Executive Summary

In the last five decades alone, an increase in the global economic output and life expectancy made the human population double. The global economy expanded by four times, and lifted over one billion people out of extreme poverty.[1] Globally, we now produce more food and energy than ever before. While improvements in human welfare and benefits from the accelerated economic growth are undeniable, this prosperity has also come at a heavy cost to the natural ecosystems that support life on Earth.

Rampant GHG emissions from human related activities continue to exacerbate the effects of climate change. Natural disturbances such as fires, insect outbreaks, windthrows, along with further long-term changes in our climate system, such as the sea level rise, have arisen as a result. An estimated 1 million species are facing extinction. Global temperatures increased by 2°C compared to the pre-industrial era, and the impact on some ecosystems may be irreversible.[2]

Biodiversity is not the only thing at stake. Climate-related risks to health, human livelihood, food security, water supply and economic growth are all projected to increase alongside global warming and nature loss. All sectors depend on natural capital assets and ecosystem services either directly or indirectly through their supply chains. About $44 trillion of economic value generation is moderately or highly dependent on nature, and therefore exposed to the associated risks from its degradation.[3] Unsurprisingly, primary industries such as the agribusiness exhibit the highest dependency. They rely on either the extraction of resources or the ecosystem services provided by nature, such as healthy soils, clean water, pollination and stable climate. As nature loses the capacity to provide such services, these industries could potentially suffer major losses.

Agriculture, forestry, and other land use activities are among the highest contributors to nature's degradation, especially to climate change, as they account for about 18% of total human GHG emissions[4]. However, the sector is uniquely positioned to help reverse the climate crisis. Plants remove carbon from the air and store it below the ground during photosynthesis, so crops, when well-managed, can provide powerful carbon withdrawals. Soil organic matter is also an effective "carbon sink", as it can store the carbon plants pull from the atmosphere. With new ways of farming, agriculture could go from a GHG source to an efficient tool to restore the soil's carbon content and mitigate greenhouse effect. Since it occupies nearly 40% of Earth's surface[5] - far more than any other human activity - it is unlikely that any other sector has the potential to change our current climate trajectory.

As the global momentum on preserving nature continues to strengthen, sectors whose businesses can be transformed to reverse nature loss tend to benefit. In the food and land-use industry alone, there is an annual business opportunity of $4.5 trillion by 2030 associated with transitioning to a nature-positive economy. This includes organic and regenerative farming.[6] If these crops are promising, and there are people willing to finance the transition, the question that remains is why isn't everyone farming them? Well, it takes a lot more than designing radically new systems to change the food production status quo. Farmers need support to convert and scale their crops using these new models. This requires new technology, special financing, segregated logistics, and different off-take contracts from the ones currently available in conventional markets.

Impact assessment is also a major challenge facing pioneers. The new farming frameworks are still under development and lack standards for production, even more for measuring impact. This causes a lot of misunderstanding and spreads false information which, most of the time, cannot be demystified without academic scientific research and strong R&D investments.

Rizoma Agro is a Brazilian grower, researcher and technology developer specialized in regenerative organic agriculture. Our company launched in 2018 to accelerate the transition of croplands by creating an efficient, productive, and net-positive supply network. In order to meet this challenge, we focused our efforts on solving existing tensions around regenerative organic farming practices and proving the positive impact of our work. For the latter, we have been counting on the help of reputable experts, think tanks, and research-based institutes to measure and validate our impact on key indicators.

The present report shows that our regenerative organic farming systems are sequestering up to 45.8 tons of carbon per hectare, per year. Our soils harbor more biodiversity in comparison to conventional farmlands within the same region. Our crops benefit from greater hydro capacity and higher resilience to water stress. Throughout this document we will share our own research with farmers, investors, consumers, and other interested parties whom we intend to inform the results we have achieved so far. Our dedication to creating a simple and clear report reflects our desire to make regenerative organic agriculture accessible to all people, but we still have a lot to learn, as you will see in the coming pages. While we are committed to move forward and share our results, we know that our journey is far from over.

Regenerative Organic Indicators

Soil Is The Starting Point

Rizoma Agro's three impact indicators, biodiversity, water, and carbon - all orbit around a common point: soil health. Soil is the basis of life in all terrestrial ecosystems and is the main raw material required for almost all agricultural activities. Not only do they provide a physical structure for the crops above them, but they also absorb and store water and nutrients that plants need to grow and prosper.

However, this major reservoir of water and nutrients is useless to crops when the living conditions are dysfunctional. Without life and the diversity of organisms, soils cannot nourish or hydrate plants efficiently, even in the case when they get huge amounts of fertilizers and water. Soil insects, together with soil worms, protozoa, fungi and bacteria, are responsible for gradually breaking down organic matter into smaller particles. These particles turn into exudates that vegetables can assimilate in their roots. The same organisms also release substances that contribute to root and root-hair proliferation, which optimizes the absorption of water and nutrients in crops.

When there is biodiversity, there is organic matter being cyclically produced and decomposed within the soil ecosystem, which is essential for crops to thrive. Soils become soft and fertile sponges where plant roots can deeply penetrate and organisms can dig tunnels to get the air, water and food they need to survive. When rich in organic matter, soils also infiltrate more water. This reduces the runoff, erosion and leaching events that can destroy crops, contaminate water bodies, and compromise aquatic fauna and flora. Fortunately, these soils can retain the water they absorb more efficiently, and help crops cope with longer periods of drought. Increases in soil organic matter – which is also known as SOM - together with the benefits delivered to biodiversity and ecosystem services, are an important indicator of health and the regeneration of agricultural landscapes.

In addition to the features mentioned above, healthy soils and strong plants also help regulate the carbon cycle on earth. Just like any other vegetables, agricultural crops pull CO_2 out of the air and store it in their leaves, stems, and roots. Some of that carbon also makes its way into the soil and is ultimately mothballed for years. By improving soil conditions and ensuring well-nourished crops, the regenerative organic management leverages the photosynthesis in plants and causes them to sequester a greater amount of atmospheric carbon per hectare. Furthermore, as soil organic matter is primarily composed of carbon, when SOM increases in crop soils, it not only means that nutrients are being cycled and made available in the ecosystem, it also means that the amount of carbon entering the soil is higher than the amount of carbon coming out of it.

Carbon

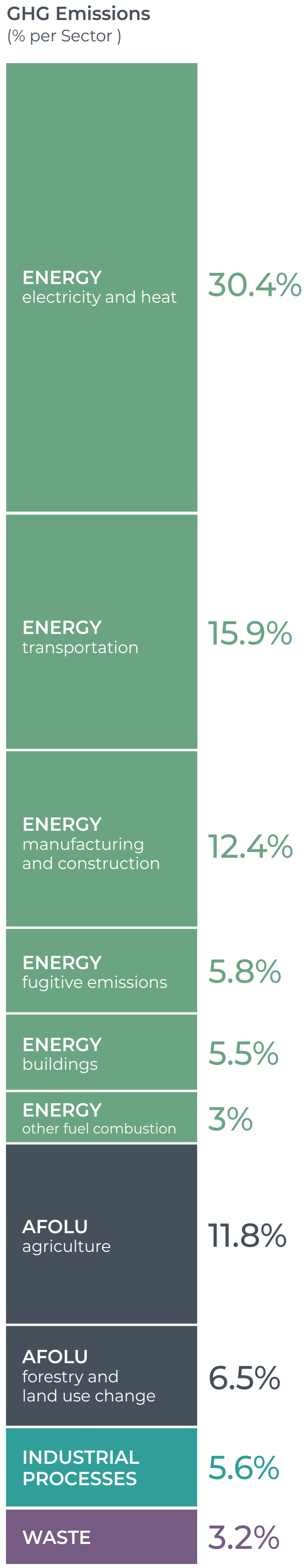
Carbon is the building block of all organic compounds. Not only for living things, but fuels, pharmaceuticals, and plastics are all built with carbon too. Civilizations and economies need carbon in order to live, grow, and prosper, but that need is also entwined with one of the major problems facing humanity: global climate change.

