# Sustainable Land Use in Brazil

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Impactful Governance
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## ACKNOWLEDGEMENTS

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# Objectives

## Short-term

The purpose of the project is to explore all the opportunities and ideas on how to utilise the land in a sustainable manner. In analysing and researching the possibilities, it was crucial to look at the ecology on and around the land, Brazil's own environmental objectives and the community's experiences and perspectives.

## Medium-term

Although Impactful Governance is a community-focused organization, an important element of the project was to be semi-commercial. Through generating some form of financial return, Impactful Governance is then able to replicate the project elsewhere and therefore have a greater environmental impact.

## Long-term

In the future Impactful Governance is looking to create long-term professional relationships. The project is not a quick-fix solution, instead an open dialogue needs to be maintained to ensure the success of the project. Interactions include organisations that have already carried out similar projects and with individuals in the surrounding community.

***"Creating sustainability by imbuing independence and strength into organisations: supporting them to deliver services more effectively"***

# What is sustainable land management?

The ethics of the project are to use the land in Brazil in a sustainable manner. The United Nations have developed a set of 4 principles outlining what criteria must be met for sustainable land management (SLM). Therefore, it is useful for the purpose of the report to utilise the criteria as a broad framework to assess the potential opportunities and recommend which idea is most suitable for Impactful Governance.

These are:

- **Targeted policy and institutional support including development of incentive mechanisms for SLM adoption and income generation at local level**
- **Land user driven and participatory approaches**
- **Integrated use of natural resources at ecosystem and farming system levels**
- **Multi-level, multi-stakeholder engagement and partnership**

SLM can be defined as "the adoption of land-use systems that through appropriate management practices enable land users to maximise the economic and social benefits from the land, whilst maintaining or enhancing the ecological support functions of the land resources."[1] The principle of SLM is highlighted in Goal 15 of the Sustainable Development Goals to halt and reverse land degradation, as 1 in 3 people worldwide are affected by some form of land degradation.[2] In Brazil specifically, it is estimated that 75% of the land is under some degree of land degradation and that figure is expected to rise to 90% by 2050.[3]

[1] FAO, "Sustainable Land Management | Land & Water | Food and Agriculture Organization of the United Nations | Land & Water | Food and Agriculture Organization of the United Nations," www.fao.org, 2023, https://www.fao.org/land-water/land/sustainable-land-management/en/.

[2] United Nations, "The 17 Sustainable Development Goals," United Nations (United Nations, 2015), https://sdgs.un.org/goals.

[3] Stephen Leahy, "75% of Earth's Land Areas Are Degraded, IPBES Report Warns," National Geographic, March 26, 2018, https://www.nationalgeographic.com/science/article/ipbes-land-degradation-environmental-damage-report-spd.

Land degradation arises from a variety of factors such as: soil compaction from excessive grazing of animals and tillage machinery, soil acidification mainly catalysed by anthropogenic gases and aridity where there is a frequent deficit of water.[4]

*Figure 1: Example of sustainable land management using an agroforestry technique: Image by Green News.ie*

A prominent consequence of land degradation is soil erosion, which impacts the fertility of the soil and thereby presents food security problems.[5] Therefore the project can help play an important role in reducing the effects of land degradation by following the principles of SLM.

[4] IPCC, "Chapter 4 : Land Degradation — Special Report on Climate Change and Land," IPCC, 2022, https://www.ipcc.ch/srccl/chapter/chapter-4/.

[5] World Wildlife Fund, "Soil Erosion and Degradation," World Wildlife Fund, 2023, https://www.worldwildlife.org/threats/soil-erosion-and-degradation.

# Interview Discussion

It was important as part of the research for the project to understand the perspectives of those who live in the village close to the land. It is a crucial aspect of any project that wants to provide an environmental solution and fulfil the participatory element of SLM, to include the viewpoints of those close to the area. Humans are also part of the ecosystem and not as a separate entity. It is through the lens of seeing nature as 'other', as an object to be commodified, that there is planetary emergency. Therefore, the opinions of those interviewed have also shaped, alongside my research, what recommendation is proposed.

Isabelly Silvestre carried out a series of interview discussions. The reasoning for interviews over an in person or Google survey, was because of the limited number of people that would take part in the process. I did not want to put pressure on Isabelly to speak to as many people as possible, so I set a target of ten (managed seven) which will be shown following-on as percentages for the purpose of this report. However, with the 70% of people interviewed, each discussion was in great detail and often gave additional information to questions that required short answers.

The interview questions were designed to establish environmental and economic issues that are faced in the area. The questions were also aimed at understanding how open the communities were to an environmental project taking place. I was also aware that the interviewees, being Brazilian (Portuguese language) may not understand the wording of every question or some of the concepts. However, the objective of the interviews was to stimulate discussion and encourage the interviewees to offer their opinions and stories. Furthermore, having such open dialogue is also an opportunity to form connections in helping with the project and increase community involvement.

In trying to achieve an understanding of the local's viewpoints the questions asked were as follows:

1) ***What do you feel are the greatest economic barriers/issues in your neighbourhood?*** [To ascertain what bespoke issues locals face as often economic issues can be associated with environmental]
2) ***General views about the environment [strongly agree/agree/neither agree nor disagree/disagree/strongly disagree*]-** [These questions are to grasp a general sense of attitudes towards the environment]

   a. Jobs today are more important than protecting the environment for the future
   b. If my job caused environmental problems, I would rather be unemployed than carry on causing them
   c. Humans are severely abusing the planet
   d. Nature is strong enough to cope with the impact of modern industrial nations
   e. Plants and animals have the same rights as humans to exist

3) ***Please state your concern with the below statements [each question can be answered with extremely concerned/concerned / neutral /unconcerned /extremely unconcerned*]** – [These options were specifically selected as bespoke issues for Brazil, but they are also broader global issues. The questions aimed to understand the level of awareness the locals have on these problems.]
   a. Air Pollution
   b. Global warming/temperature increase
   c. Extinction of endangered animals
   d. Infertile land/soil
   e. Depletion of the ozone layer
   f. Neuro affections (general health) on human beings from climate change
4) ***What is the most important environmental issue(s) in your neighbourhood in your opinion?*** (ideas were given to prompt discussion such as noise, water or soil pollution)- [ To gauge an awareness of environmental issues in their own neighbourhood]
5) ***In your view, has pollution ever affected your health? [yes/no/don't know question] – if yes state which type of pollution?*** - [Again understanding issues that directly affect the locals]
6) ***What does the phrase sustainability mean to you?*** [to uncover their understandings and beliefs as there are multiple definitions of sustainability and the whole project is focused around the concept of sustainability]
7) ***Are there any barriers to being more eco-friendly or performing more sustainable practices?*** [They may state economic/government funding/education/lack of time on their hands – hoping that the project can try and address any barriers]
8) ***In your opinion, what factors should be taken into consideration when utilising land in a sustainable manner?*** [This is to engage with their own practices and

ideas on utilising land /may help with ideas for the project/could be protecting the land for wildlife/renewable energy/communal space to grow food]

9) ***In your opinion, what are the best ways to encourage the community/village to take more care towards the environment and being more sustainable?*** [What steps would they take to encourage awareness such as, funding, community garden or education]

10) ***Have you in the last 5 years experienced any form of flood damage?*** [This was asked as through my research I came across recent floods in February][6]

11) ***Gender*** [These were asked to ensure a range in demographic]

a. Male
b. Female
c. Other

***12) Age Range***

a. 10-14
b. 15-20
c. 21-25
d. 26-35
e. 36-45
f. 46-55
g. 56-65
h. 65+

***Figure 2: The destruction left after torrential rain in the state of São Paulo- Image by Fernando Marron***

## Trends in Results

Common trends from the interviews found that 100% were concerned about air pollution and 6 out of 7 (86%) commented that air pollution had affected their health. Another pattern was that 5 out of 7 (71%) were also extremely concerned about increasing global temperatures. Often 71% of the interviewees (5 out of 7) felt that spreading awareness and education about climate change is important to encourage members of the community to be more sustainable. Furthermore, every interviewee expressed worry about the welfare of biodiversity, with two stating care for animals is part of the definition of sustainability.

