 The 21st century. The contradiction between conscious consumption (market solutions) and non-conscious consumer (market regulation)

This 21st century foresees several new challenges for world food producers. One of them is carbon neutralization, not only in food production but in all human activities. Conscious consumers started to see the carbon emissions produced by all human activities as being responsible for climate change through the emission of greenhouse gases. The market may offer, through companies, solutions to reduce carbon emissions that serve their consumers, concerned with the effects of global climate change. In a simplified way, they will be products and services that guarantee the consumer that they were produced with carbon neutralization. This guarantee can be made through certification processes accredited by third party organizations and that have the credibility of the consumer. In countries or regions where producers and consumers are not aware of and do not want to internalize the costs of reducing carbon emissions, regulatory measures imposed by the authorities to curb emissions through command and control mechanisms may take place. Taxes and polluter-payer solutions may be adopted, but have unsatisfactory effectiveness in mitigating the emissions problem. It is known from our own experience in Brazil that these mechanisms are not always efficient in solving environmental problems. The command is sometimes strong but the control is often flawed. A third alternative that is being outlined is the voluntary carbon markets, existing in some states of the United States and some provinces of China. Some are not new experiences, some dating back to the 1980s, as in the case of issues in the Detroit and Chicago region in the United States and their commercialization in stock exchanges and over-the-counter. In China, however, the most recent experiences involved the provinces of Guang Zhou, Shanghai, and Huang Zhou.

Polarized Views

a) The clash between productivism and virtuosity

We are witnessing a real clash between people and technicians who fiercely defend the productivist and the virtuous models, using different arguments.

The arguments most commonly used to defend **productivism** are:

- There is no space to produce without chemical and synthetic inputs and areas of three planets equal to the earth would be needed to satisfy the food needs of a growing population.
- The spectrum of hunger hangs over the planet and can only be solved with conventional agriculture.
- There is no danger in using products that are toxic to man or chemical fertilizers in agriculture as long as they are well used within the best agronomic practices.
- Historically, the action of public research and extension institutions according to Moro (2012) has assumed its development, linked to the agricultural industrialization process, known as the Green Revolution.
- Public institutions and rural extension agencies promoted, according to Moro (2012), productivity contests aiming only at greater productivity among farmers without other goals involved.
- The training of agronomists and technicians in general, was aimed at increasing productivity. The great quest was to increase productivity and increase production. In the wake of the green revolution, this model was a success, an almost unquestionable paradigm because it worked. With this model, food production doubled, tripled, and quadrupled it doubled, tripled, quadrupled improving the quality of life of some farmers who adopted the use of modern inputs and mechanization.
- The main pillars, according to Jesus (2005), of the conventional model were: (1) Pillar of agrochemicals: production of agrochemicals that allow environmental restrictions, both concerning soil fertility, and in the control of weeds, diseases and plants invasive; (2) The mechanization pillar: which made production costs

68% cheaper, with the replacement of labor, facilitating intensive and extensive monoculture; and (3) Genetic pillar: it provided work with plants and animals with a high response to chemical inputs, also contributing to the increase of genetic uniformity and reduction of biodiversity

The most common arguments for the defense of **unconventional agriculture** are:

- The products exogenous to the property can threaten the integrity of the soil-plant-man ecosystems, causing harm to the environment and man. Soil and human poisoning occur via the food that people consume.
- It is not possible to produce healthy food if the soil is not healthy.
- The balanced and holistically integrated production medium produces more vigorously, better resists attacks from diseases, pests, and predators.
- Natural or organic food does not cause diseases to mankind in the long run due to the absence of harmful waste.
- Integrative philosophy where high productivity is not better. Balanced production produces healthy food. Quality over quantity. Less is more.
- Food must be produced in harmony with nature and human dignity, increasing the quality of life, notably the health of those who produce and those who consume
- The agriculture and animal production must generate tasty, nutritious, healthy, and abundant food, without toxic residues and good commercial aspect
- Rational use of natural production resources, recovering soil, water, air, and organisms.
- Conserve the biological diversity of cultivars and breeds, avoiding genetic erosion, through the maintenance of plant, animal, and microbial biodiversity, ensuring the stability of agroecosystems and natural systems.

Lobbies, speeches, the communication war

Real lobbies are defending opposite sides in the communication dispute. Consumers in more advanced countries, the generation of Millennials, generations x, y, and z tend to be more inclined towards unconventional food to satisfy their needs and are more likely to seek balance rather than price in food. In the food-importing countries, however, the center of the decision is still the price, since their condition as an importer makes them accept conventional products at the lowest possible prices.

Virtuous farming in practice

In practice, virtuous agriculture already exists under a large number of denominations. It appears that a broad front of movements that value ethics, the health of the planet, of people and other living beings moves in an attempt to join forces for a more dignified and long-lived life on planet earth.

6.5 Incentive Solutions

As we saw previously, climate change is a market failure. The carbon market, the carbon pricing mechanisms, and the carbon taxes are solutions created to internalize the environmental and social costs of carbon pollution that were transferred to society.