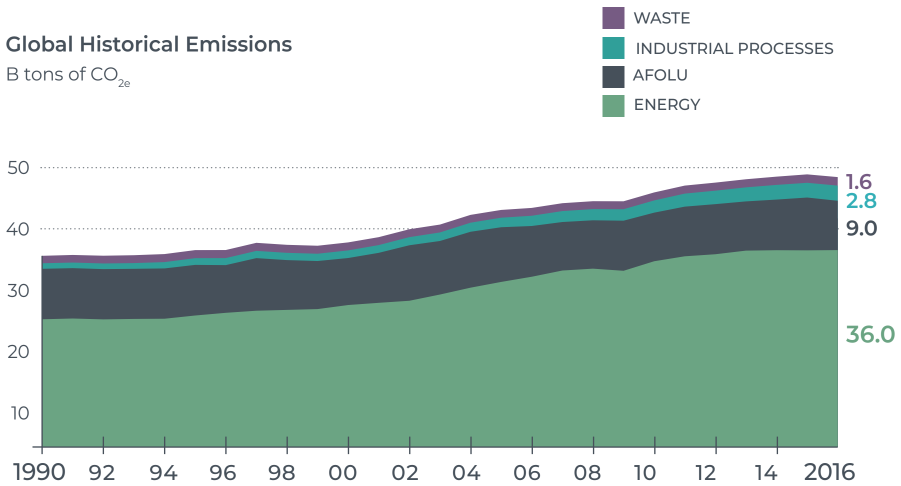
Agriculture's GHG Footprint

Greenhouse gases play an important role in influencing the earth's average temperature. They trap heat inside the atmosphere when they allow sunlight to enter, but prevent the escape of counter radiation back into space. The main GHGs are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). Please note that 4 out of 6 are carbon-based and that 6 out of 6 are influenced by human activities.[9]

Each of the GHG have different warming potentials based on their ability to absorb energy and their lifetime inside the atmosphere. This potential is measured against the reference gas CO_2, so that emissions from all gases can be represented with a single unit. Carbon dioxide equivalent, or CO_{2e}, is the global standard metric measure for GHG footprints. The "equivalent" expresses the impact of each gas in terms of amounts of CO_2 that would generate the same warming.

Agriculture, forestry, and other land-use activities (the AFOLU sector) account for 18% of global human-caused GHG emissions. Most farm-related contributions come from ruminant livestock and soil management which are sources of carbon dioxide, methane and nitrous oxide. The AFOLU is the largest contributor after the energy sector, releasing 9 billion tons of CO_{2e} annually.[10]

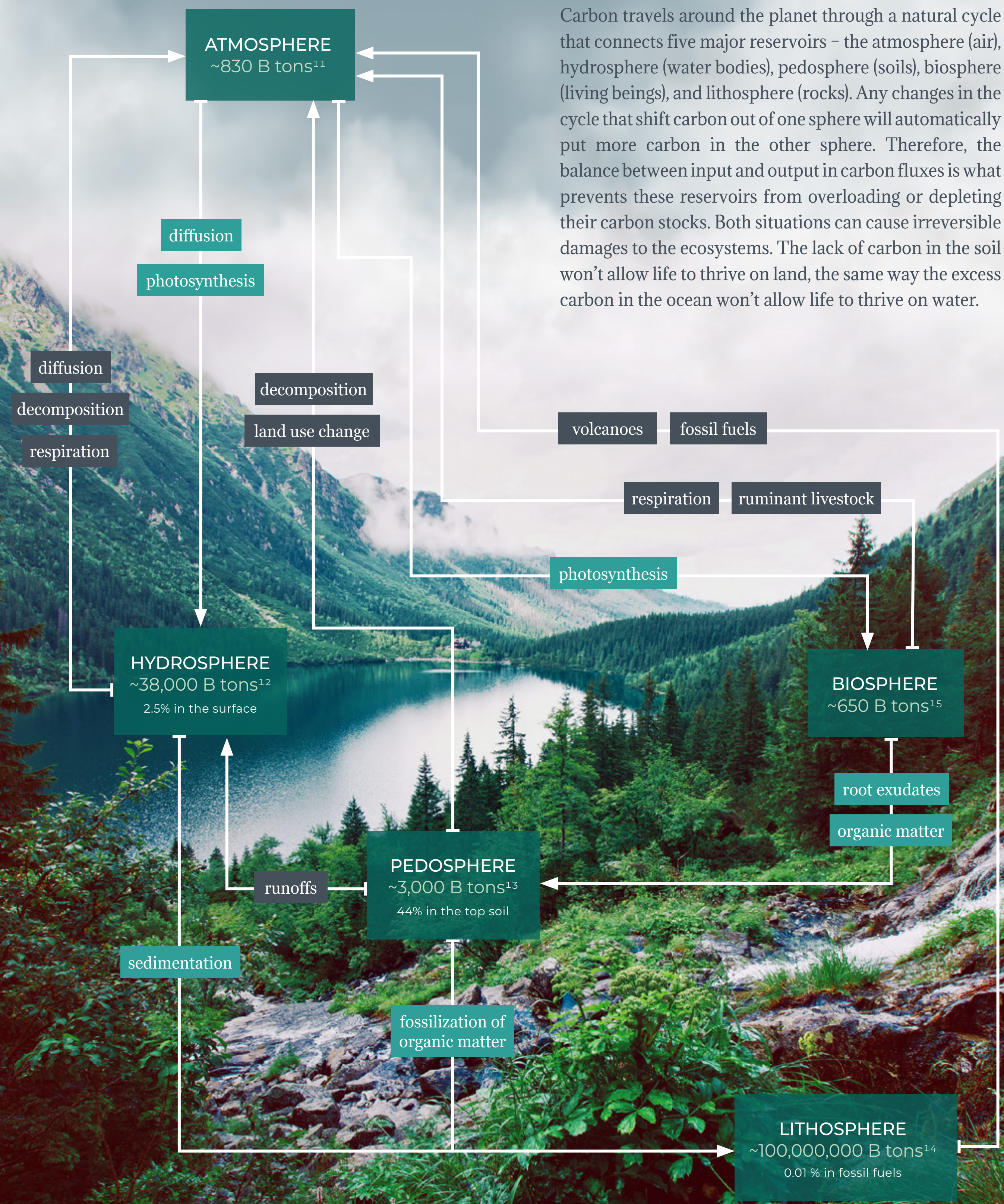




Source: Climate Watch, based on raw data from IEA (2016)

The global carbon cycle

Carbon travels around the planet through a natural cycle that connects five major reservoirs – the atmosphere (air), hydrosphere (water bodies), pedosphere (soils), biosphere (living beings), and lithosphere (rocks). Any changes in the cycle that shift carbon out of one sphere will automatically put more carbon in the other sphere. Therefore, the balance between input and output in carbon fluxes is what prevents these reservoirs from overloading or depleting their carbon stocks. Both situations can cause irreversible damages to the ecosystems. The lack of carbon in the soil won't allow life to thrive on land, the same way the excess carbon in the ocean won't allow life to thrive on water.