[6] **Betsy Reed, "Brazil Floods: Death Toll Rises to 48 as Landslides and Looters Prevent Aid Reaching Survivors," *The Guardian*, February 23, 2023, sec. World news, https://www.theguardian.com/world/2023/feb/23/brazil-floods-death-toll-flooding-landslides-looters-sao-paulo-state.**

# Explored Opportunities

In this section various ideas were investigated as part of fulfilling the short-term objective of the project. Each opportunity is analysed by assessing both the positives and negatives, and then comparing against the SLM criteria. For various reasons the ideas were not recommended due to other concepts meeting the SLM and the project's requirements more effectively.

## Renewables

Renewables are an increasingly popular source of energy, largely for their ability to avoid releasing harmful emissions and being virtually inexhaustible. Various forms of renewable energy were explored for this project including:

⇒ Solar power

⇒ Wind turbine

⇒ Hydro electricity

**Solar Power** [For the project this form of renewables are the most realistic]. Solar power generates electricity using sunlight, which is extremely effective when Brazil receives on average 3000 hours of sunlight per year.[7] According to the Brazilian government, solar energy is the 3rd largest form of renewable energy after wind and hydro power[8] and has avoided almost 28 million tons of carbon dioxide being emitted.[9] Furthermore, to combat the volatile Brazilian interest rates, in 2020 the government issued a bill removing all import taxes on solar panels, thereby decreasing the price of solar panel equipment.[10]

*Figure 3: Solar panel farm in Brazil- Image by Renewables Now*

[7] Mauro Mantica, "In the Sunniest Country in the World, Solar Energy Finally Explodes," Update Brazil, February 17, 2022, https://updatebrazil.com/2022/02/17/in-the-sunniest-country-in-the-world-solar-energy-finally-explodes/. Government of Brazil, "Solar Energy Becomes the Third Largest Source in Brazil," Serviços e Informações do Brasil, September 8, 2022, https://www.gov.br/en/government-of-brazil/latest-news/solar-energy-becomes-the-third-largest-source-in-brazil.

[9] Beatriz Albuquerque, "Use of Solar Energy Grows in Brazil," Agência Brasil, December 26, 2022, https://agenciabrasil.ebc.com.br/en/geral/noticia/2022-12/use-solar-energy-grows-brazil.

[10] Jose Artur Fortunato, "The Economics of Solar in Brazil," Jose Artur Fortunato, March 12, 2021, https://www.jafortunato.com.br/post/the-economics-of-solar-in-brazil.

There are many benefits to using solar power, such as avoiding the use of unsustainable and harmful fossil fuel energy and their minimal maintenance. The energy produced will also keep energy prices low, whether that be for the adjacent factory situated on the land or for locals as a form of cooperative, rather than relying on state-owned energy grids. Moreover, producing the energy for potential customers will certainly generate a financial return for Impactful Governance either by selling to the Brazilian grid or for the adjacent factory. Although there is a reliance on fossil fuels to make solar panels, as high temperatures are needed to create steam from the materials, they only emit 50g of carbon dioxide per panel.[11] A typical[12] solar panel will save 900kg of carbon dioxide per year,[13] offsetting their emissions in roughly three years.[14]

However, the main issue with the technology is the initial expense. For just one house installation for roof panels the price quoted is $16,359 or $23,393 plus ongoing maintenance costs. [15] If the solar farm is produced on a commercial scale (such as producing 1MW of energy which is equivalent to powering 2,000 homes for an hour) there needs to be additional space for the batteries and inverters, amounting to roughly 6-8 acres of land in total.[16] In addition there are damaging environmental effects (as mentioned earlier) associated with manufacturing the equipment, such as extracting raw natural materials and releasing harmful fossil fuel emissions in the process. In assessing the cradle to grave cycle, there are also issues with recycling the panels.

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**[11] Solaris Renewables , "What Is the Carbon Footprint of Solar Panel Manufacturing?," Solaris Renewables, April 25, 2022, https://solarisrenewables.com/blog/carbon-footprint-of-solar-panel-manufacturing/#:~:text=Solar%20panels%20emit%20around%2050g.**

**[12] A panel that has around 60 photovoltaic cells.**

**[13] The Renewable Energy Hub UK, "Solar Photovoltaics- Cradle to Grave Analysis and Environmental Cost ," The Renewable Energy Hub UK, April 2023, https://www.renewableenergyhub.co.uk/main/solar-panels/solar-panels-carbon-analysis#:~:text=A%20typical%20solar%20panel%20will,payback%20period%20of%20~%201.6%20years..**

**[14] Beth Howell, "What's the Carbon Footprint of Solar Panels?," The Eco Experts, September 30, 2021, https://www.theecoexperts.co.uk/solar-panels/how-eco-friendly-are-they#:~:text=After%20three%20years%20of%20use.**

**[15] Melissa Smith, Karsten Neumeister, and James Savino, "Solar Panel Cost Guide for Brazil, in (2023) - Local Solar Panel Price Estimates and Calculator - EcoWatch," www.ecowatch.com, August 1, 2023, https://www.ecowatch.com/solar/panel-cost/in/brazil.**

**[16] Melissa Smith, Karsten Neumeister, and James Savino, "Solar Panel Cost Guide for Brazil, in (2023) - Local Solar Panel Price Estimates and Calculator - EcoWatch," www.ecowatch.com, August 1, 2023, https://www.ecowatch.com/solar/panel-cost/in/brazil.**

Reports have identified that solar panels quickly become hazardous waste, as it is often more economically viable ($1 versus $18 in the US)[17] to discard the equipment in landfills, where harmful chemicals in the panels escape into the environment and add to the current global e-waste issue.[18] [19]

Therefore, although solar panels are incredibly suited to Brazil's environment, there are considerable environmental problems associated with the technology which can be avoided with other solutions (see recommendations section). In applying the SLM principles it is also clear that there will be very limited community engagement as the solar panels will need minimal maintenance. Damage to the land will also occur, as the plot will need to be levelled for construction. Consequently, grading the land can detrimentally affect local ecosystems and lead to soil erosion and sediment run off. This should be particularly noted as there is a small stream on the land, as any run-off can affect the water quality and effect aquatic life in the area.

## Wind Turbines

Another form of renewable energy is harnessing the power of wind which is then converted into electricity. Most of the same benefits affiliated with solar are applicable for wind turbines. Namely the turbines avoid any harmful emissions. The Brazilian government are currently seeking to expand the wind energy capacity to nearly 27 GW by 2027 and have provided incentives by removing VAT charges on turbine equipment.[20]

However, installing and deciding whether wind turbines are a suitable option can often be a lengthy and expensive process. In Brazil in particular there needs to be investigators to conduct studies over a 2-3 year period to establish factors such as, how much wind is generated in the area, the amount of noise pollution and whether the area is a path where birds migrate.

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[17] Atalay Atasu, Serasu Duran, and Luk N. Van Wassenhove, "The Dark Side of Solar Power," *Harvard Business Review*, June 18, 2021, https://hbr.org/2021/06/the-dark-side-of-solar-power.

[18] Michael Shellenberger, "Dark Side to Solar? More Reports Tie Panel Production to Toxic Pollution," Forbes, 2021, https://www.forbes.com/sites/michaelshellenberger/2021/06/21/why-everything-they-said-about-solar---including-that-its-clean-and-cheap---was-wrong/.

[19] E-waste refers to the waste from electronic goods such as batteries and cables where often the unused products are shipped to countries such as Ghana where they pose a major health hazard for the environment and communities.

[20] Ted Rhodes, "Renewable Energy Law and Regulation in Brazil | CMS Expert Guides," cms.law, December 18, 2020, https://cms.law/en/int/expert-guides/cms-expert-guide-to-renewable-energy/brazil.

