

A critical analysis on the economic theory behind the impact of negative externalities, and relating it to real world situations: the lessons learnt with respect to the agricultural sector: case study of Indonesian agricultural sector

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ABSTRACT

The Indonesian agricultural sector is an important source of foreign exchange and supports a large proportion of the population. The increasing demand for palm oil has led to the increasing standard of living and fortune of those involved in the production of this primary raw materials. Along with this, cocoa and coffee are an important agrarian commodity which has gained importance world wide to such an extent that Indonesia is the third largest producer of Cocoa. The production of these commodities have led to a number of negative externalities being emitted in the atmosphere. This paper analyzes the various theories behind these externalities and how to address them. It also researches whether the price mechanism that exists in the economy takes into account the social cost of production. What are the steps that the government has taken to address the issues of social costs and social benefits in the final pricing of the product? Has this been indicated in the pricing of the product? How far has the government been in successfully implementing the real issue that climate change has brought about in the country? What are the impediments in implementation of such policies?

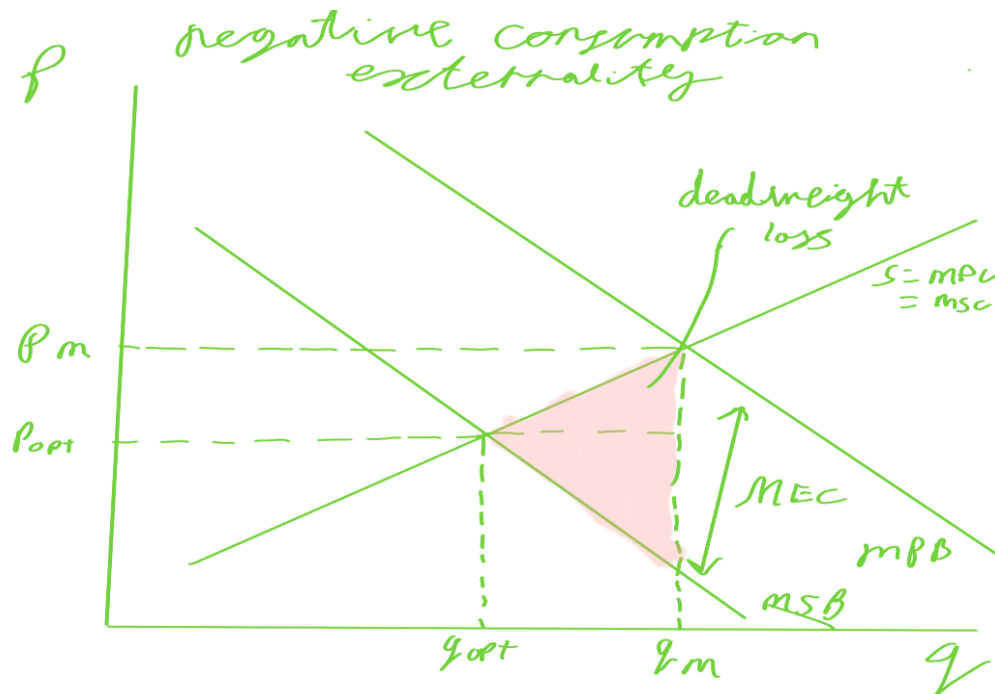
Key words: Negative externality, palm oil production, deforestation, subsidies, taxes, Palm Oil Plantation Fund, tariffs, market failure.

1. Introduction:

Negative externalities represent a foundational concept in economic theory, capturing the unintended and uncompensated costs imposed on third parties by economic activities. Rooted in the broader framework of market failures, negative externalities highlight the divergence between private and social costs, therefore inefficiencies that distort allocative outcomes and compromise Pareto optimality. The framework for understanding negative externalities is derived from the extensive efforts of Arthur Pigou, whose articulation of the imbalance between

private and social costs laid the groundwork for optimal interventions through Pigouvian taxes and regulatory policies. In essence, negative externalities highlight the classical market failure wherein the price mechanism fails to internalize the full societal costs of production and consumption, leading to overproduction or overconsumption relative to socially optimal equilibrium.

Figure 1:



Source: Own source

The X axis represents the Quantity demanded of a specific good or service. The Y axis represents the Price of such goods or services. P_m represents the price of the good in the market, P_{opt} represents the optimal price of said good or service. Q_m represents the quantity demanded of said good or service in the market. Q_{opt} is the optimum quantity demanded for society. S represents supply which is equivalent to MPC which represents the marginal private cost, Which is also equivalent to MSC which represents the marginal social cost. The triangle shaded in red represents the deadweight loss. MPB represents marginal private benefit, while MSB represents marginal social benefit. This leads to overconsumption compared to the socially optimal level. The social benefit is less than the private benefit due to the negative externality. The ideal optimal quantity should be at Q_{opt} and the deadweight loss is the loss of social welfare due to overconsumption. The MSB curve is lower than the MPB curve because the social benefit is less than the private benefit. This diagram indicates that the consumer is only taking into account

their own benefit and not the negative impacts on society leading to overconsumption and welfare loss.