Carbon is food for soil fauna

Carbon is passed from the atmosphere to the biosphere through photosynthesis. After the green plants remove the carbon dioxide from the air, the carbon becomes part of complex molecules such as proteins, fats and carbohydrates in these vegetables. The same thing happens when an animal eats a plant: the carbon within the plant then becomes part of the fats and proteins in the animal. This is how carbon is passed from one organism to the next, until it is returned to the atmosphere as carbon dioxide through respiration, or until it is passed to pedosphere as organic matter, in the dead plants and animal remains.

Carbon also enters the soil in the form of organic molecules released by plant roots. Root exudation of soluble organic carbon provides soil microorganisms, which are often carbon-limited, with an important energy source. It is a key process that drives microbial activity in the soil and improves nutrient availability in the rhizosphere, and thus plant growth itself.

Dr. Rattan Lal, one of the world's most famous soil scientists, describes the reason why life is much more diverse in healthy soils: because they are full of organic carbon. Carbon is food for soil fauna. The more carbon a farming system puts in the ground, the more it provides diverse populations of organisms with the ability to thrive and improve soil properties.

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Soil organic matter and CO_2 sequestration

Soil organic matter, or SOM, is the most abundant form of soil carbon. Additions of SOM will not only feed soil biota, but will also provide aggregate formations that improve the soil's structure, water infiltration, and resilience to water stress. One of the reasons why SOM is used as a gauge or indicator of healthy landscapes is because of its sensitivity to soil changes caused by unsustainable land management. A decrease in soil organic matter over time is usually associated with degenerative farming practices such as using high levels of chemical inputs, heavy tilling, and burning or removing crop residues. On the other hand, practices that increase SOM are known for improving yields and carbon sequestration in agricultural soils.

Increasing the soil's carbon content is being pointed as one of the best strategies to mitigate climate change. However, two important features of carbon sequestration in agricultural soils are still under scientific debate: the length of the withdrawal period and maximum soil carbon stock. After carbon enters the soil, it is very difficult to accurately quantify how much of it will be kept below the ground and how much will eventually be released into the atmosphere. Soil carbon stocks can persist for decades, centuries, or even millennia, but they can also be lost in erosion, leaching, decomposition, and volatilization processes. For example, it is known that part of the carbon from dead fauna and flora will be released as CO_2 with decomposition. It is also known that when SOM increases over time, it is because the additions of organic material are occurring at higher rates than microbial decomposition and soil loss. In other words, carbon is being stored below the ground. The same happens the other way around: when SOM decreases over time, it is a clear sign that carbon is being lost.

As soil carbon sinks built by farming are not permanent, they will only exist as long as appropriate management practices are maintained. This means that once established, these sinks need to be preserved in perpetuity otherwise the carbon accumulated will be lost. Alongside carbon permanence, sink strength (i.e. the rate which carbon is removed from the atmosphere) is another issue. It becomes lesser with time as the soil carbon stock approaches a new equilibrium. At equilibrium, the sink is saturated. While carbon stock may have increased, the sink strength has decreased to zero. The time for sink saturation to occur is variable. Some experts say soils can take up to 100 years to reach a new equilibrium after a land-use change.[16] As a compromise, good practice guidelines give sink saturation 20 years to occur. [17]

Biodiversity

In 2020, the World Economic Forum ranked biodiversity loss and ecosystem collapse as one of the top five risks in terms of likelihood and impact in the next 10 years.[18] The current rate of species extinction is ten to hundreds of times higher than the average over the past 10 million years.[19]

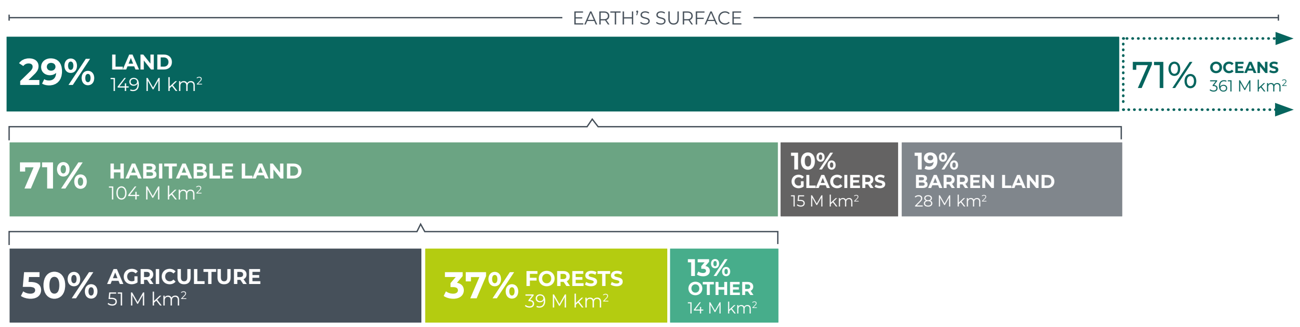
Agriculture's impact on the global biodiversity

A thousand years ago, only 4 million square kilometers – less than 4% of the world's ice-free and non-barren land area - was used for farming.[20] But when we take a look at the current breakdown of global land area, we can see that 10% of the world is covered by glaciers, 19% is barren land (deserts, dry salt flats, beaches, sand dunes, and exposed rocks) and half of what is left - what we call habitable land - is now used for agriculture and livestock.[21]

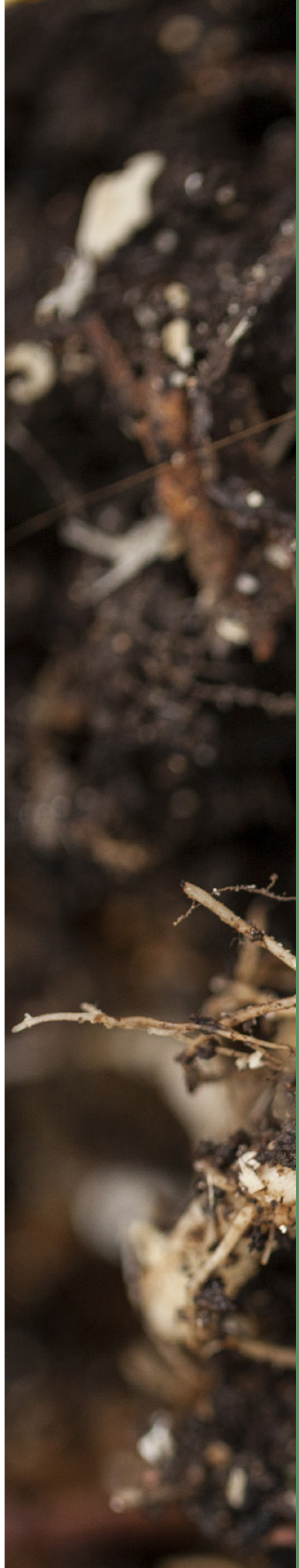
Agriculture's expansion and related activities put major pressure on biodiversity. Over the last few centuries, wild habitats have been squeezed out and turned into croplands in which unsustainable farming systems put vital species and ecosystem services at risk. Of all the animal and plant groups assessed by the IUCN's Red List, 32,000 species are evaluated to be facing extinction; over 29,000 are directly threatened by farming activities.[22]

Together with deforestation, agrochemicals are responsible for a mass loss of terrestrial and aquatic biodiversity. Around 115 million tons of mineral nitrogen fertilizers are applied to croplands each year globally. A fifth of these accumulate in soils and plant biomass and other 35% end up in oceans.[23] While these chemicals are affecting the behavior and population dynamics of birds and insects, they are also entering freshwater and coastal ecosystems and creating dead zones, which are now estimated in the 400s.