Furthermore, wind turbines operate most effectively in mountains, hills or coastal areas. Dense areas with high rise buildings, or valleys between high hills are often problematic, as the objects affect the wind flow. Thus, for efficiency purposes, wind turbines would not be the best solution for the geography of the land as the land is located only up a small hill.

There is also the matter of funding the project. A small free-standing wind turbine generating 2,600 kw in a year would only cost around £7,000 (in the UK) but this is only enough for one household. Whereas a wind turbine generating 36,000 kw in a year would generate electricity for around 15 houses but would cost Impactful Governance £70,000 (in the UK). Various wind farm projects also cited the need for good road access to the site. Transporting the equipment often requires modification of the existing roads to facilitate the vehicles. Adjustment of the road will likely be required as it is reported that there is no clear road to the plot, which therefore involves further expenditure.

## Hydro Electricity

Energy is produced by a high head (vertical distance of the waterfalls) and the flow (the quantity of water). Hydro power is an incredibly popular form of generating energy in Brazil. In 2021 alone, hydro power accounted for 55% of Brazil's energy resource.[21]

*Figure 4: Image taken by Isabelly*

*Figure 5: Stream on the land- Image taken by Isabelly*

A benefit of hydropower in comparison to its renewable counterparts, is the constant water flow. Solar and wind are less flexible as sunlight and wind change with the seasons, whereas the flow of water is more reliable and can therefore meet the demands of the consumers more efficiently.

[21] Statista Research Department, "Brazil: Electricity Generation Share by Source 2021," Statista, January 25, 2023, https://www.statista.com/statistics/985665/brazil-electricity-generation-source/#:~:text=Hydropower%20is%20by%20far%20the.

The flow of water can even be adjusted depending on the desired usage, therefore minimising waste.

Nevertheless, there are some considerable downsides to using such technology; installing even a micro hydro-power system involves some manipulation of the river. Consequently, aquatic ecosystems are affected, by creating fast flowing water but also stagnant water which kills vegetation and emits greenhouses gases as they rot.

In particular relation to the river/stream on the land, from the research the water is very stagnant and shallow, therefore it would not be appropriate to fit a hydropower system.

Renewables Summary

Although all forms of renewable energy are 'clean' in terms of not releasing any harmful fossil fuels into the atmosphere, thereby presenting a more sustainable option to meet consumer demands; for the project there are some financial and environmental hurdles. All of the equipment needed for turbines, solar and hydro still rely on extracting natural resources and emitting fossil fuels in the production process. In applying the SLM principles broadly, all the technologies are also limited in involving the local community (in needing minimal maintenance and specialist engineering knowledge) and will upset local habitats in the construction process.

## Emerging technology

In the face of climate change and issues caused by global warming, new and innovative concepts are necessary. In identifying technology suitable for the objectives set out earlier, two prominent methods of farming stood out as potential ideas to utilise the land.

⇒ Vertical Farming
⇒ Hydroponics

## Vertical Farming

Vertical farming could be a solution to the wider climate change adaption processes. The style of farming optimises space by growing plants vertically rather than horizontally, which confronts the issues associated with land degradation and lack of arable land.

*Figure 6: Vertical farming- Image by Eden Green Technology*

Apart from saving space, the plants are grown in a contained environment. Therefore, producers can control how much water and sunlight the plants receive, rather than being subject to adverse weather hazards such as droughts or excessive rainfall. As a result, there is more certainty for farmers that their crops will be successful and thus a more consistent return on investment for Impactful Governance. Moreover, growing in a warehouse reduces transportation costs of exporting the goods, as the farm can be built close to where the customers reside. The ability to not rely on fertile land with perfect conditions, is useful when thinking about the medium-term objective of replicating the project elsewhere, as the farm can effectively be built anywhere the farmer wishes.

The method of farming also increases efficiency of water usage as researchers estimate traditional farming uses up to 99% more water.[22] The proficient use of water is crucial with global warming where the risks of droughts are becoming more frequent, especially in 2014 where the city of São Paulo's reservoirs came close to running completely dry.[23] Furthermore, depending on how advanced the technology of the farm is, there are options to have it completely automated, however in meeting the criteria for SLM it is advisable that those in the community should be given some opportunity for employment.

[22] Laura Carotti et al., "Improving Water Use Efficiency in Vertical Farming: Effects of Growing Systems, Far-Red Radiation and Planting Density on Lettuce Cultivation," *Agricultural Water Management* 285 (July 1, 2023): 108365, https://doi.org/10.1016/j.agwat.2023.108365.

[23] Philip M Fearnside , "Lessons from Brazil's São Paulo Droughts (Commentary)," Mongabay Environmental News, July 30, 2021, https://news.mongabay.com/2021/07/lessons-from-brazils-sao-paulo-droughts-commentary/.

Moreover, the farms come at a cost. Not only is there the initial outlay but also the ongoing monitoring needed, such as regulating the temperature, lighting and humidity. In managing these variables, requires specialist knowledge which can also increase the overall costs. In the UK, the average cost per square metre of the farm is around £1,400-£2,000, which is above the set budget, as although it is easy to build smaller farms, for commercial viability purposes it is recommended to build at least a 5,000 square metre space.

There is the additional concern for biodiversity, as farmers have to manually pollinate the plants. As a result, insects like bees will be unable to collect the nectar for their diet. Moreover, pollinating the plants is a delicate task in itself and will require further training and knowledge.[24] Thus, growing in a closed environment and thereby removing the roles of the ecosystem network, could have detrimental effects on biodiversity in the long run.

## Hydroponics

Hydroponics is a branch of vertical farming, whereby plants are grown in a contained environment, but without any soil. The soil is substituted by a fertilisation solution and the plants are still provided with sunlight (commonly LED lights) and water.

Again, this style of farming has been presented as the resolution to the concerns raised around how much topsoil is left, with UN Food and Agriculture Organisation stating 90% of Earth's topsoil is at risk by 2050,[25] alongside feeding a growing global population. Other benefits associated with hydroponics are the avoidance of irksome jobs for farmers such as weeding or other species that may affect the growth rate of the plants. There is also no need to apply any form of pesticides or chemical weed control, due to the regulated environment, thereby removing any related health concerns.

[24] Jesse James, "How to Pollinate Plants in a Greenhouse | Greenhouse Emporium," Greenhouse Emporium , June 30, 2020, https://greenhouseemporium.com/greenhouse-pollination/.
[25] FAO, "FAO Warns 90 per Cent of Earth's Topsoil at Risk by 2050," UN News (United Nations, July 27, 2022), https://news.un.org/en/story/2022/07/1123462.

*Figure 7: Lettuce grown using a hydroponic system- Image by Earth.org*

Although, much like vertical farming, there needs to be a constant monitoring of water and sunlight and a stable electricity source, as a prolonged power outage could have irreversible consequences on the crops. Moreover, growing without soil means there are limitations on what the farmers can plant. Tall, deep roots or vining plants are not suitable for a hydroponic system.

There are also debates on whether the products produced are organic, as the plants do not absorb the microbes in the soil.[26] Furthermore, some ecologists have exclaimed that hydroponic production does not 'enhance the living ecosystems that connect mineral soils, organic matter, billions of microbes and soil animals.'[27] Instead the role of nature in producing food is diminished and extracted from the whole growing process.

Emerging technology summary

Although both styles of farming confront the current and pressing issues surrounding soil quality and land degradation, they are both still expensive and exceed the budget. Furthermore, there are environmental concerns surrounding the fact the plants are growing in isolation and not benefiting the native biodiversity. Although there is the possibility for professional partnerships such as Pink Farms (a new vertical farm business in Brazil) to help with the technology; in meeting the SLM requirements there are more effective methods in involving the community and utilising the land and the broader ecosystem.

[26] Allen V Barker, *Science and Technology of Organic Farming.* (S.L.: Crc Press, 2021), 1–5.