At the pinnacle of this theoretical construct is the recognition that when private entities—whether producers or consumers—do not bear the full social costs of their actions, the resultant negative spillovers impose welfare losses on society. The examples of negative externalities are environmental degradation, pollution, and congestion—phenomena that underline the systemic underpricing of scarce environmental and public resources. In the absence of corrective measures, such externalities detail a misallocation of resources, leading to deadweight losses that undermine both productive and allocative efficiency. This market failure is compounded by the non-excludable and non-rivalrous nature of certain public goods, which amplifies the challenge of internalizing external costs within a decentralized market framework.

2. Economic theories behind addressing negative externalities:

From a theoretical perspective, the internalization of negative externalities needs interventionist strategies aimed at aligning private incentives with social costs. These are:

1. Pigouvian taxation,
2. tradable permit systems,
3. regulatory caps

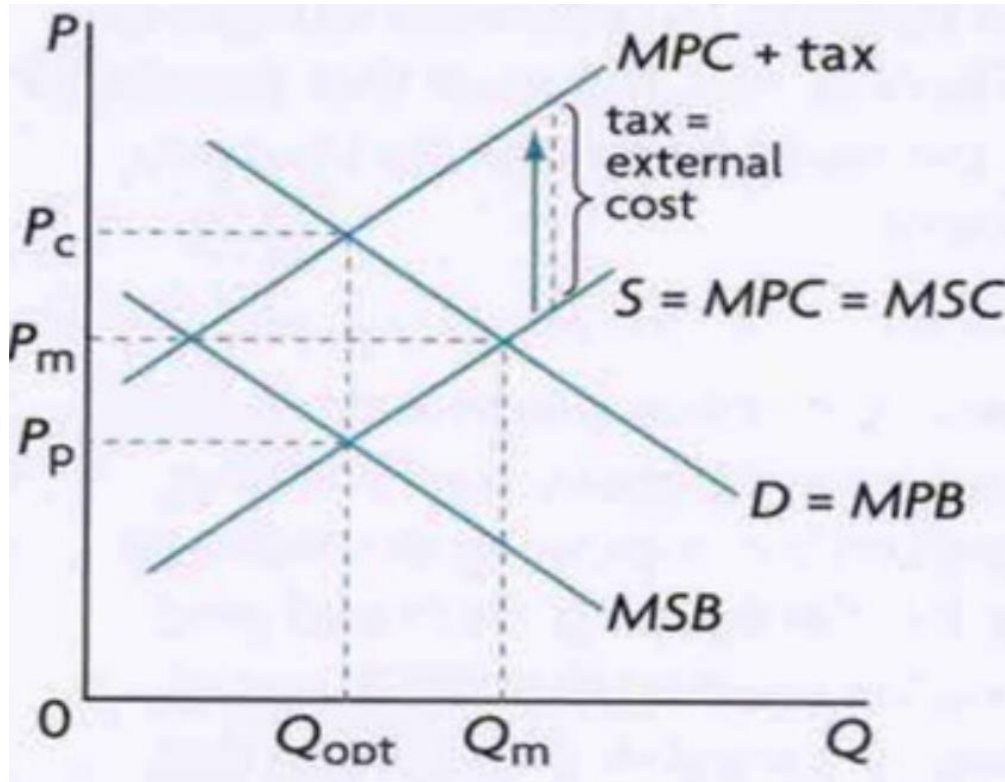
All of the above are optimal forms for addressing these negative externalities.

2.1 Pigouvian taxes operate by imposing a corrective levy equivalent to the marginal external cost, thereby forcing producers and consumers to internalize the true social costs of their activities.

Tradable permit systems, paired with cap-and-trade mechanisms in the carbon markets where a fixed cap is placed on total emissions and firms are allocated or auctioned permits to pollute, which they can trade in leverage market-based incentives that allow firms with lower pollution emissions to sell their unused permits to those firms with higher pollution emissions cost. This ensures the net result to be the same, thus limiting negative externalities while preserving flexibility. This system allows firms to retain the discretion of either reducing emissions or acquiring additional permits at a price, enabling compliance in a manner that best suits their cost structures and technological capabilities.

Regulatory interventions, that include quantitative restrictions and performance standards, represent more direct forms of intervention aimed at diminishing socially detrimental activities.

Figure 2: Diagrammatic representation of Pigou's taxation



Source: Cambridge IB Economics Coursebook (page 167)

In the diagram above, prior to the pigouvian tax, the demand curve is MPB which intersects with the supply curve at point A. At this point $S=MPC=MSC$. On implementation of the Pigouvian tax, the cost of production increases causing a leftward shift of the supply curve from $S=MPC=MSC$ to $MPC+ Tax$, this raises the price of the good or service leading to a leftward shift of the demand curve from MPB to MSB due to a reduction in demand for the good or service. Point C represents the price that the consumer pays for the good or service at price P_c , and point B represents the revenue generated from the imposition of a tax on the good or service indicated by price P_p .