Global Land Use



Source: Food and Agriculture Organization of the United Nations (FAO)



Soil Life

The environmental crisis is increasing public awareness of impacts from human activities on biodiversity and natural habitats. An interesting fact, however, is that most of the conversations on the subject seem to focus only on aboveground ecosystems. For example, while many people know that polar bears will soon starve due to melting sea ice, they are completely unaware of the fact that soils are also facing extinction, and they harbor some of the highest levels of diversity on the planet.

A single gram of soil houses as many different organisms as an entire square kilometer above ground.24 It might contain 100 million bacteria, 10 million viruses, 1000 fungi, and other populations living amidst decomposing organic matter. These creatures help degrade pollutants, suppress diseases, ensure food security and keep our climate stable, and yet people know surprisingly little about how they might be impacted by human actions.

Agriculture is for sure one of the biggest threats to soil biodiversity. The use of agrochemicals combined with other intensive farming practices hurt soil, turning it acidic, dry, salty and very hostile to living organisms. By altering the soil's microbiological composition in favor of more pathological strains, these practices cause a cascade of problems. They make crops more vulnerable and farmers more dependent on synthetic fertilizers and pesticides to achieve optimal performance. The continuous use of these agrochemicals increasingly reduces soil organic matter and decreases soil properties, culminating in the complete degradation of the soil's ecosystem.

Water

There is no shortage in ways that agriculture touches the water issues, but two of them are particularly critical. The first is related to agriculture's impact on the global water resources. The second refers to how farming can affect the soil's water capacity and thus its resilience to water stress.

Agriculture's water footprint and efficiency of use

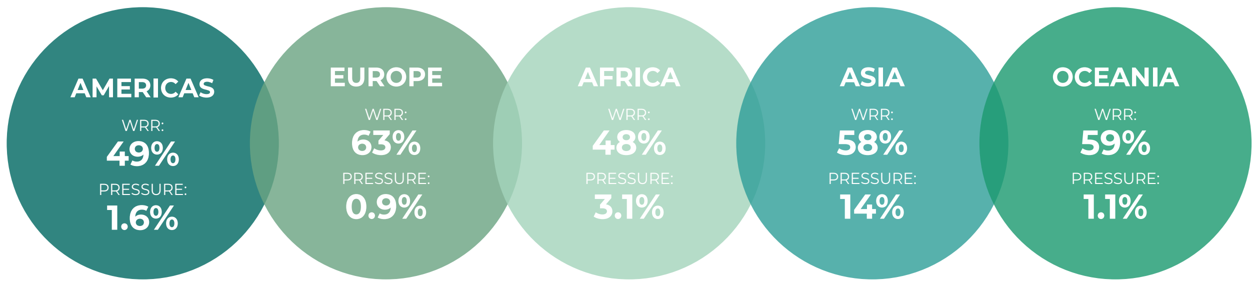
Agriculture is the largest consumer of water worldwide. It accounts for 70% of total freshwater withdrawals.[25] The pressure on hydric resources, together with increasing water demand in competing sectors, is leading to the idea that agriculture must "grow more food using less water." While convincing, this idea can lead to misconceptions. It is not clear that water use inefficiency and contamination by agrochemicals are bigger problems than the amount of water made available for irrigation.

The right amount of water can increase yields of most crops from 100% to 400%.[26] Therefore, irrigation plays an important role in gearing agriculture development towards economic growth. This is the reason why it has been incorporated into key operational strategies for governments to increase their agricultural production and ensure food security. Irrigation management, however, is a complex task that requires specific technologies and planning at many levels.

Many farmers, specially the small-holders, lack financial resources to adopt the modern pressurized irrigation systems, which are more expensive than the surface irrigation systems but have higher efficiency at field scale. The lack of financial resources may also impede the appropriate operation and maintenance of these farmers' current irrigation projects. Without the adequate means to measure crop water usage levels, actual irrigation applications and yield responses to different water management practices, they cannot assess irrigation efficiency and often end up wasting water.

Irrigation efficiency is traditionally defined as the ratio of the amount of water consumed by the crop to the amount of water supplied through irrigation. For traditional flood irrigation systems, delivering water through earthen channels, the ratio of water consumed by the crop and water delivered to the project is often as low as 40%.[27] The common inference from this figure is that 60% of the water is being wasted, but this is not necessarily so. In some cases, the recoverable fraction of the non-consumed water can be used further down-stream in the irrigation scheme, it can flow back to the river or it can contribute to the recharge of aquifers. For this reason, the reports on agriculture's irrigation impact use the term "water requirement ratio" - or WRR - when referring to the ratio between the amount of water required and withdrawn for irrigation.

According to the UN Food and Agriculture Organization (FAO), the average water requirement ratio of global agriculture is around 56%, and the pressure on the freshwater resources due to irrigation is estimated in 5.1%.[28]



Source: FAO's AQUASTAT Main Database

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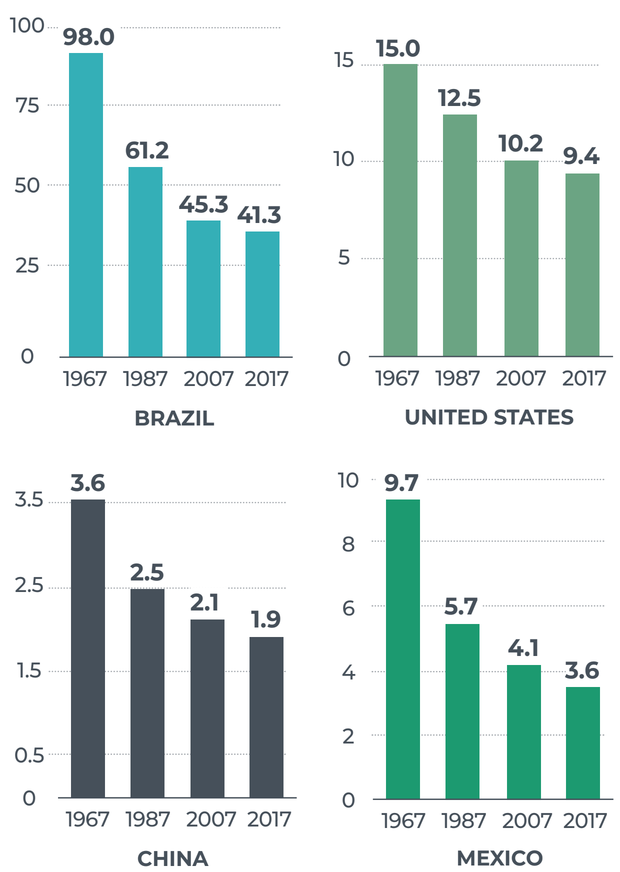
Water contamination by agrochemicals

Agriculture is a major source of water contamination in most high-income countries and emerging economies, where pollution caused by farming have already overtaken the contamination from settlements and industries. In Europe, 38% of water bodies are under pressure from agricultural pollutants, while in the US, these chemicals are already the main source of contamination in rivers and streams.[29]

The most common chemical contaminant found in the world's groundwater aquifers is nitrate, that comes from nitrogen fertilizers leaching from agricultural soils. Nitrate can cause potentially fatal illnesses, such as cancer, for those who drink water from the tap. It can also cause the eutrophication of the water bodies by hyper charging the growth of algae and bacteria which use up most of the oxygen in the water and leave it uninhabitable. Livestock and its associated wastes have serious implications on water quality too. Residues from manure and veterinary medicines such as antibiotics, vaccines and hormones are also pollutants that move from farms through water runoffs into ecosystems and drinking-water sources.[30]

Total Renewable Water Resources Per Capita
In Thousands of m³ / inhab / yr



Source: FAO's AQUASTAT Main Database

Soil water capacity and resilience to water stress

Drought manifests when evapotranspiration from soils and plants is superior to hydric resources of the terrain. While the changes in climate can leverage evapotranspiration, they can also affect rainfall, changing the frequency, intensity and quantity of water falling in one region. Due to the combination of these two aspects, the biomes are facing "heat peaks" that exceed physiological thresholds.[31]

Throughout agricultural history, farmers have always managed to adjust their practices to environmental changes. However, with temperatures rising, the pace of these changes will likely be unprecedented. Producers will have to continuously improve their water management by favoring the accumulation of water in soil, choosing suited varieties, and adopting more efficient irrigation. Furthermore, with agriculture's expansion to non-optimal environments and non-arable lands, the development of climate resilient crops will be key to ensure food security.