[27] Sarah Compson, "Hydroponics Are Not Organic," theecologist.org (Ecologist , September 7, 2021), https://theecologist.org/2021/sep/07/hydroponics-are-not-organic#:~:text=Hydroponic%20production%20is%20completely%20dependent.

## Eucalyptus Plantation

Eucalyptus plantations have become increasingly popular in Brazil, either as a source of income from the timber or the pulp which can produce paper. Near the project's plot of land there are Eucalyptus trees planted, demonstrating the success of growing the plants in the area.

Other than utilising the trees for commercial use, trees are one of the most, if not *the* most, effective methods to capture carbon. Eucalyptus trees themselves after 4 years of growth, capture on average 15.7 tons per hectare.[28] Planting trees also helps combat the deforestation occurring in Brazil, specifically as it is claimed 55% of GHG emissions are due to the effects of deforestation.[29]

The trees themselves are particularly resilient, as native species to Australia and Tasmania, they are highly tolerant to infertile soil. Therefore, Eucalyptus can still grow in areas where there has been any form of land degradation, which as highlighted earlier, is a growing issue. They can also develop quickly at around 2 metres per year meaning there is a fast investment return when cutting down the trees for timber.[30]

Despite their resilient qualities, they release harmful toxins (allelopathy) up to 11 metres away, inhibiting the growth of other plants.[31] Furthermore, growing so quickly also means they deplete the soil's nutrients and water around them, with studies showing how they absorb the water supply for other species.[32]

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[28] Calix, "Plant a Tree and Help Us Reduce Carbon Emissions," Calix | Because Mars is for quitters, 2022, https://calix.global/co2-mitigation-focus-area/plant-a-tree/#:~:text=How%20much%20CO2%20can.

[29] McKinsey & Company, "Pathways to a Low- Carbon Economy for Brazil," 2019, https://www.mckinsey.com/en/Client_Service/Sustainability/Latest_thinking/~/media/McKinsey/dotcom/client_service/Sustainability/cost%20curve%20PDFs/pathways_low_carbon_economy_brazil.ashx#:~:text=Unlike%20more%20industrialized%20nations%20and,for%2043%20percent%20in%202030.

[30] Edward Hodgson and Bryan Elliot, "Eucalyptus as a Short-Rotation Forestry Crop for the UK," www.biomassconnect.org, October 29, 2023, https://www.biomassconnect.org/technical-articles/eucalyptus-as-a-short-rotation-forestry-crop-for-the-uk/#:~:text=When%20planted%20in%20favourable%20locations.

[31] Quynh Nguyen, "How Sustainable Is Eucalyptus Wood? Here Are the Facts," Impactful Ninja, April 2023, https://impactful.ninja/how-sustainable-is-eucalyptus-wood/.

[32] GK Bayle, "Ecological and Social Impacts of Eucalyptus Tree Plantation on the Environment," *Journal of Biodiversity Conservation and Bioresource Management* 5, no. 1 (July 13, 2019): 93–104, https://doi.org/10.3329/jbcbm.v5i1.42189.

There are current protests in Brazil against the company Suzano, who set up Eucalyptus plantations, by farmers who claim their crops are worse or failing due to the intrusive nature of Eucalyptus trees. Often locals rely on the land and water, but harmful chemicals are leaching into the waterways from fertilisers and pesticides, and large eucalyptus roots are absorbing water supplies for the people and their produce.

*Figure 8: A farmer next to a Eucalyptus plantation holding pumpkins smaller than previous harvests: Image by Hanna Nikkanen via Flickr*

It should also be noted, in Eucalyptus' pursuit to find water, their roots are very shallow, which can affect the foundations of buildings. Given that there is a factory near the site, it is advisable to be careful about the location of planting the trees at least 40 to 50 feet away from the building. As a result, this does limit the number of trees that can be planted on the land to generate a financial return.

In addition, not only does cutting down trees in quick succession limit the opportunity for biodiversity to settle and thrive, but as they are a non-native species, animals tend to stay away from the plant. Koala's and the like have adapted to the plant's allelopathy, therefore species local to Brazil do not gravitate towards them.

In acknowledging the tree's beneficial quality for carbon sequestration and capture, it is also important to recognise the damaging effect ecologically but also potentially on humans. Through applying the SLM principles, there are opportunities to employ locals and provide an income for the neighbouring community through timber and firewood. However, the principles demand use of natural resources and as eucalyptuses are not native to Brazil, and given the potential negative impact on native species, it cannot be considered to fulfil this criterion.

# Tourism Opportunities

## Animal Sanctuary

An animal sanctuary could be an effective way to help protect permanently or temporarily endangered species. Animals like the black lion tamarin and the southern muriqui are endangered specifically in the São Paulo region. It has also been reported in the São Paulo state, how overwhelmed wildlife care centres are in being unable to cope with the 30,000 plus animals seized per year.[33]

*Figure 9: Black Lion Tamarin- Image by Jersey Zoo*

The benefits of utilising the land as a sanctuary also means that the landscape can be preserved against urbanisation, destruction and pollution levels. In addition, the sanctuary could provide an opportunity for ecotourism. There will be a need to market the site to attract visitors, but the sanctuary would as a result generate an income whilst providing education and increased awareness for visitors about the animals. As part of running the sanctuary, local communities can also be employed. However, it should be noted that there are a number of regulations and legal obstacles to overcome when setting up a sanctuary. It is important to consider the proximity of the land to the surrounding village, as if there isn't enough of a buffer i.e. land and trees, neighbours can file a legal complaint about the noise. Other legal considerations are seeking approval by the IBAMA (the federal environment protection agency) alongside some form of liability insurance, should an animal harm a visitor. In addition, not only is there the initial outlay of building the facility, food and a constant supply of energy, but also the ongoing veterinary expenses, as running a sanctuary will most likely mean the animals will be in need of some form of medical assistance. There will also be a need to recruit a zoologist or vet to help run the site, increasing the overall expense of the project. Therefore, the costs with running a sanctuary will most likely be too high and would require further investment than what is already budgeted, unless vets or professional animal experts were willing to carry out pro bono work.

[33] Dimas Marques, "In Brazil's Wildlife Care Centers, Struggles and Successes Go Unseen," Mongabay Environmental News, November 25, 2021, https://news.mongabay.com/2021/11/in-brazils-wildlife-care-centers-struggles-and-successes-go-unseen/.

## Agritourism

Agritourism combines agricultural production with tourism to generate an income by attracting visitors to the farm or other agricultural enterprise. The purpose can be for educating or engaging visitors about sustainable farming (particularly useful when interviewees mentioned that education was an important element of sustainability). For example, a guided tour where workers explain different aspects of the farming industry and increase awareness about sustainable practices. Studies have confirmed that there is an increasing 'demand made by tourists for traditional agricultural landscapes [because they are] perceived as a source of mental, physical and spiritual wellness.'[34]

Agritourism can be combined with agroforestry or other forms of farming as an additional source of income for the organisation. Diversifying income that relies on agriculture is especially important where competition, droughts and floods are increasingly common. To set up the agritourism business there needs to be an established brand or logo, alongside an online presence through a website and social media. It is also useful to maintain email lists to inexpensively announce special events and promotions. Agritourism has been found to increase the quality of a farm's produce.[35] The touristic feature means close attention is paid to the sustainability element and therefore promotes ethical practices such as organic farming. Methods of farming which are focused on the origin and production of the produce can reduce the negative effects of intensive agricultural practices, use of harmful pesticides and have a positive impact on biodiversity and natural resources. Moreover, recent studies which have focused on agritourism in rural areas, have mentioned how agritourism has created positive opportunities to develop local businesses and entrepreneurship and local sustainability.[36]

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[34] Luigi Mastronardi et al., "Is Agritourism Eco-Friendly? A Comparison between Agritourisms and Other Farms in Italy Using Farm Accountancy Data Network Dataset," *SpringerPlus* 4, no. 1 (October 12, 2015), https://doi.org/10.1186/s40064-015-1353-4.