2.2 Tradable permit systems:

Tradable permits are used to prevent negative externalities from degrading the environment. Those firms that have a positive impact on the environment earn credits while those that pollute the environment earn debits. These debits have to be paid from the credits that they earn or else they need to buy it from the companies that have extra one. The negative externalities are calculated based on permissible allowances by the government. Every country whether the US or

EU or any other, has in place an environmental protection agency which offers credits at annual auctions. The implementations of such programs have been estimated to save a number of billions of dollars per year. The agency, most likely the pollution regulator of a country, fixes established norms for emissions of nitrogen dioxide, sulfur dioxide, in various states. There are some states which allow limited or no grass burning, some have water effluent plants in place (this is the problem that India is facing in cleaning up the Ganges. The polluted river passes through industrial areas of various cities where their effluent is allowed to enter into the river unchecked. The government is trying extremely hard to penalize these companies but without much success.)

3. Explanation of Negative Externalities in real world situations:

Real-world examples of negative externality of pollution occur on land, water, and air.

In the case of land, pollution arises when solid and hazardous waste, including plastics, industrial by-products, and agricultural chemicals, accumulate in terrestrial ecosystems, degrading soil quality, reducing land productivity, and generating negative impact on citizens' health and on the biodiversity of the environment.

Water pollution occurs when harmful substances, that include chemical effluents, untreated sewage, and excess nutrients, enter rivers, lakes, and oceans, resulting in the deterioration of water quality, the disruption of aquatic ecosystems, and the imposition of social costs through the impact on human health, fisheries, and water supplies.

Air pollution refers to the emissions of particulate matter, greenhouse gases, and other airborne contaminants that diminish air quality, contribute to adverse climate conditions, imposing significant external costs on society in the form of respiratory illnesses, reduction in labor productivity, and environmental degradation

Firms in industries like manufacturing or energy production emit pollutants into the air or water as a byproduct of their production. Firms sustain the costs related to production, for example: labor, capital, enterprise, and land. But they do not account for the negative impact that they have on the environment and on the health of citizens. The costs that are imposed on society are through increased healthcare expenses, climate change, and reduced biodiversity, leading to a market equilibrium where the quantity of pollution-intensive goods are higher than the socially optimal level. *This is due to the fact that the pricing of polluting goods is not correctly indicated.*

Another example of air pollution is urbanization. Individuals migrate from towns to cities in search of meaningful employment resulting in overcrowding of metropolitan areas. In such a

situation if individuals choose to drive their personal vehicles in densely populated areas, they contribute to traffic congestion, longer ride times, and increased air pollution. Although drivers deal with their personal costs such as: fuel, time, and vehicle maintenance, they do not incur the negative externalities imposed on others like the impact on health on pedestrians as well as, leading to the overuse of roads resulting in inefficiencies in the existing systems. This could be categorized as mounting garbage and high carbon emissions in the air, leading to pulmonary diseases, especially for the young and aged.

4. Research gap and methodology:

The paper would attempt to understand the impact of negative externalities in the availability of scarce resources with special reference to the agricultural sector of Indonesia. What is the pricing of palm oil, a major produce for agriculture in Indonesia? How far is the pricing impacted by subsidies that have been doled out by the government, has the government penalty, levy's, taxes on citizens who pollute land, air, and capital? Have they restricted subsidies on scarce resources? What are the ways in which they are attempting to follow principles of sustainability? How far has the policies of the government impacted the tribes who earned their livelihood from forests where now palm trees stand? Has the government worked towards helping these people, if so? in which manner?

The methodology adopted would be both quantitative and qualitative. The quantitative data would be from secondary authentic sources and these would be analyzed to answer the above stated questions. Qualitative data would be adopted to explain nuances that have arisen due to the inefficient pricing mechanisms.

Table 1, number of people impacted by air pollution in Jakarta:

Year	Deaths due to air pollution:	Number of people impacted by air pollution:
2019	5,054	10.5 million
2020	13,000 / 6,700	10.5 million
2021	7,390	10.5 million
2022	10,500-12,000	10.7 million
2023	10,800-13,000	10.8 million
2024	10,000+	10.9 million

A specific example of a negative externality in agriculture is the case of palm oil plantations in Indonesia. In order to meet global demand for palm oil, which is used in processed foods, cosmetics, and biofuels, large areas of tropical rainforest are cleared, often through slash-and-burn operations.

Table 2, deforestation in Indonesia:

Years	Deforestation(hectares)	carbon emissions due to the deforestation
2019	1,176,884 ha	2.4 Gigatonnes
2020	960,000 ha	0.44 Gigatonnes
2021	841,000 ha	1.2 Gigatonnes
2022	590,000 ha	1.4 Gigatonnes
2023	434,000 ha	1.3 Gigatonnes

This deforestation leads to severe environmental consequences: the release of massive amounts of stored carbon dioxide into the atmosphere, and drastically increasing air pollution across Southeast Asia. In 2015, Indonesia's fires were so intense that daily carbon emissions from the burning forests exceeded those from the entire United States economy for several days. These fires also created a haze crisis, causing illnesses, school losers, and significant economic disruptions in neighbouring countries like Singapore and Malaysia. 7.8 million children in 2019 in Jakarta were affected by air pollution. For subsequent years, this statistic is unavailable. One of the reasons could be that it adversely impacts the claims made by policy makers and is detrimental to politicians.