Two conditions are essential for optimizing the water cycle in soil and increasing its resilience to water stress. The first is to ensure the soil has good water infiltration, in order to prevent water from escaping through the draining net. The second is to improve soil's available water capacity, more specifically, its collectible water volume and its ability to avoid evapotranspiration. Both conditions are intrinsically related to soil health and to farming practices applied on the farm. The amount of water soil is capable of infiltrating depends on the composition (balance between sand, silt, clay), structure, and also on levels of organic matter. The latter, aside from being an important indicator of soil life, is particularly crucial to improve water infiltration and capacity of the fields, since it favors the formation of stable agglomerates that preserve soil porosity and permeability.

Healthy soils not only enhance crop resilience, but also preserve water resources. They are free from surface compaction which often causes runoffs and leaching of chemicals into water bodies. Degraded agricultural soils, on the other hand, are major sources of contamination of water reservoirs. They are usually very low in humid organic materials, so their surfaces can be very hard and dry. Thus, rather than steadily seep through soil and recharge the groundwater supply, the water that falls from rain or irrigation systems will simply rush through the field, leading to runoffs, floods, leaching, and erosion.

RIZOMA AGRO'S

Carbon Assessment

The Paris Agreement's policy to prevent an increase in the global temperatures aims to reduce the CO_2 emissions in order to "achieve a balance between anthropogenic GHG sources and removals by GHG sinks". To meet the agreement's targets, we need to reach 10 billion tons of negative emissions – 20% of today's annual anthropogenic emissions – by approximately mid-century, and 20 billion tons by the end of the century.

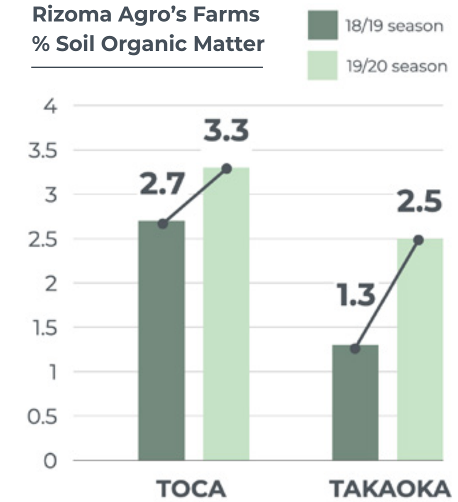
Agriculture, Forestry and Other Land Use (AFOLU) is responsible for almost a quarter of anthropogenic GHG emissions; thus, the sector is critical to meet mitigation targets. Land plays an important role in the global cycles of GHGs. As part of the land sector, agriculture can help reduce emissions and additionally sequester atmospheric carbon in the soil. Global implementation of best agriculture and livestock practices is estimated to provide 21-40% of cost-effective climate change mitigation needed in the sector through 2030 . Therefore, this implementation is key meeting the climate targets and also for ensuring food security.

Under the Paris Agreement, signatory countries stipulate their Intended Nationally Determined Contributions (INDCs) with their main commitments and contributions to achieve climate goals. The Brazilian INDC proposes to reduce GHG emissions by 37% by 2025, based on 2005 emissions (which were an estimated 2.1 B tons of CO_{2e}). Agriculture and livestock are the second largest source of GHG emissions in Brazil, accounting for 25% of the country's total carbon footprint. In 2018, the sector released 492 M ton CO_{2e} into the atmosphere, with enteric fermentation from ruminant animals, livestock manure, fertilizers and rice cultivation as major contributors.

Soil Organic Matter

Rizoma Agro's soil monitoring points to an increase in SOM, which indicates our crops are indeed accumulating carbon below the ground. Soil organic matter levels have risen from 2.7% to 3.3% and from 1.3% to 2.5% at the Toca and Takaoka farms, respectively, in a one-year period. Aside from soil organic matter, we are working on a protocol that will allow for the assessment of total organic carbon, an indicator that is not yet being measured in Brazilian soils. Since it does not require the use of correction coefficients to calculate the size of the organic carbon pools – usually required in SOM analysis – we believe this indicator will provide even more accurate results on carbon sequestration provided by our farms.

Rizoma Agro's Farms
% Soil Organic Matter



GHG Balance

Although the increase in SOM a strong indicator of carbon sequestration in the soil, it is not enough to ensure an agricultural operation has a negative GHG balance. The impact assessment must also consider the GHG footprint of livestock, land management, and other farming activities, which must be lower than carbon sequestration in soils and plants biomass.

Imaflora, a reputable Brazilian think-thank dedicated to environmental research, was hired to perform the GHG impact assessment for our 18/19 growing season. They used the GHG Protocol to measure the footprint of farm activities on our two farms in São Paulo. The appraisal confirmed that Rizoma Agro's operation is carbon negative and that together our production systems have a total GHG balance of -2,238 tons of CO_{2e} per year.

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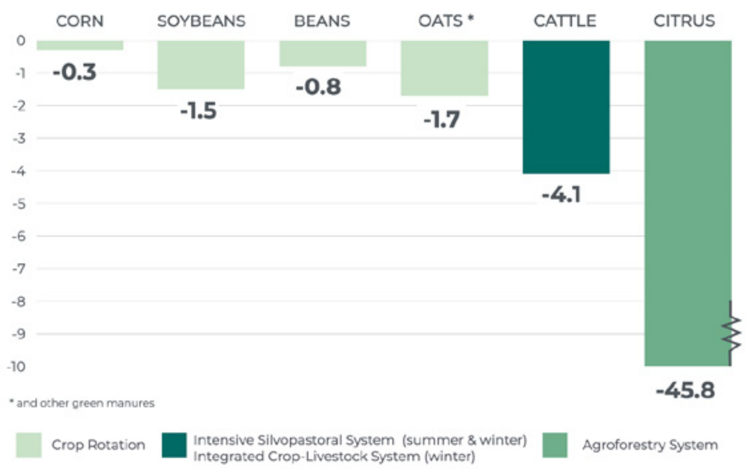
Rizoma Agro's
GHG Balance Per Produce Category
Tons of CO_{2e} / hectare / year



RIZOMA AGRO'S
TOTAL GHG BALANCE
for all produces
1,100 hectares

-2,238
Tons of CO_{2e} / year

GHG Offset

GHG offset programs can help businesses and individuals neutralize unavoidable emissions. However, these programs are only valuable when they can prove that the GHG reductions they provide are additional. In other words, that the GHG offset would not have happened without an investment, or in the absence of a market for its credits.