[35] Cosmin Alin Popescu et al., "The Impact of Agritourism Activity on the Rural Environment: Findings from an Authentic Agritourist Area—Bukovina, Romania," *Sustainability* 15, no. 13 (January 1, 2023): 10294, https://doi.org/10.3390/su151310294.

[36] Cosmin Alin Popescu et al., "The Impact of Agritourism Activity on the Rural Environment: Findings from an Authentic Agritourist Area—Bukovina, Romania," *Sustainability* 15, no. 13 (January 1, 2023): 10294, https://doi.org/10.3390/su151310294.

Therefore, there is a dual benefit in agritourism not only providing a source of income and educating others about sustainable practices, but it can also act as an incentive mechanism to produce high quality and environmentally friendly produce.

Nonetheless, it should be acknowledged that attracting visitors to the location can create conflict with those who neighbour the land. Although increasing the number of people that pass through the village can help local businesses, there may be upset over the increased traffic.

Additional facilities would be required when offering a service to the public such as providing toilets which will be an additional cost to factor in. Agritourism may also be a better idea to consider for larger plots of land as they would more effectively facilitate tours and tourists.

In meeting the SLM requirements, agritourism could potentially be an effective method to involve the local community in employment, whilst using natural resources in showcasing novelty farming methods and preserving the native wildlife. However, to engage with the multi-stakeholder element of the criteria, it would be important to consult with people in the community on their perspective.

# Recommendations

## Agroforestry

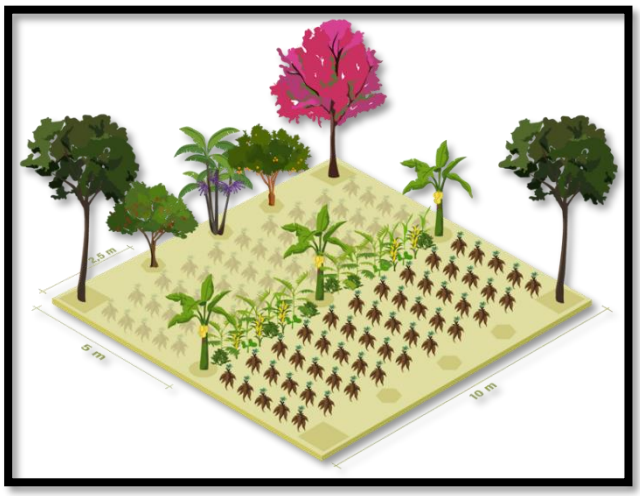


*Figure 10- Pretaterra Illustration example of an agroforestry system: Bruno Felin and Pretaterra , "Making Agroforestry in the Amazon a Family Affair," World Resources Institute (Pretaterra , January 26, 2021), https://www.wri.org/faces-restoration/soares-agroforestry-brazil.*

Agroforestry is described as a farming technique designed to mimic natural forests, by creating mixed landscapes where native vegetation is merged with fruit trees, agricultural crops or even livestock.[37][38] The variety of vegetation helps diversify income, whether from the tall mature trees for timber, the low tree layer for fruits or nuts or the shrub layer for berries. In planning an agroforestry farm there needs to be an awareness of trees and plants already present and ensuring species introduced to the plot complement each other. Otherwise there may be competition for water, thereby depleting the soil of water and nutrients. Examples of what already grows successfully close to the area (from Isabelly's research) are pears, sweet chestnut, cabbage, shallots, oranges, lemons, jackfruit, bananas, guava, Barbados cherry (acerola) and tangerines. In addition, native trees in the area comprise of Brazilian pine typically used for timber, Brazilian orchid tree (Bauhinia forticata) commonly used in medicine for the skin and coconut palm trees. An example of an agroforestry system in practice (10mx10m plot) is planting cassava or a form of annual crop in the middle of the plot. Then high value native trees that take longer to mature are planted 10 metres apart around the edges of the plot such as red cedar or rosewood which are used for perfumes, cosmetics and other uses. Between the native trees fruit plants such as the ones listed above, separated 2.5 metres apart. Amongst the cassava to build up the biomass, short term and valuable plants can be included such as banana trees.[39]

[37] Claire Asher, "Brazil's Agroforestry Farmers Report Many Benefits, but Challenges Remain," Mongabay Environmental News, March 2, 2022, https://news.mongabay.com/2022/03/brazils-agroforestry-farmers-report-many-benefits-but-challenges-remain/.

[38] Agroforestry that combines livestock is also known as silvopasture.

[39] Bruno Felin and Pretaterra , "Making Agroforestry in the Amazon a Family Affair," World Resources Institute (Pretaterra , January 26, 2021), https://www.wri.org/faces-restoration/soares-agroforestry-brazil.

Brazil itself has modified their 2012 Native Protection Law to accept agroforestry as a method of forest restoration, but research shows how there is a lack of knowledge of agroforestry techniques.[40] However, Brazilian initiatives have recognised the importance of reforestation and offer technical and financial expertise, where landowners can demonstrate that there is a genuine preservation of the land.[41] An example is the PSA, a type of payment for environmental services, administered by environmental agencies (not regulated by the government). They currently run an Atlantic Forest Connection initiative jointly with São Paulo, Minas Gerais and Rio de Janeiro, where landowners who have complied with practices such as agroforestry by transforming 'areas of low productivity…into systems of greater ecological function' can apply through a public notice for 'financial and technical support.'[42]

*Figure 11: Image taken by Isabelly*

There are also Brazilian Environmental NGOs such as IPÊ who have helped 51 families in the Pontal do Paranapanema region with agroforestry coffee production and organisations such as Pretaterra Academy who specialise in designing and implementing agroforestry systems, offering online courses at around £89 for 60 hours.

Apart from the support available in Brazil, agroforestry has many environmental benefits when compared to traditional modes of farming. For example, soil fertility and salinity are improved as trees, unlike crops, tend to have deeper roots and are therefore able to extract deeper soil layers. These deeper roots can also slow down any runoff and retain soil nutrients more effectively.

*Figure 12: Image taken by Isabelly*

[40] Yara Shennan-Farpón et al., "The Role of Agroforestry in Restoring Brazil's Atlantic Forest: Opportunities and Challenges for Smallholder Farmers," *People and Nature* 4, no. 2 (January 23, 2022): 462–80, https://doi.org/10.1002/pan3.10297.

[41] Alexei Bonamin et al., "Agricultural Law in Brazil: Overview," Practical Law (Thompson Reuters, September 22, 2022), https://uk.practicallaw.thomsonreuters.com/co_anchor_a382776Legal/system/.

[42] Alexei Bonamin et al., "Agricultural Law in Brazil: Overview," Practical Law (Thompson Reuters, September 22, 2022), https://uk.practicallaw.thomsonreuters.com/co_anchor_a382776Legal/system/.

This feature of agroforestry is particularly important after speaking to Isabelly's family and my research of the flooding in the area. The factory adjacent to the plot of land (owed by Isabelly's uncle) did experience some recent flood damage. Therefore, trees' ability for efficient water management could prove useful should another flood event occur. Moreover, by growing a variety of plants increases opportunities for biodiversity to thrive. Unlike Eucalyptus plantations which are monoculture and are felled every 2 to 3 years, agroforestry requires a multitude of plants where some can grow for decades and produce food in perpetuity. The richness of diversity in plants simultaneously encourages an affluence in diversity of animals. A comparative study was conducted in Brazil between agroforestry and traditional cultivation which found that farmers reported bird abundance was 'high' or 'very high', whereas non-agroforestry farming ranked 'low'.[43]

Agroforestry's ability to provide habitats is not only incredibly important when deforestation in Brazil is so high,[44] but also research has shown that higher diversity in ground predators and parasitoids can reduce some arable pests.[45] As a result, agroforestry reduces the need for synthetic pest-control chemicals, which can be harmful for human health, as well as for the environment. The use of pest-control and fertiliser chemicals were often cited as issues by the Eucalyptus plantation campaigners, as the toxins contaminate the water ways.[46] Additionally, recent studies have illustrated that neighbouring farmlands can also take advantage from the increased biodiversity generated by agroforestry.