The fact remains that local indigenous communities suffer an immense amount due to pollution in the form of loss of land, food resources, and cultural heritage. The companies and farmers responsible for clearing up land parcels do not bear these environmental and social costs, they are only concerned with the private benefits obtained from production and sale of palm oil in the global markets. In reality, the social cost of palm oil production is far higher than the private cost, highlighting a negative externality in modern agriculture.

Table 3, The most displaced tribes due to palm oil plantations:

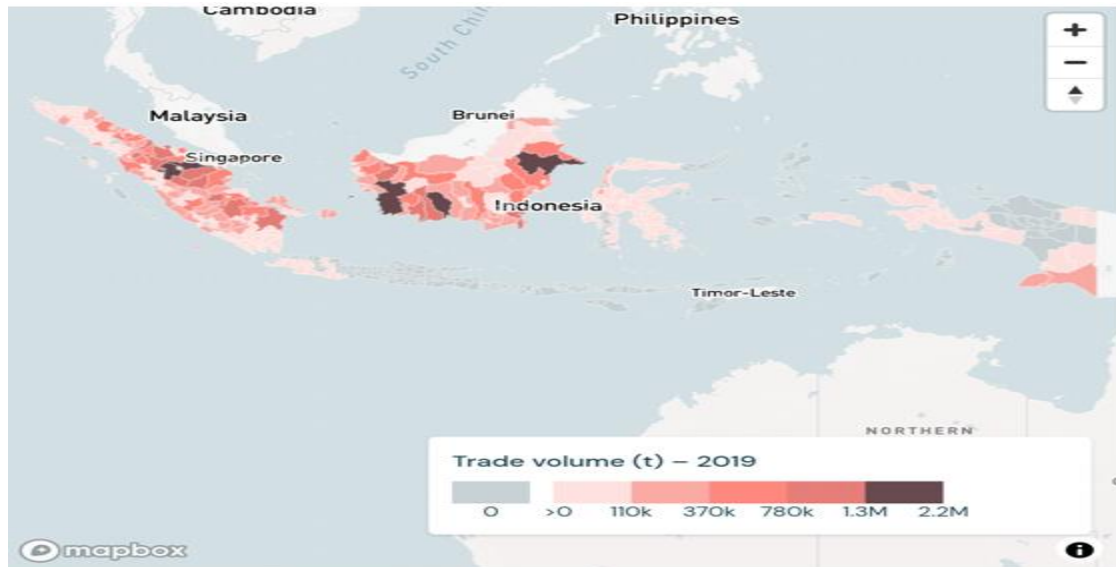
Years	Number of traditional drives displaced due to palm oil plantations
2019	170,000
2020	230,000
2021	237,000
2022	346,00
2023	323,000
2024	206,000

Table 4, Loss in terms of livelihood and habitat of these tribes.

Year	Loss of habitat and livelihood
2019	348,382 ha
2020	624,272 ha
2021	90,031 ha
2022	1,035,613 ha
2023	105,470 ha
2024	127,280 ha

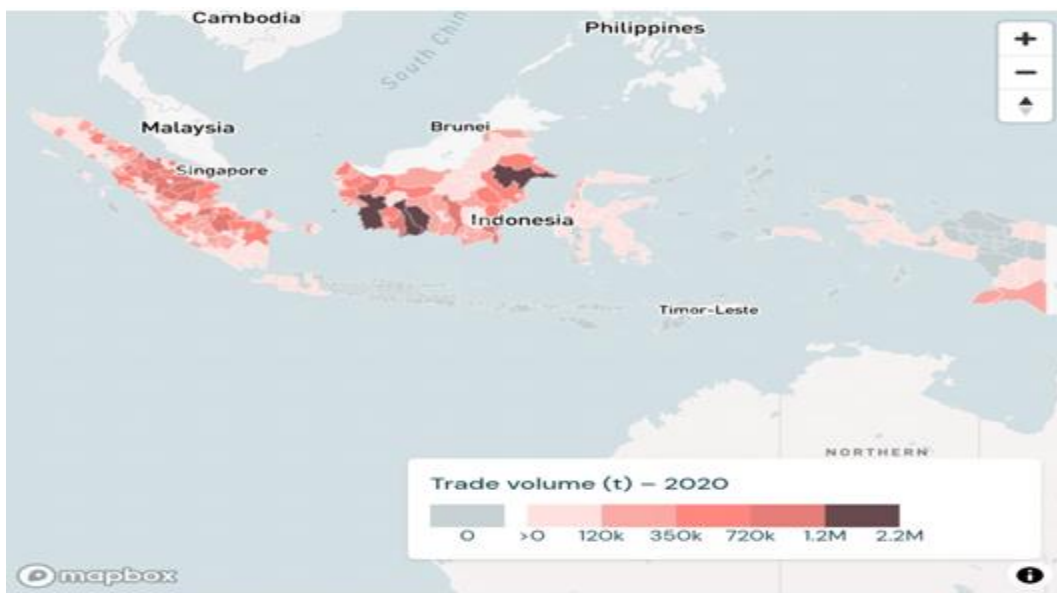
MAP of Indonesia: palm oil plantations over time, 2019-2023.