Additionality is essential to the quality of GHG offset credits. Any project that aim to prove an additional impact, must acknowledge the baseline scenario of emissions and removals that would have occurred if the project did not exist. Thus, it is possible to subtract that information from the estimated GHG balance of the project to determine the actual GHG savings.

The total GHG offset provided by Rizoma Agro's 18/19 growing season was estimated to be -8,165 tons of CO_{2e}. Please note that this figure considers the avoidance of 5,927 tons of CO_{2e} which would have been emitted if our farms were growing conventional crops, plus the additional impact provided by our operation's annual balance of -2,238 tons of CO_{2e}.

Rizoma Agro's
GHG Offset per Produce Category
Tons of CO_{2e} / hectare / year

PRODUCE	IF FARMED WITH CONVENTIONAL SYSTEMS	FARMED WITH RIZOMA AGRO'S SYSTEMS	GHG OFFSET
CORN (A)	4.8	-0.3	-5.1
SOYBEANS (A)	1.4	-1.5	-2.9
BEANS (A)	1.2	-0.8	-2.0
CITRUS (B)	5.2	-45.8	-51.0
CATTLE (C)	1.2	-4.1	-5.3

(A) Compares grains and pulses farmed with Rizoma Agro's crop rotation with green manures (Imaflora, 2019) vs. global grains and pulses crops farmed with conventional systems (Poore & Nemecek, 2018)
(B) Compares citrus farmed with Rizoma Agro's agroforestry systems (Imaflora, 2019) vs. global citrus farmed with conventional orchards (Poore & Nemecek, 2018)
(C) Compares cattle grazed on Rizoma Agro's ICL and Intensive silvopastoral systems (Imaflora, 2019) vs. global cattle grazed on in conventional extensive systems (Poore & Nemecek, 2018)

PRODUCE	IF FARMED WITH CONVENTIONAL SYSTEMS	FARMED WITH RIZOMA AGRO'S SYSTEMS	GHG OFFSET
ALL PRODUCE (D)	5,927	-2,238	-8,165

(D) Compares the weighted average balance of crops farmed with Rizoma Agro's systems (Imaflora, 2019) vs. if the same crops were farmed with global conventional systems (Poore & Nemecek, 2018)

GHG Impact Potential in Brazil

Rizoma Agro will foster regenerative organic agriculture in Brazil by expanding their own operation and offering regenerative organic production technology as a service to other farmers. Brazil is one of the world's leading agricultural powerhouses and counts on highly experienced growers to hold this position. These growers, however, are suffering from the high costs of inputs and increase in adverse climate events. The economic and ecological upsides of our farming model, combined with the opportunity of increasing resiliency of crops, is already capturing their attention.

The organic industry is growing 15% to 20% per year in Brazil, following global health and sustainability trends. Embrapa, a major Brazilian agricultural research corporation, says the boom in the organic market worldwide present an opportunity to improve Brazil's export sales to the US and Europe. These markets produce only 33% of the total volume of pesticide-free food they consume. Latin America accounts for 11% of total organic area on the planet, of which 1.1 million hectares are farmed in Brazil. Although our country is leading the commercialization of organic products in the south of the continent, organics account for less than 0.5% of our croplands and pastures. In other agricultural powers, this share is way more relevant. For example, the organic area made up 7.5% of total EU agricultural land in 2018, covering 13.4 million hectares.

If our regenerative organic farming systems were implemented on Brazil's farms for corn, soy, and fruit crops, as well as on all pasture lands, they would provide an estimated GHG offset of -1.3 B tons of CO_{2e} per year. This figure considers the avoidance of the 430.4 M tons of CO_{2e} that are released annually by the current crops farmed with conventional systems in Brazil, plus an additional impact of -887.8 M tons of CO_{2e} that would be sequestered by our systems every year.

Rizoma Agro's
Potential GHG Offset In Brazil
Tons of CO_{2e} / year

PRODUCE	PRODUCTION FARMLAND IN BRAZIL* IN HECTARES	FARMED WITH CONVENTIONAL SYSTEMS	IF FARMED WITH RIZOMA AGRO'S SYSTEMS	POTENTIAL GHG OFFSET
CORN & SOY (A)	40,000,000	31,472,727	-74,666,667	-106,139,394
FRUIT (B)	2,500,000	6,250,600	-114,500,000	-120,750,600
CATTLE (C)	170,000,000	392,700,000	-698,700,000	-1,091,400,000
ALL PRODUCE	212,500,000	430,423,327	-887,866,667	**-1,318,289,994**

POTENTIAL GHG OFFSET	
1% Production Area	-13,182,899
7.5% Production Area	-98,871,750
60% Production Area	-790,973,996

(A) Compares Rizoma Agro's corn and soy crop rotation with green manures (Imaflora, 2019) vs. corn and soy crops farmed with conventional systems in Brazil (Imaflora, 2018)
(B) Compares citrus farmed with Rizoma Agro's agroforestry systems (Imaflora, 2019) vs. fruits farmed with conventional systems in Brazil (Imaflora, 2018)
(C) Compares cattle grazed on Rizoma Agro's ICL and Intensive silvopastoral systems (Imaflora, 2019) vs. cattle grazed on conventional extensive systems in Brazil (Imaflora, 2018)
* Source: EMBRAPA

In a scenario in which we consider the conversion of only 1% of Brazil's conventional corn, soy, fruits and pasture lands, our regenerative organic systems provide an estimated GHG offset of -13 M tons of CO_{2e} per year. This is equivalent to neutralizing all emissions from rice cultivation in Brazil, which is currently the fourth largest farm related source of GHG in the country.

In a possible scenario where, like in the EU, 7.5% of Brazil's corn, soy, fruits and pasture lands are grown and grazed through Rizoma Agro's systems, the estimated GHG offset is -98.8 M ton CO_{2e} per year. This is equivalent to neutralizing 20% of the annual emissions from the AFOLU sector in the country. In fact, this impact can be even greater, since the conversion of Brazilian pastures into integrated regenerative organic systems will increase crop and cattle production using less area, and reduce deforestation for new cropland and livestock operations.

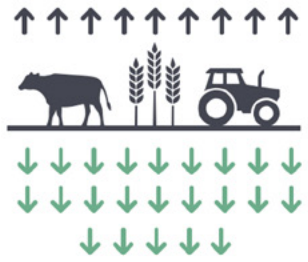
In an optimistic scenario where 60% of the same produce is grown and grazed through Rizoma Agro's regenerative organic systems, the estimated GHG offset is -790.9 M tons of CO_{2e} per year. These crops and pastures, alone, would have the potential to comply with the entire Brazilian pledge to the Paris Agreement.

GHG Impact Potential on the World

If Rizoma Agro's regenerative organic farming systems were implemented for the entire area of corn, soy, and fruit crops, as well as on all pasture lands worldwide, they would provide a total GHG offset of -22.5 B tons of CO_{2e} per year. This impact would be a result of 5.4 B tons of CO_{2e} in emissions avoided from conventional crops plus an additional -17.1 B tons of CO_{2e} sequestered by our crops annually.

How relevant is this number?