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[43] Yara Shennan-Farpón et al., "The Role of Agroforestry in Restoring Brazil's Atlantic Forest: Opportunities and Challenges for Smallholder Farmers," *People and Nature* 4, no. 2 (January 23, 2022): 462–80, https://doi.org/10.1002/pan3.10297.

[44] Steven Grattan, "Deforestation in Brazil's Amazon Rises in March," *Reuters*, April 7, 2023, sec. Environment, https://www.reuters.com/business/environment/deforestation-brazils-amazon-rises-march-2023-04-07/#:~:text=Brazil%20officially%20measures%20annual%20deforestation.
Deforestation is up by 39% year after year.

[45] Janie Caldbeck and Collin Tosh, "How Can Agroforestry Contribute towards Biodiversity Conservation?," Agricology, October 2021, https://agricology.co.uk/resource/how-can-agroforestry-contribute-towards-biodiversity-conservation/#:~:text=Integrating%20trees%20offers%20opportunities%20for.

[46] Ivonete Gonçalves de Souza and Winfridus Overbeek, "Eucalyptus Plantation for Energy: A Case Study of Suzano's Plantations for Wood Pellet Exports in the Baixo Paraníba Region, Marãnhao Brazil " (Biofuelwatch, October 2013), https://www.biofuelwatch.org.uk/wp-content/uploads/eucalyptus-plantations-for-energy-online.pdf.

Hass et al found in South East Asia that rice fields, which support a low level of bee diversity, could benefit from agroforestry's high support for bee diversity from up to a few 100 metres away.[47] Therefore, any neighbouring farm land or gardens growing produce, can equally benefit from the increased levels of biodiversity from the agroforestry system.

Agroforestry has also been recognised as a key concept for mitigating climate change. Diversified agroforestry systems are better designed, than traditional cash crops, for withstanding the changes in temperature. The UNFCCC in particular, has identified agroforestry as an important technique for assisting the agricultural sector, which is particularly vulnerable to climate change; alongside helping promote the multiple ecosystem goods and services provided by forests, which are also threatened by climate change.[48]

The variability in height of the plants creates microclimate conditions, as the larger trees offer shade for the plot of land. A report in Brazil established, that areas suitable for sun-grown coffee are expected to decline by 60% (largely as a result of climate change), whilst shaded agroforestry-grown coffee will remain suitable for the 75% of the current coffee growing areas.[49] More generally, a 2021 study also established in tropical regions that when a substantial number of trees are cleared, it can cause an increase in temperature by 8.1 degrees and affect temperatures for up to 4 miles away.[50] Thus, agroforestry has the potential to help food insecurity and meet the global food demand, by being able to adapt to the changing climatic conditions.

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**[47] Annika Louise Hass et al., "Plant-Pollinator Interactions and Bee Functional Diversity Are Driven by Agroforests in Rice-Dominated Landscapes," *Agriculture, Ecosystems & Environment* 253, no. 1 (February 2018): 140–47, https://doi.org/10.1016/j.agee.2017.10.019.**

**[48] Alexandre Meybeck et al., "ADDRESSING FORESTRY and AGROFORESTRY in NATIONAL ADAPTATION PLANS," *Food and Agriculture Organisation of the United Nations* (Rome: Food and Agriculture Organization of the United Nations and Center for International Forestry Research, November 2020), https://www4.unfccc.int/sites/NAPC/Documents/Supplements/FAO_Forestry%20and%20agroforestry_CB1203EN.pdf.**

**[49] L.C. Gomes et al., "Agroforestry Systems Can Mitigate the Impacts of Climate Change on Coffee Production: A Spatially Explicit Assessment in Brazil," *Agriculture, Ecosystems & Environment* 294 (June 2020): 106858, https://doi.org/10.1016/j.agee.2020.106858.**

**[50] Octavia Crompton et al., "Deforestation-Induced Surface Warming Is Influenced by the Fragmentation and Spatial Extent of Forest Loss in Maritime Southeast Asia," *Environmental Research Letters* 16, no. 11 (October 26, 2021): 114018, https://doi.org/10.1088/1748-9326/ac2fdc.**

In particular one of the interviewees mentioned that the cost of local food is too high and often has to travel into bigger cities. Therefore, producing food more locally can help ease this pressure for the community, specifically when multiple interviewees also complained about the efficiency of the public transport.

It is also important to recognise the drawbacks to agroforestry which are orientated around return of profit/initial costs. Initially agroforestry will not achieve the financial gain of monoculture crops. However, the longevity of the project feeds into the new business venture of Impactful Futures, investing in a sustainable future and not striving for the immediate profit of a project. Besides this initial concern, the WWF conducted a report in 2020 for farmers transitioning from soy to agroforestry farming. Although the cost per acre was considerably more (between $1,060 to $1,180 per acre, versus $300 to plant soybeans) the farmers managed to recoup the original set up costs in 2 years and earned approximately twice as much as what they initially invested.[51]

Wilmot et al recognise that the diversity of the produce may be an issue because the quantity of each crop is small.[52] Thus, there will need to be access to traders that will offer a fair price for the quality of the product, or Impactful Governance sells directly to the consumer.

There are additional costs associated with labour. The style of farming is more labour intensive, as producers are unable to utilise big machinery because of the dense biomass in mimicking a forest. Nevertheless, the necessity for a labour force can be approached as an opportunity to strengthen partnerships and provide jobs for those in the community.

[51] WWF Brasil, "Agrofloresta é Alternativa de Desenvolvimento Na Amazônia," www.wwf.org.br (WWF, September 2020), https://www.wwf.org.br/?76990/Agrofloresta-e-alternativa-de-desenvolvimento-na-Amazonia.

[52] Aaron Willmott et al., "Harnessing the Socio-Ecological Benefits of Agroforestry Diversification in Social Forestry with Functional and Phylogenetic Tools," *Environmental Development* 47 (June 1, 2023): 100881–81, https://doi.org/10.1016/j.envdev.2023.100881.

## Agroforestry summary

In meeting the SLM requirements, agroforestry meets the criteria most successfully when compared to all the other explored opportunities. In relation to renewables, there are opportunities for partnerships with the adjacent factory, however there will be less potential for employing the locals, as specialist engineering knowledge will be necessary for their maintenance. Whereas agroforestry can employ farmers or less skilled workers to help harvest the fruit and maintain the farm, which does not require the same years of experience.

Emerging technology ostensibly has financial barriers to be a viable option for the project.

There is a constant demand for stable energy (which is expensive in the current climate) and specialist knowledge. Furthermore, the requirement of building a factory on the land does not utilise the plot and its natural resources in the same manner agroforestry does.

Agroforestry respects the dynamics of ecological diversity, whereas the emerging technology must create a synthetic version.

The Eucalyptus plantation is an area I wanted to avoid because of the controversy surrounding the topic, but also agroforestry encourages native species rather than non-native. As a result, agroforestry not only fulfils the SLM criteria more successfully, by avoiding importations of non-native species, but has a dual benefit of attracting more biodiversity to make their own habitat when theirs is rapidly decreasing.

Agritourism can also be included as part of the business model if the agroforestry farm is successful, to diversify the income of the farm. As previously discussed, ‘wellness tourism’ is becoming an increasingly popular form of attraction for travellers. However, this may be a long-term strategy as marketing and facilities for the tourists will be necessary, which would require further investment.