2019:



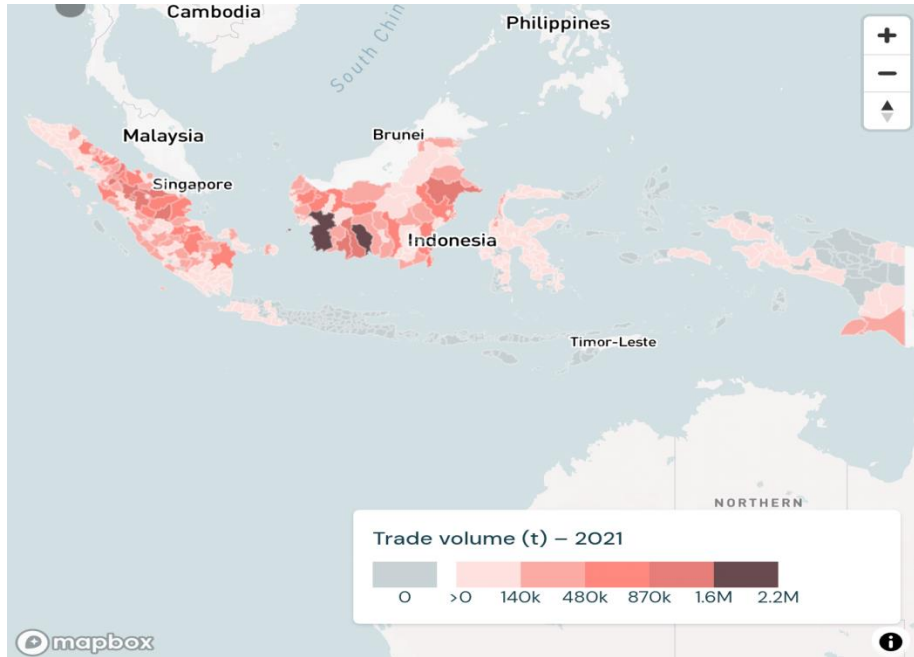
Source: Trase

2020:



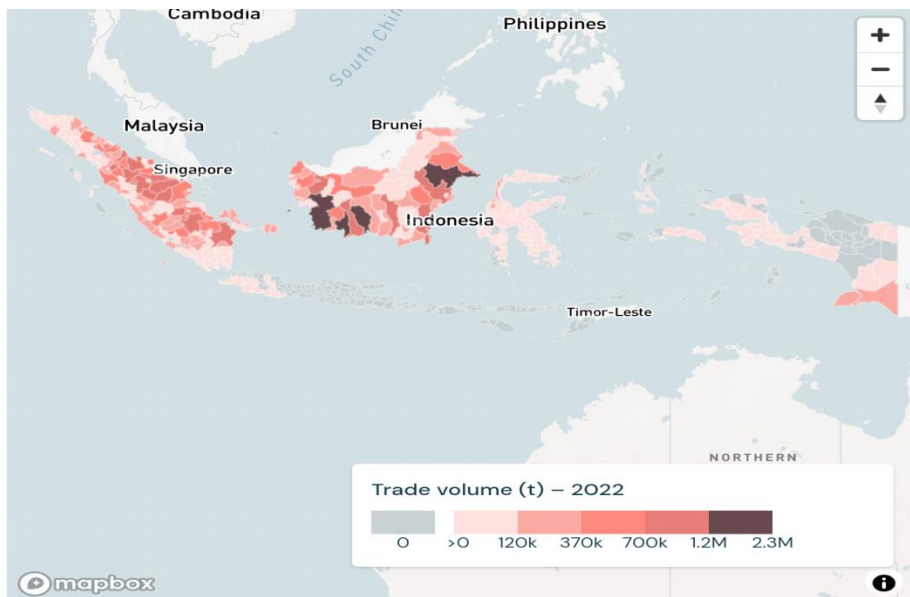
Source: Trase

2021:



Source: Trase

2022:



Source: Trase

5.1 How have negative externalities affected the agricultural sector?

Negative externalities in Indonesia's agricultural sector have significantly reduced soil quality and long-term productivity. One of the most prominent examples is the large-scale burning of trees, particularly in Sumatra and Kalimantan, to clear land for palm oil and other cash crops. It produces large amounts of smoke and particulate matter, leading to the Southeast Asian haze crisis. The haze particularly affects farmers, by disrupting photosynthesis as the haze blocks the necessary sunlight. This reduces crop yields, and contaminates water sources with ash deposits. Additionally, burning releases substantial carbon emissions that adversely contribute to climate change. This has altered rainfall patterns and has increased the frequency of droughts and floods, which have been further detrimental to the agricultural sector.

Burning is not the only negative externalities that has affected the country's agriculture sector. The other negative externalities are the overuse of chemical fertilizers and pesticides in rice, palm oil, and vegetable farming. Instead of increasing productivity, these actions have degraded soil health, reduced biodiversity, and polluted waterways, impacting long term agricultural output by reducing soil fertility and increasing farmers dependence on costly chemical inputs. To take advantage of the increasing demand for palm oil, farmers have resorted to agricultural expansion by deforestation. This has further aggravated the frequency of floods that in turn damaged crops and infrastructure.