The proper functioning of the carbon market gives time and encourages companies to adapt and innovate to reduce greenhouse gas emissions. In chapter 3 of this report, "Emissions trade systems: how effective they are?", Marco Antônio Fujihara explains that carbon credit is a generic term for any tradable certificate or permit representing the right to emit one tonne of carbon dioxide or the equivalent amount of different greenhouse gases (tCO2e). The carbon markets aim to reduce the cost of greenhouse gas emissions by setting limits and allowing the trading of emission units.

There are many criticisms about the effectiveness of carbon offsets. There are polarized views even about the anthropic influence on global warming. Despite the criticism, many initiatives have been developed as market solutions. The turnover in global emissions trading hit a record high of 214 billion dollars in 2019[1].

In addition to the compliance market, there is a voluntary market, where agents buy carbon offsets to mitigate their emissions from transportation, electricity use, and other sources. This market is much smaller, nevertheless, voluntary sector initiatives have played a prominent role and they can be the focus of change in the future.

There is also the role of conscious consumers, they can value lower carbon attributes and then stimulate the entire system of production.

Offsets typically support projects that reduce the emission of greenhouse gases in the short or long-term. There are many initiatives where Negative Emissions Technologies (NETs) are used in agriculture with significant socio-environmental benefits, especially in developing countries. Some projects have complex governance structures and incentive systems involving multinational corporations (such as Bayer and Cargill), cooperatives, and producer-based organizations. They involve multitudes of private-private, public-private partnerships, alliances, and/or contractual relationships.

The pilot program of Bayer will pay farmers from Brazil and the US for capturing carbon in croplands. They expect to invest 5 million euros in the next three years. To participate farmers are required to sign up in their digital farming platform to inform their eco-friendly agricultural practices, including no-till farming or planting cover

1. Reuters. Global carbon trading turnover at record $214 billion last year: research. JANUARY 24, 2020. Available in: https://www.reuters.com/article/us-carbontrading-turnover-idUSKBN1ZN1RN

crops. Satellite imagery could then verify that information. The payment is going to be in credits to buy products or in cash.

Another initiative involves Land O'Lakes Inc. and Microsoft Corp. They announced a multiyear strategic alliance to create pioneering innovations in agriculture and improve the supply chain, expand sustainability practices for farmers and the food system, and close the rural broadband gap. Land O'Lakes can obtain insights to motivate intelligent agriculture solutions for farmers while lowering the farm carbon footprint. Also, the alliance will develop capabilities to predict the carbon benefits of regenerative practices.

Some companies have attained the Climate Neutral Certification, it establishes that they have achieved absolute net zero or better impact on the world's climate. The first company that receives this Climate Neutral certification was in April 2000. The first coffee company recognized as carbon neutral was Salt Spring Coffee in 2010.

Among voluntary actions by companies, we can highlight the action of illycaffè that launched in July 2020 the project #ONEMAKESTHEDIFFERENCE[2]. The goal is becoming carbon neutral by 2033, 100 years since the company was founded. This project is part of its global sustainability plan. The first step is the elimination of approximately 175 tons of plastic per year.

6.6 Regulatory Solution

In chapter 4 of this publication, Kostas Karantininis presents the study "Overview of policies and institutional frameworks on GHG emissions in the EU, China, Africa, with special reference to the role of agriculture". He explains that climate change is a global problem that requires global action. The global policy framework comprises the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol, and the Paris Agreement.

All the countries that signed the Kyoto Protocol and the Paris agreement follow two lines of policy: Mitigation and Adaptation. Mitigation refers to reduce the emissions of greenhouse gases and enhancing their sinks. Adaptation to climate change refers to policies to minimize their adverse impacts or to explore any opportunities that may arise.

European Union was the first region to implement an emissions trading system (ETS) and it is the largest regional ETS in the world. The 31 countries plus Albania, Liechtenstein, Turkey, Kosovo, Bosnia and Herzegovina, Montenegro, North Macedonia, Serbia formed the European Environmental Agency (EEA). They follow three instrumental strategies:

2. More information: https://www.illy.com/en-us/live-happilly/sustainable-coffee-one-makes-the-difference

- The EU Emissions Trading System (ETS),
- The Effort Sharing Regulation (sets mandatory annual targets to reduce GHG emissions in sectors not covered by the ETS (eg road transport, waste, agriculture, and buildings),
- LULUCF Regulation (Land Use, Land Use Change, and Forests), this regulation commits that member States have to ensure the offset of emissions.

The EU has implemented many legislative acts aiming to reduce gas emissions and to enhance their sinks. The governance of the Energy Union and Climate Action establishes a framework for cooperation between the Member States and the EU with long-term strategies, integrated reports, and data publication. There are metrics for measuring the annual emission trajectories for each Member State. The policy targets for adaptation to climate change are less quantifiable, the focus is mainly the monitoring activities.

There were substantial reductions in ETS emissions since 2005. The carbon and energy intensity of the EU economy is lower now than it was in 1990. The reduction was due to the combined result of policies and measures and economic factors. They have been mainly in power generation. Transport remains one of the biggest challenges. Nevertheless, member States' projections are not yet in line with the target for 2030. So far, only Greece, Portugal, and Sweden from 27 countries have met their commitments.