In relation to the social element of the project, interviewing those close to the site, agroforestry addresses the concerns more effectively. There is a shared anxiety around air pollution and in particular the impact on their health. Trees and plants are one of the best ways to absorb carbon dioxide and improve the air quality. There are multiple reports highlighting that if the agroforestry system can mimic the structural diversity of a natural forest, it has the capacity to sequester 2.8 tons of carbon per acre per year.[53] Hence why the style of farming has been recognised on the global stage, such as the IPCC identifying agroforestry as 'particularly important strategy for SLM…because of the large potential to sequester carbon in plants and soil.'[54]

Agroforestry is identified as finding the balance between the increased demand for agricultural production and conserving natural ecosystems. Furthermore, the shared concern about biodiversity welfare can also be addressed. Agroforestry has demonstrated significant benefits for providing habitats and encouraging wildlife into the area. The project is also important in increasing awareness. Agroforestry has been slow in its implementation due to the associated initial investment, which is risky and often not a choice for rural farmers, but also the lack of knowledge around how to farm in this manner. This is where I believe Impactful Governance can bridge this gap. Through providing the preliminary funding and increasing awareness and education on how to farm in a sustainable manner, which can then be replicated elsewhere and provide food security in a climate which is drastically changing and where land degradation and infertile land is a common reality.

[53] Sara Popescu Slavikova, "Advantages and Disadvantages of Agroforestry | Greentumble," Green Tumble, September 12, 2019, https://greentumble.com/advantages-and-disadvantages-of-agroforestry.

[54] IPCC, "Chapter 4 : Land Degradation — Special Report on Climate Change and Land," IPCC, 2022, https://www.ipcc.ch/srccl/chapter/chapter-4/.

# Recommendations summary

In implementing the agroforestry system, the first stage would be to contact the suggested organisations who can offer advice and expertise on how to plan the farm; such as including what should be grown in the area and how to farm them. The next stage would address the maintenance of the farm, engaging with locals in the area for employment and potentially volunteers who are passionate about sustainability to be involved in the project. The roles would involve the upkeep of the plants such as watering, cutting back and harvesting the produce. It would also be advisable to plan how Impactful Governance wishes to sell the produce, either through an independent local market or to other traders. For example, one of the interviewees for the project is a shop keeper and thus may be an important contact for selling the goods.

It is worth noting that the land will be taxed at a lower rate as there is a higher level of productivity on the land.

According to Isabelly's research the size of the land qualifies as a 'small' plot and with an agroforestry system there will be a high level of productivity.

Therefore, the land will only be taxed at the minimum rate of 0.03%. It is also worth applying to the initiatives/public authorities outlined above, for any additional technical expertise or finance to help with the implementation of the project.

# References

Albuquerque, Beatriz . “Use of Solar Energy Grows in Brazil.” Agência Brasil, December 26, 2022. https://agenciabrasil.ebc.com.br/en/geral/noticia/2022-12/use-solar-energy-grows-brazil.

Artur Fortunato, Jose . “The Economics of Solar in Brazil.” Jose Artur Fortunato, March 12, 2021. https://www.jafortunato.com.br/post/the-economics-of-solar-in-brazil.

Asher, Claire. “Brazil’s Agroforestry Farmers Report Many Benefits, but Challenges Remain.” Mongabay Environmental News, March 2, 2022. https://news.mongabay.com/2022/03/brazils-agroforestry-farmers-report-many-benefits-but-challenges-remain/.

Atasu, Atalay, Serasu Duran, and Luk N. Van Wassenhove. “The Dark Side of Solar Power.” Harvard Business Review, June 18, 2021. https://hbr.org/2021/06/the-dark-side-of-solar-power.

Barker, Allen V. Science and Technology of Organic Farming. S.L.: Crc Press, 2021.

Bayle, GK. “Ecological and Social Impacts of Eucalyptus Tree Plantation on the Environment.” Journal of Biodiversity Conservation and Bioresource Management 5, no. 1 (July 13, 2019): 93–104. https://doi.org/10.3329/jbcbm.v5i1.42189.

Bonamin, Alexei , Jerry Levers de Abreu, Luiz Renato Okumura, Marco Aurélio Torronteguy, Vera Kanas, and Vladimir Miranda Abreu. “Agricultural Law in Brazil: Overview.” Practical Law. Thompson Reuters, September 22, 2022. https://uk.practicallaw.thomsonreuters.com/co_anchor_a382776Legal/system/.

Caldbeck, Janie, and Collin Tosh. “How Can Agroforestry Contribute towards Biodiversity Conservation?” Agricology, October 2021. https://agricology.co.uk/resource/how-can-agroforestry-contribute-towards-biodiversity-conservation/#:~:text=Integrating%20trees%20offers%20opportunities%20for.

Calix. “Plant a Tree and Help Us Reduce Carbon Emissions.” Calix | Because Mars is for quitters, 2022. https://calix.global/co2-mitigation-focus-area/plant-a-tree/#:~:text=How%20much%20CO2%20can.

Carotti, Laura, Alessandro Pistillo, Ilaria Zauli, Davide Meneghello, Michael Martin, Giuseppina Pennisi, Giorgio Gianquinto, and Francesco Orsini. “Improving Water Use Efficiency in Vertical Farming: Effects of Growing Systems, Far-Red Radiation and Planting Density on Lettuce Cultivation.” Agricultural Water Management 285 (July 1, 2023): 108365. https://doi.org/10.1016/j.agwat.2023.108365.

Compson, Sarah. “Hydroponics Are Not Organic.” theecologist.org. Ecologist , September 7, 2021. https://theecologist.org/2021/sep/07/hydroponics-are-not-organic#:~:text=Hydroponic%20production%20is%20completely%20dependent.

Crompton, Octavia, Débora Corrêa, John Duncan, and Sally Thompson. “Deforestation-Induced Surface Warming Is Influenced by the Fragmentation and Spatial Extent of Forest Loss in Maritime Southeast Asia.” Environmental Research Letters 16, no. 11 (October 26, 2021): 114018. https://doi.org/10.1088/1748-9326/ac2fdc.

FAO. “FAO Warns 90 per Cent of Earth’s Topsoil at Risk by 2050.” UN News. United Nations, July 27, 2022. https://news.un.org/en/story/2022/07/1123462.

———. “Sustainable Land Management | Land & Water | Food and Agriculture Organization of the United Nations | Land & Water | Food and Agriculture Organization of the United Nations.” www.fao.org, 2023. https://www.fao.org/land-water/land/sustainable-land-management/en/.

Fearnside , Philip M. “Lessons from Brazil’s São Paulo Droughts (Commentary).” Mongabay Environmental News, July 30, 2021. https://news.mongabay.com/2021/07/lessons-from-brazils-sao-paulo-droughts-commentary/.

Felin, Bruno, and Preta Terra . “Making Agroforestry in the Amazon a Family Affair.” World Resources Institute. Preta Terra , January 26, 2021. https://www.wri.org/faces-restoration/soares-agroforestry-brazil.

Gomes, L.C., F.J.J.A. Bianchi, I.M. Cardoso, R.B.A. Fernandes, E.I. Fernandes Filho, and R.P.O. Schulte. “Agroforestry Systems Can Mitigate the Impacts of Climate Change on Coffee Production: A Spatially Explicit Assessment in Brazil.” Agriculture, Ecosystems & Environment 294 (June 2020): 106858. https://doi.org/10.1016/j.agee.2020.106858.

Gonçalves de Souza, Ivonete, and Winfridus Overbeek. “Eucalyptus Plantation for Energy: A Case Study of Suzano’s Plantations for Wood Pellet Exports in the Baixo Paraníba Region, Marãnhao Brazil .” Biofuelwatch, October 2013. https://www.biofuelwatch.org.uk/wp-content/uploads/eucalyptus-plantations-for-energy-online.pdf.

Government of Brazil. “Solar Energy Becomes the Third Largest Source in Brazil.” Serviços e Informações do Brasil, September 8, 2022. https://www.gov.br/en/government-of-brazil/latest-news/solar-energy-becomes-the-third-largest-source-in-brazil.

Grattan, Steven. “Deforestation in Brazil’s Amazon Rises in March.” Reuters, April 7, 2023, sec. Environment. https://www.reuters.com/business/environment/deforestation-brazils-amazon-rises-march-2023-04-07/#:~:text=Brazil%20officially%20measures%20annual%20deforestation.