Offsetting 22.5 B tons of CO_{2e} is equivalent to offsetting:



2.5x

Global Emissions From Agriculture, Livestock & Land-use

The AFOLU sector emits 9 B tons of CO_{2e} annually; **CLIMATE WATCH.**

46%

Global Emissions From Human Related Activities

Global anthropogenic emissions are estimated in 49.4 B tons of CO_{2e} per year; **CLIMATE WATCH.**

4.9B

Transatlantic Flights

A flight from New York to Singapore emits 4,6 tons of CO2e; **3 Green Car Congress.**

RIZOMA AGRO'S

Biodiversity Assessment

Rizoma Agro dedicates time and care to nurture biodiversity and enhance the living conditions within agricultural production. Our farming practices build healthy landscapes and encourage the preservation of life above and below ground. All of our crops are organic, so no agrochemicals are applied to our fields.

The biodiversity indicators we measure on our farms range from visible macro-fauna, such as the amount and diversity of insects and natural predators found in our crops, to invisible micro-fauna, such as the enzymes released by soil bacteria and fungi. The latter are becoming particularly relevant among academic studies due to the critical role they play in the biological balance of croplands. Preliminary results point to an important trend line: biodiversity thrives through integration. The more a production system mimics nature and stimulates regeneration processes, the more balanced and structured the biological populations within it.

Natural Predators

Rizoma Agro's citrus agroforest soil samples presented 7 times more organisms with predatory or omnivorous habits than soil samples taken from a conventional farm within the same region. As the agroforestry system provides a higher diversity of plant species in consortium, it helps attract insects and pollinators. Organic management also allows for the perpetuation of species population within the system, thus rather than broad-spectrum chemical pesticides, Rizoma Agro uses specific biological inputs to control citrus pests and diseases. Meanwhile, natural predators themselves help fight pests, reducing the need for phytosanitary interventions. This indicator is extremely valuable from both an environmental and economic perspectives.

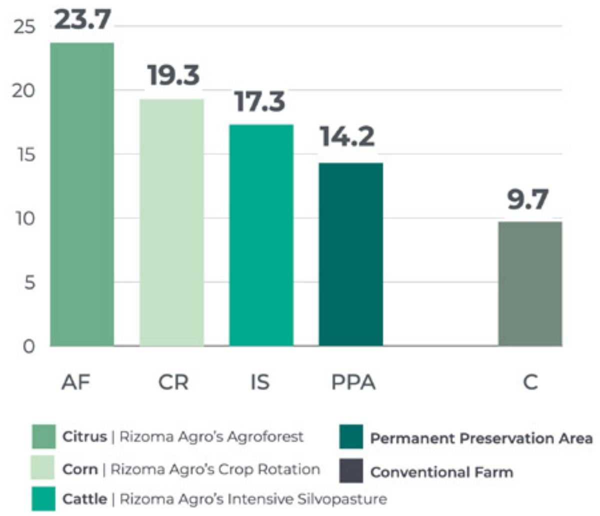
Rizoma Agro's
Population and Diversity of Natural Predators
(Per Number of Individuals and Species)

NATURAL PREDATORS	POPULATION (number of individuals)	DIVERSITY (number of species)
Rizoma Agro's Citrus Agroforest	28	20
Conventional Farm next to our operation	4	3

Surface Edaphic Fauna

The surface edaphic fauna index reflects the interaction between the quantity and diversity of species living in the topsoil. These species are responsible for breaking organic materials at the soil's surface in the very beginning of the decomposition process, making it readily available for the soil's microorganisms. Rizoma Agro's crops present a considerably higher surface edaphic fauna index in comparison to conventional references, as shown below.

Rizoma Agro's
Surface Edaphic Fauna Index
(Per Production System or Land Occupation)

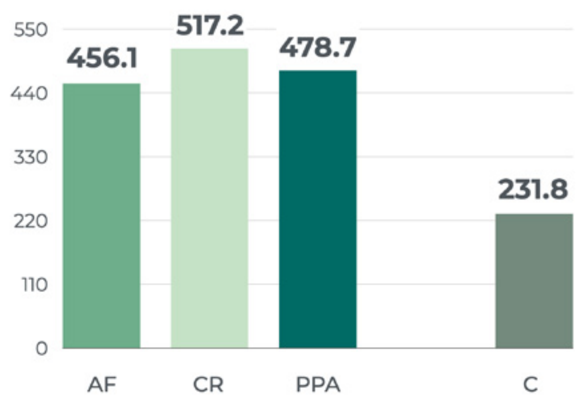


Soil Enzyme Activity

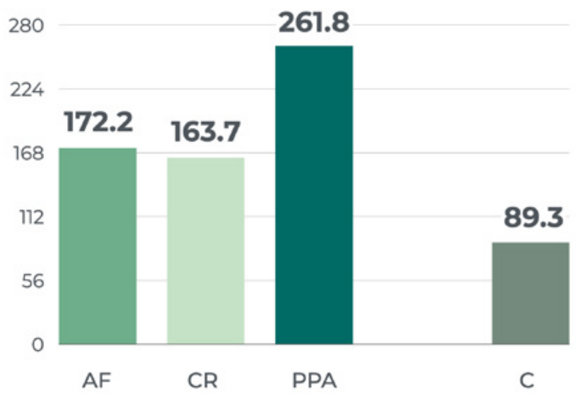
Plant growth is highly dependent on bacteria and fungi which improve the cycling and mobilization of nutrients in the soil. The enzymes arylsulphatase, beta glycosidase and acid phosphatase are released by soil micro-fauna during decomposition. Therefore, when they are largely found in the soil, it is an indirect sign that soil bacteria and fungi are abundant and active. Thus, enzyme activity is an indicator of living soils and healthy crops.

Please note that Rizoma Agro's farming systems have higher levels, in comparison to conventional references, for all three enzymes. In some cases, our figures surpass the figures from the preserved areas located next to our farms, indicating a strong regeneration provided by a healthy and productive landscape.

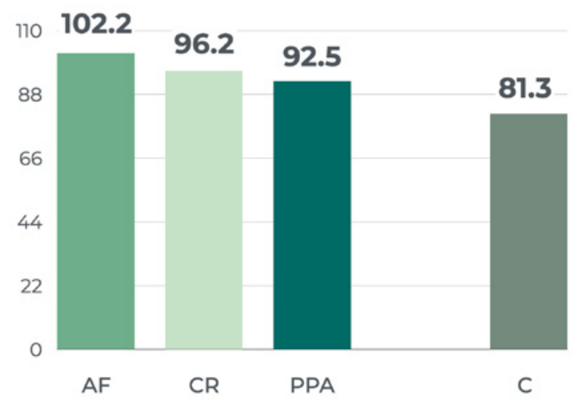
Rizoma Agro's Soil Enzyme Activity
Acid Phosphatase
µg PNS. G-1 solo. H-1



Rizoma Agro's Soil Enzyme Activity
Arylsuphatase
µg PNS. G-1 solo. H-1



Rizoma Agro's Soil Enzyme Activity
Beta Glycosidade
µg PNS. G-1 solo. H-1

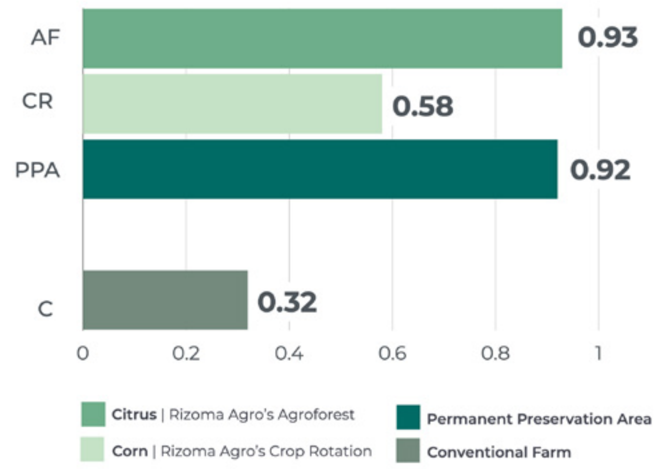


Citrus | Rizoma Agro's Agroforest
Corn | Rizoma Agro's Crop Rotation
Permanent Preservation Area
Conventional Farm

Microbial Biomass Carbon

Microbial biomass carbon (MBC) refers to the living fraction of soil carbon, or in other words, carbon inside the micro-fauna. This estimate of biological activity in the soil is also an indicator of proper soil management, since microbial biomass changes rapidly in response to soil degradation. Please note that Rizoma Agro's systems present higher MBC in comparison to conventional references.