These externalities clearly indicate how short-term gains from unsustainable practices have imposed wider social and economic costs. Without stronger enforcement of environmental regulations and promotion of sustainable farming methods, Indonesia's agricultural sector risks long-term decline despite its current economic importance.

5.2 How have positive externalities affected the agricultural sector?

Positive externalities in Indonesia's agricultural sector like the preservation of traditional rice farming through the *subak* irrigation system in Bali has been recognized as a UNESCO World Heritage practice in water management. This system not only boosts crop productivity but also preserves cultural heritage and promotes ecotourism, generating income beyond just farming. The spillover effects benefit local communities and support sustainable agriculture and land use.

Limitations

There were no authentic secondary data that indicated an increase in crop yields from one year to the other.

Government's investment in agricultural, research and training programs, such as the Indonesian Agency for Agricultural Research and Development (IAARD) encourages knowledge sharing on improved seed varieties, sustainable irrigation, and organic farming methods has enhanced productivity of agricultural land at the same time reducing vulnerability to pests. These knowledge spillovers extend beyond individual farmers, raising overall productivity and food production. The amount that has been invested by these agencies from 2019 to 2022 has been increasing as indicated by the table below.

Year	Amount invested into IAARD (\$)
2019	72,300,000
2020	118,300,000
2021	114,400,000 (covid year)
2022	62,230,000 *
2023	N/A (dissolved and was split into ministry of agriculture and BRIN(National Research and Innovation Agency))

(2017,2018, 2023,2024)

*The reasons for this decline was primarily due to the fact that the agency dissolved and was split into the Ministry of Agriculture and BRIN (National Research and Innovation Agency).

This indicates the importance that the government of Indonesia places on Research and Development in the Agricultural sector.

Another format of positive externality is a mixed land use known as Agroforestry. This system intentionally integrates trees and shrubs with crops and livestock practices which has provided significant internal and external benefits. By integrating trees with crops, particularly in coffee and cocoa farming it has improved soil fertility, prevented erosion, and enhanced carbon absorption(has it increased productivity of Cocoa and coffee, if so indicated through table).

Production of these have relatively stayed the same, no significant increases in the past few years have been noticed. National data does not indicate specific areas, only that the government has indicated that total production has remained stagnant. But research has indicated that agroforestry that is used for production of cacao and coffee have produced enhanced harvest leading to increased standard of living of local farmers and society. This indicates a positive impact of a reduction in the effect of climate risk and enhanced biodiversity preservation. The

primary beneficiaries have been small farmers as 90 % of the produce is by them. It is their effort which has led to Indonesia being the third largest producer of Cocoa in the world.

Unforeseen climate risks like El Niño and ENSO (El Niño-Southern Oscillation) have adversely impacted cocoa production through the spread of *witches broom disease* reducing yield per hectare.

As the impact of adverse climate change is visibly affecting cocoa and coffee yield per hectare it is important that deforestation should be curtailed.

Agricultural by-products are increasingly being used for renewable energy. Palm oil waste is being converted into biomass energy, reducing reliance on fossil fuels and providing rural electrification. This creates environmental benefits through lower emissions and gives farming communities additional forms of revenue.

6. Role of the Indonesia government in addressing issues arising due to externalities and political influence on policy measure

The Indonesian government has made significant efforts to address the incorrect pricing caused by agricultural externalities through a mix of taxes and subsidies. One key tool is the palm oil levy and variable export tax, collected by the Palm Oil Plantation Fund (BPDPKS). These levies internalize part of the environmental costs of palm oil expansion, such as deforestation and haze, by taxing exports and channeling revenue into replanting programs, research and development, and sustainability programs. This helps bring private costs closer to social costs.

On the other hand, they have also used subsidies to address the incorrect pricing by promoting biofuels through the B30/B35 program, where subsidies cover the price gap between biodiesel and fossil diesel. This corrects for underinvestment in renewable energy by accounting for its positive externalities, such as energy security and reduced fossil fuel use. Fertilizer subsidies are designed to ensure food security, a positive externality of crop production but this scheme has also produced negative side effects by lowering fertilizer costs, encouraging its overuse, leading to soil degradation and water pollution, showing that not all the policies have effectively addressed incorrect pricing of commodities which emit externalities.

The Indonesian government's response to agricultural externalities is not only influenced by economics, its political and institutional pressures also play a large role in determining how policies are designed and implemented. Palm oil is a politically sensitive commodity, employing millions of Indonesians and generating substantial export revenue. Policies such as the BPDPKS levy have often been influenced by lobbying from large plantation companies and regional elites who benefit from relaxed enforcement of sustainability standards. This has weakened the

environmental objectives of the tax, as revenue distribution and replanting funds sometimes favor major producers instead of small holders, limiting the overall effectiveness of internalizing external costs.

Fertilizer subsidies are politically unpopular because they appeal to rural voters and demonstrate government commitment to food security which is a key political goal. However, their continuation despite environmental effects shows how political incentives can outweigh economic efficiency. Subsidy reform is often resisted due to fears of social unrest or backlash from farmer groups. The same applies to biofuels subsidies, which promote positive externalities like energy diversification, but also reflect strong political alliances between the government and state owned energy companies such as Pertamina.