Hass, Annika Louise, Bernhard Liese, Kong Luen Heong, Josef Settele, Teja Tscharntke, and Catrin Westphal. “Plant-Pollinator Interactions and Bee Functional Diversity Are Driven by Agroforests in Rice-Dominated Landscapes.” Agriculture, Ecosystems & Environment 253, no. 1 (February 2018): 140–47. https://doi.org/10.1016/j.agee.2017.10.019.

Hodgson , Edward , and Bryan Elliot. “Eucalyptus as a Short-Rotation Forestry Crop for the UK.” www.biomassconnect.org, October 29, 2023. https://www.biomassconnect.org/technical-

articles/eucalyptus-as-a-short-rotation-forestry-crop-for-the-uk/#:~:text=When%20planted%20in%20favourable%20locations.

Howell, Beth. "What's the Carbon Footprint of Solar Panels?" The Eco Experts, September 30, 2021. https://www.theecoexperts.co.uk/solar-panels/how-eco-friendly-are-they#:~:text=After%20three%20years%20of%20use.

IPCC. "Chapter 4 : Land Degradation — Special Report on Climate Change and Land." IPCC, 2022. https://www.ipcc.ch/srccl/chapter/chapter-4/.

James, Jesse . "How to Pollinate Plants in a Greenhouse | Greenhouse Emporium." Greenhouse Emporium , June 30, 2020. https://greenhouseemporium.com/greenhouse-pollination/.

Leahy, Stephen. "75% of Earth's Land Areas Are Degraded, IPBES Report Warns." National Geographic, March 26, 2018. https://www.nationalgeographic.com/science/article/ipbes-land-degradation-environmental-damage-report-spd.

Mantica, Mauro. "In the Sunniest Country in the World, Solar Energy Finally Explodes." Update Brazil, February 17, 2022. https://updatebrazil.com/2022/02/17/in-the-sunniest-country-in-the-world-solar-energy-finally-explodes/.

Marques, Dimas . "In Brazil's Wildlife Care Centers, Struggles and Successes Go Unseen." Mongabay Environmental News, November 25, 2021. https://news.mongabay.com/2021/11/in-brazils-wildlife-care-centers-struggles-and-successes-go-unseen/.

Mastronardi, Luigi, Vincenzo Giaccio, Agostino Giannelli, and Alfonso Scardera. "Is Agritourism Eco-Friendly? A Comparison between Agritourisms and Other Farms in Italy Using Farm Accountancy Data Network Dataset." SpringerPlus 4, no. 1 (October 12, 2015). https://doi.org/10.1186/s40064-015-1353-4.

McKinsey & Company. "Pathways to a Low- Carbon Economy for Brazil," 2019. https://www.mckinsey.com/en/Client_Service/Sustainability/Latest_thinking/~/media/McKin

sey/dotcom/client_service/Sustainability/cost%20curve%20PDFs/pathways_low_carbon_economy_brazil.ashx#:~:text=Unlike%20more%20industrialized%20nations%20and,for%2043%20percent%20in%202030.

Meybeck, Alexandre, Vincent Gitz, Julia Wolf, and Theresa Wong . "ADDRESSING FORESTRY and AGROFORESTRY in NATIONAL ADAPTATION PLANS." Food and Agriculture Organisation of the United Nations . Rome: Food and Agriculture Organization of the United Nations and Center for International Forestry Research, November 2020. https://www4.unfccc.int/sites/NAPC/Documents/Supplements/FAO_Forestry%20and%20agroforestry_CB1203EN.pdf.

Nguyen, Quynh. "How Sustainable Is Eucalyptus Wood? Here Are the Facts." Impactful Ninja, April 2023. https://impactful.ninja/how-sustainable-is-eucalyptus-wood/.

Popescu, Cosmin Alin, Tiberiu Iancu, Gabriela Popescu, Tabita Adamov, and Ramona Ciolac. "The Impact of Agritourism Activity on the Rural Environment: Findings from an Authentic Agritourist Area—Bukovina, Romania." Sustainability 15, no. 13 (January 1, 2023): 10294. https://doi.org/10.3390/su151310294.

Reed, Betsy. "Brazil Floods: Death Toll Rises to 48 as Landslides and Looters Prevent Aid Reaching Survivors." The Guardian, February 23, 2023, sec. World news. https://www.theguardian.com/world/2023/feb/23/brazil-floods-death-toll-flooding-landslides-looters-sao-paulo-state.

Rhodes, Ted. "Renewable Energy Law and Regulation in Brazil | CMS Expert Guides." cms.law, December 18, 2020. https://cms.law/en/int/expert-guides/cms-expert-guide-to-renewable-energy/brazil.

Shellenberger, Michael. “Dark Side to Solar? More Reports Tie Panel Production to Toxic Pollution.” Forbes, 2021. https://www.forbes.com/sites/michaelshellenberger/2021/06/21/why-everything-they-said-about-solar---including-that-its-clean-and-cheap---was-wrong/.

Shennan-Farpón, Yara, Morena Mills, Aline Souza, and Katherine Homewood. “The Role of Agroforestry in Restoring Brazil’s Atlantic Forest: Opportunities and Challenges for Smallholder Farmers.” People and Nature 4, no. 2 (January 23, 2022): 462–80. https://doi.org/10.1002/pan3.10297.

Slavikova, Sara Popescu. “Advantages and Disadvantages of Agroforestry | Greentumble.” Green Tumble, September 12, 2019. https://greentumble.com/advantages-and-disadvantages-of-agroforestry.

Smith, Melissa , Karsten Neumeister, and James Savino. “Solar Panel Cost Guide for Brazil, in (2023) - Local Solar Panel Price Estimates and Calculator - EcoWatch.” www.ecowatch.com, August 1, 2023. https://www.ecowatch.com/solar/panel-cost/in/brazil.

Solaris Renewables . “What Is the Carbon Footprint of Solar Panel Manufacturing?” Solaris Renewables, April 25, 2022. https://solarisrenewables.com/blog/carbon-footprint-of-solar-panel-manufacturing/#:~:text=Solar%20panels%20emit%20around%2050g.

Statista Research Department. “Brazil: Electricity Generation Share by Source 2021.” Statista, January 25, 2023. https://www.statista.com/statistics/985665/brazil-electricity-generation-source/#:~:text=Hydropower%20is%20by%20far%20the.

The Renewable Energy Hub UK. “Solar Photovoltaics- Cradle to Grave Analysis and Environmental Cost .” The Renewable Energy Hub UK, April 2023. https://www.renewableenergyhub.co.uk/main/solar-panels/solar-panels-carbon-analysis#:~:text=A%20typical%20solar%20panel%20will,payback%20period%20of%20~%201.6%20years..

United Nations. “The 17 Sustainable Development Goals.” United Nations. United Nations, 2015. https://sdgs.un.org/goals.

Willmott, Aaron, Miriam Willmott, Ingo Grass, Betha Lusiana, and Marc Cotter. “Harnessing the Socio-Ecological Benefits of Agroforestry Diversification in Social Forestry with Functional and Phylogenetic Tools.” Environmental Development 47 (June 1, 2023): 100881–81. https://doi.org/10.1016/j.envdev.2023.100881.

Witt, Arne. “Eucalyptus - the ‘Thirsty’ Trees Threatening to ‘Drink’ South Africa Dry.” The Invasives Blog, January 21, 2020. https://blog.invasive-species.org/2020/01/21/eucalyptus-the-thirsty-trees-threatening-to-drink-south-africa-dry/.

World Wildlife Fund. “Soil Erosion and Degradation.” World Wildlife Fund, 2023. https://www.worldwildlife.org/threats/soil-erosion-and-degradation.

WWF Brasil. “Agrofloresta é Alternativa de Desenvolvimento Na Amazônia.” www.wwf.org.br.

WWF, September 2020. https://www.wwf.org.br/?76990/Agrofloresta-e-alternativa-de-desenvolvimento-na-Amazonia