Rizoma Agro's
Microbial Biomass Carbon
mg C. G-1 solo



RIZOMA AGRO'S

Water Assessment

Efficiency of Use

It is known that crop yield increases along with water availability in the root zone, at least until soil moisture reaches a saturation level, above which irrigation has very little effect on crop productivity. However, the crops' yield response curve to water availability depends on various factors, such as soil type, weather conditions, and use of chemical inputs such as inorganic fertilizers. Therefore, without the right technology, it is unlikely that a producer can tell whether a cropland is suffering from water deficit or not before impacts from osmotic stress are already visible and irreversible.

Over-irrigation can cause problems such as water logging, favorable environments for crop diseases, leaching of soil nutrients and contamination of aquifers by agrochemicals. Still, overabundant water usually causes less harm than insufficient water. So, farmers tend to "play safe" and increase irrigation even when there is no real need for doing so.

Rizoma Agro's irrigation management aims to match water availability and water need in quantity and quality to make responsible use of hydric resources. Part of our crops are rain-fed, and other parts are irrigated with specific technologies to ensure the efficiency of water use. Our farms are equipped with tensiometers and on-farm weather stations which are essential tools for creating a safe irrigation schedule, as well as for ensuring an efficient execution of the water management.

Our citrus production in agroforests uses localized drip irrigation, which is widely recognized as the most sustainable method of watering crops. For the drip systems, crops are exposed to small amounts of water in frequent or continuous doses. Irrigation is carried through narrow plastic pipes with small openings that slowly drop water at very precise points, near to the soil or directly into it. Thus, all of the water drops reach the soil, instead of stopping on the leaves and stems, where they can easily evaporate due to exposition into the air.

Some of our grain crops are irrigated with a mobile sprinkler system in which water is expelled from center pivots. These pivots apply water to the crop fields as if they were simulating a light rain. Thus, they prevent puddling, surface runoffs and leaching, which are common in hand moved or big gun sprinkler systems. Also, the pivots have drop nozzles that can be set up close to the ground and even below canopy level as crops grow. This reduces waste as the water is less exposed to the wind.

Water Quality

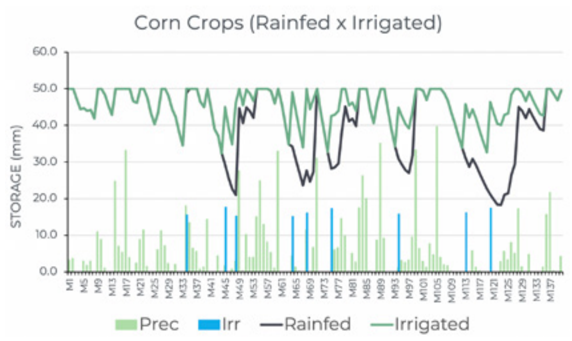
Chemical inputs from agriculture are a major source of water degradation and offer imminent health risks to aquatic and terrestrial ecosystems. It leaches from soils into aquifers and waterways. Along the winding route, it converts to nitrate, which is highly pollutant. As a regenerative organic agricultural company, Rizoma Agro does not apply chemical pesticides and fertilizers to crops. We are committed to ensuring safe sources of food and water for all humans, plants and animals.

Available Water Capacity

The available water capacity indicator refers to the amount of water that can be stored in the soil in a given depth, and therefore to how crops may fare in extremely dry conditions. Soils with a lower storage capacity have a greater risk of drought stress and crop loss. Meanwhile, they are also more vulnerable to deep percolation and leaching during heavy rains. Thus, a high AWC indicates that the soil is resilient to extreme weather.

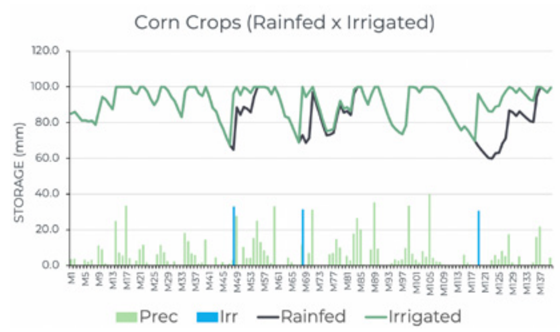
As previously mentioned, the infiltration and retention of water in the soil depends on many variables, such as soil type and weather conditions, but can also be increased or decreased through practices. Referring specifically to croplands, a high AWC is an indicator of proper soil management, as it is directly associated to the soil's structure, aeration, microbial activity and organic matter content. Given the composition of the soils on our farms and climate conditions of our region, it was possible to estimate what would be the expected AWC for our croplands if they were not being farmed in any agricultural system. The figures show that the expected AWC is equivalent to half of the actual AWC that our soils present today, due to the increase in SOM our systems provide. As a consequence, our crops have lower water deficit and require fewer water applications.

Rizoma Agro's
Expected Available Water Capacity **50 mm**
CORN AREA



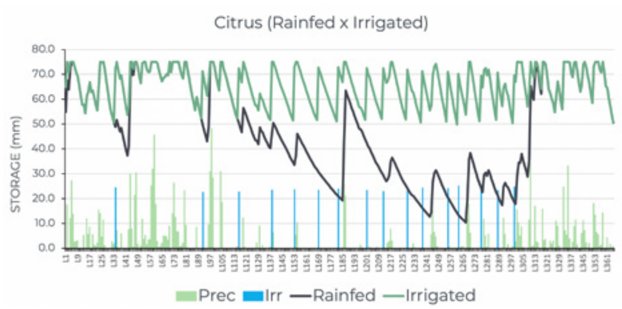
Water deficit: 95 mm
Irrigation: 156 mm
Frequency: 9 applications

Rizoma Agro's
Actual Available Water Capacity **100 mm**
CORN AREA



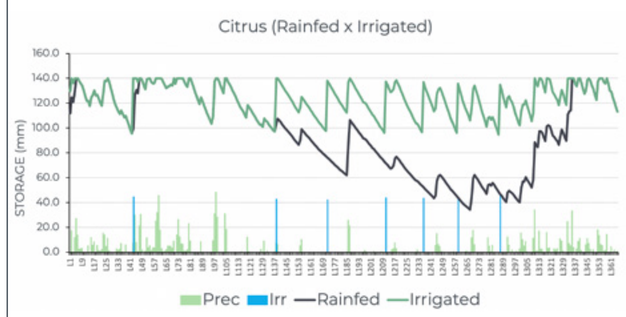
Water deficit: 63 mm
Irrigation: 106 mm
Frequency: 3 applications

Rizoma Agro's
Expected Available Water Capacity **75 mm**
CITRUS AREA



Water deficit: 364 mm
Irrigation: 459 mm
Frequency: 19 applications

Rizoma Agro's
Actual Available Water Capacity **140 mm**
CITRUS AREA



Water deficit: 288 mm
Irrigation: 351 mm
Frequency: 8 applications

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