China, one of the world's largest contributors to GHG emissions, launched a national ETS in December 2017. The project's performance is evaluated as poor, however, China pioneers the world on alternative energy production.

On the opposite situation, Africa, has a very low contribution of carbon dioxide emissions (3.6% of the total per year), however, has 14% of the population of the world, and it is going to be affected strongly by climate change, mainly because of high dependency on agriculture and limited capacity to adapt. South Africa became the first African nation to launch a carbon tax after Parliament passed the Carbon Tax Bill on February 19, 2019.

Offsets are an important political tool, they can value environmental attributes if linked to sustainability policies. To function properly and deliver carbon sequestration, they need to engage and incentivize many participants, such as companies, farmers, certification agencies, as well as a market to buy and sell carbon certificates.

Another mechanism to reduce emissions is carbon tax. It is a fee imposed to reduce the use of fossil fuels. This policy has been applied in some countries, like the United Kingdom, Ireland, Australia, Chile, Sweden between others.

New efforts and initiatives are fragmented. It is necessary to involve all the sectors of the agribusiness system, including investment in consumer education and investment in research, as we will see in the next section.

6.7 Responses from Science and Technology

In chapter 5 of this report, "State of art about methods of measuring soil carbon stocks": Agriculture in general and coffee production, Carlos Eduardo Cerri explains the soil can store three times more carbon than the atmosphere, a process called "soil carbon sequestration". Moreover, the fixation of carbon in the soil brings additional benefits such as increased fertility and reduced erosion. With these arguments, the Brazilian Low carbon agriculture plan invested more than R$16 billion Reais between 2010 and 2019, but the country still cannot prove the amount of soil C sequestration derived from these actions. The challenge consists mainly of three points:

- Lack of knowledge about the assessment of soil Carbon stock potential. Most research indicates that soils have a limited capacity to store carbon until an equilibrium. It is known that many factors influence directly carbon sequestration, such as soil type, climatic conditions, quantity and quality of inputs, diversity of microorganisms, land use, agricultural management practices, among others. However, it is not yet clear when carbon saturation is reached (years/decades / centuries) and how much carbon can be stored in the soil.
- There is also the difficulty of measuring variations in the soil C stock due to the great heterogeneity of the soils, topography, and vegetation types. The surveys that measure the carbon stock of the soil in different systems and overtime are very scarce, especially in Brazil.
- The financial cost to measure changes directly from the C stock in the soil. For the quantification of soil C stocks, it is highly recommended that the assessment be based on data obtained from real field conditions. Therefore, it is necessary to collect soil samples correctly, to prepare the samples properly, to determine the C content of the soil in a specialized laboratory, and correctly express the results in the form of "C stocks".

Some studies have indicated that the implementation of coffee production in degraded pastures and agricultural areas (with a low annual C contribution) results in significant increases in soil C stocks, especially when associated with the adoption of good agricultural practices.

Many types of research show greater potential of soil C sequestration after the adoption of sustainable agricultural practices, such as no-till, rotation systems, regenerative agriculture, organic production, and agroforestry systems. Therefore, this is a path for further research and policies (public and private) that aim to promote agricultural sustainability and reduce the effects of climate change.

The difficulty in measuring soil carbon sequestration is a challenge that deserves the attention of academia, the public, and the private sector. The lack of investment proof compromises the development of the market[3] and puts at risk the future of the carbon credit market.

6.8 A Long-Term view

Like all global movements that mean a paradigm shift, the sides of unconventional agriculture evolve. In general, some contributions sound like a warning sign. The theme of environmentalism was born with the contribution of Rachel Carlson in the book "The Silent Spring", among others. Likewise, leaders seen as utopians generate discomfort and move different actors in productive systems, including scientists, universities, and governments. Such movements are usually slow, however, the problems often require immediate solutions. Sometimes the warning signs make mistakes, as was the case of the Rome Club debate in the 1960s. Then, it was claimed that non-renewable resources would be at critical limits in the 2000s. This did not happen for different reasons.

In 2020 we lived with new warning signs, whether in the political or in the environmental theme, such as global warming. There are warnings such as Yuval Harari that demonstrate a pessimistic view of the new technologies impacts on life as we know. At the same time, global warming shows signs of being real, regardless of the reasons that motivate it.

In the agricultural scenario, urgent measures must be taken. It may be worth considering that we can make two kinds of mistakes. Moving forward with the adoption of new paradigms and discovering that they would not be necessary. Alternatively, we do not take any measures and discover late that they were necessary. Moving forward with the spread of virtuous and regenerative agriculture can be a measure of high benefit to society.

3. Measurement cost theory explains that problems and costs of measurement permeate and significantly affect all economic transactions. Individuals exchange goods only when they can realize which values are transacted, so, the lack of correct measurement of soil C sequestration can prejudice those transactions to take place (Barzel, 1982). Barzel, Y. Measurement cost and organization of markets, The Journal of Law and Economics, v. 25, n. 1, p. 27-48, 1982. http://dx.doi.org/10.1086/467005

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