While Indonesia's policy mix of taxes and subsidies aims to correct externalities, political considerations often distort these mechanisms, prioritizing short-term political stability and vested interest over long-term environmental sustainability and efficient pricing.

7. Limitations

The main limitation is the lack of authentic data on the exact impact of various policy measures and adverse climatic change on the yield per hectare of Cocoa, coffee, and palm oil. There are reports that palm oil production has increased due to flouting of rules and regulations that should have and are in place to prevent further climate risks. Data on the ineffective implementation of policy measures adopted by the government are not available. The reasons may be that the palm oil lobby is extremely powerful, both politically and financially, that it becomes difficult to implement the schemes that have been initiated by the government.

Smaller but significant limitations include the lack of data for smaller regions within the country. Most secondary data sources report national level figures, without distinguishing between provinces or type of farms (e.g. smallholders vs large plantations). This makes it difficult to assess how policies or externalities specifically affect local communities, triable areas, or particular crops in high deforestation zones like Sumatra or Kalimantan.

Data on subsidy distribution, pollution impact, and the effectiveness of environmental levies are not publicly detailed. Government and industry reports sometimes omit sensitive information due to political or economic interests, especially regarding palm oil. This restricts independent verification of the true environmental social costs of production.

8. Conclusion

This research highlights that while Indonesia's agricultural sector remains a vital contributor to economic growth and rural livelihoods, it also generates significant negative externalities, particularly through deforestation, air pollution, and soil degradation. Government interventions like palm oil levies, biofuels subsidies, and fertilizer support, have sought to internalize these external costs and promote sustainability, but their effectiveness has been uneven. Political pressures, data limitations, and enforcement challenges have often diluted policy outcomes, allowing environmental degradation to persist. Positive measures, like agroforestry and agricultural R&D, have shown potential in mitigating climate risks and improving farmer welfare, especially in coffee and cocoa production. However, progress depends on better transparency, accurate pricing of environmental costs, and long term commitment to sustainable practices. Overall, Indonesia's experience highlights the complexity in addressing market failures caused by externalities.

Bibliography

1. *Agricultural Policy Monitoring and Evaluation 2023: Indonesia*. Organisation for Economic Co-operation and Development (OECD), 2023, https://www.oecd.org/en/publications/agricultural-policy-monitoring-and-evaluation-2023_b14de474-en/full-report/indonesia_4ff13b00.html.
2. "Agroforestry Policy Framework in Indonesia." Food and Agriculture Organization (FAO), 2022, <https://www.fao.org/agroforestry>.
3. "Agroforestry Roles for Food Security." Sustainable Development UGM, 23 Oct. 2020, <https://sustainabledevelopment.ugm.ac.id/2020/10/23/agroforestry-roles-for-food-security/>.
4. "Biodiesel Mandate and Fuel Blending Ratios." Ministry of Energy and Mineral Resources, 2023, <https://www.esdm.go.id>.
5. "Bioenergy and Peatland Restoration in Indonesia." United Nations Development Programme (UNDP), 2022, <https://www.undp.org/indonesia>.
6. "Bioenergy Sustainability in Indonesia: Challenges and Prospects." *Journal of Cleaner Production*, vol. 389, 2023, pp. 112–130.
7. "Carbon Emission Trends from Agriculture in Indonesia." Our World in Data, 2023, <https://ourworldindata.org/co2-emissions>.

8. "Climate Change and Peatland Degradation in Indonesia." *Nature Climate Change*, vol. 13, no. 6, 2023, pp. 541–548.
9. "Economic Value of Indonesia's Palm Oil Industry." OECD Development Centre, 2023, <https://www.oecd.org/development>.
10. "Energy Prices and Subsidies in Indonesia." World Bank, 2023, <https://www.worldbank.org/en/topic/energy/publication/energy-subsidies>.
11. "Energy Use and Emission Factors in Indonesia." International Energy Agency (IEA), 2023, <https://www.iea.org/data-and-statistics>.
12. "Fires, Peatlands, and Health Impacts in Indonesia." *The Guardian*, 3 Oct. 2023, <https://www.theguardian.com/world/2023/oct/indonesia-peatland-fires-health>.
13. "Government Optimizes Use of Alternative Energy Sources from POME." BritCham Indonesia, 17 Aug. 2022, <https://britcham.or.id/government-optimizes-use-of-alternative-energy-sources-from-pome/>.
14. "Green Energy Investment in Indonesia." United Nations ESCAP, 2023, <https://www.unescap.org>.
15. "Green Energy Transitions in Southeast Asia." Asian Development Bank Institute (ADBI), 2023, <https://www.adb.org>.
16. Hidayat, Rahman, and Anisa Sari. "Economic Impact of Palm Oil Biodiesel Policies in Indonesia." *Renewable Energy Economics Journal*, vol. 12, no. 3, 2022, pp. 55–68.
17. Incentives for Biodiesel. International Energy Agency (IEA), 2023, <https://www.iea.org/policies/13539-incentives-for-biodiesel>.
18. "Indonesia Biodiesel Production 2018–2023." Statista, 2024, <https://www.statista.com/statistics/indonesia-biodiesel-production>.
19. "Indonesia Bioenergy Outlook 2023." International Renewable Energy Agency (IRENA), 2023, <https://www.irena.org/publications/2023/Jan/Indonesia-Bioenergy-Outlook-2023>.
20. "Indonesia Biofuel Subsidy Policy." International Energy Agency (IEA), 2023, <https://www.iea.org/policies/indonesia-biofuel-subsidy>.

21. "Indonesia Energy Sector Assessment, Strategy, and Road Map." Asian Development Bank (ADB), 2023, <https://www.adb.org/publications/indonesia-energy-sector-assessment-strategy-road-map>.
22. "Indonesia Palm Oil — Supply Chain (2022)." Trase, 2025 (last updated 22 Apr. 2025), <https://trase.earth/explore/supply-chain/indonesia/palm-oil>.
23. "Indonesia Peatland Restoration Progress 2016–2022." Peatland Restoration Agency (BRGM), 2023, <https://brgm.go.id>.
24. "Indonesia's Agricultural Greenhouse Gas Inventory." Ministry of Agriculture, 2023, <https://www.pertanian.go.id>.
25. "Indonesia's Bioenergy Potential and Policy Framework." IRENA Policy Report, 2023, <https://www.irena.org/policy-reports>.
26. "Indonesia's Bioenergy Potential from Palm Oil Waste." CIFOR-ICRAF Forests News, 18 Apr. 2022, <https://forestsnews.cifor.org/76629>.
27. "Indonesia's Bioenergy Roadmap 2021–2040." Ministry of National Development Planning (BAPPENAS), 2021, <https://bappenas.go.id>.
28. "Indonesia's Biodiesel Expansion Plan." Reuters, 15 Mar. 2023, <https://www.reuters.com/business/energy/indonesia-biodiesel-expansion-plan-2023-03-15/>.
29. "Indonesia's Emission Reduction Targets." Climate Action Tracker, 2023, <https://climateactiontracker.org/countries/indonesia>.
30. "Indonesia's Energy Outlook 2023." Ministry of Energy and Mineral Resources, 2023, <https://www.esdm.go.id>.
31. "Indonesia's Forest and Land Fire Statistics." Ministry of Environment and Forestry, 2023, <https://www.menlhk.go.id/statistics>.
32. "Indonesia's National Energy Policy (RUEN)." Ministry of Energy and Mineral Resources (MEMR), 2023, <https://www.esdm.go.id/en/publication/national-energy-policy>.
33. "Indonesia's Net Zero Emission Strategy 2060." Ministry of Environment and Forestry, 2022, <https://www.menlhk.go.id>.

34. "Indonesia's Palm Oil and Biodiversity Loss." World Wide Fund for Nature (WWF), 2023, <https://www.wwf.or.id>.
35. "Indonesia's Palm Oil-Based Biofuel Policy." Asian Development Bank (ADB), 2022, <https://www.adb.org/publications/indonesia-palm-oil-based-biofuel-policy>.
36. "Indonesia's Peatland and Wetlands Restoration." Wetlands International, 2023, <https://www.wetlands.org>.
37. "Indonesia's Peatland Fires and Restoration Efforts." United Nations Environment Programme (UNEP), 2021, <https://www.unep.org/news-and-stories/story/indonesias-peatland-fires-and-restoration-efforts>.
38. "Indonesia's Peatland Fires: The Cost of Sustainability." World Resources Institute (WRI), 2022, <https://www.wri.org/insights/indonesia-peatland-fires>.
39. "Indonesia's Peatland Restoration Agency: Achievements and Challenges." Global Landscapes Forum, 2023, <https://www.globallandscapesforum.org>.
40. "Indonesia's Peatland Restoration Initiative." World Bank, 14 Oct. 2022, <https://www.worldbank.org/en/news/feature/2022/10/14/indonesia-peatland-restoration-initiative>.
41. "Indonesia's Progress Toward SDG 7: Affordable and Clean Energy." United Nations Development Programme (UNDP), 2023, <https://www.undp.org/sustainable-development-goals>.
42. "Indonesia's Renewable Energy Regulation." International Renewable Energy Agency (IRENA), 2022, <https://www.irena.org/policy>.
43. "Indonesia's Renewable Energy Share in Total Primary Energy Supply." International Energy Agency (IEA), 2023, <https://www.iea.org>.
44. "Indonesia's Renewable Energy Transition." International Energy Agency (IEA), 2023, <https://www.iea.org/reports/indonesia-renewable-energy-transition>.
45. "Indonesia's Peatland and Wetlands Restoration." Wetlands International, 2023, <https://www.wetlands.org>.
46. "Indonesia's Peatland Fires and Restoration Efforts." UNEP, 2021, <https://www.unep.org>.

47. "Integrating Bioenergy and Food Production on Degraded Landscapes in Indonesia for Improved Socioeconomic and Environmental Outcomes." CIFOR-ICRAF Forests, Trees and Agroforestry, 2022, <https://www.foreststreesagroforestry.org/integrating-bioenergy-and-food-production-on-degraded-landscapes-in-indonesia-for-improved-socioeconomic-and-environmental-outcomes/>.
48. Jelsma, Idsert, and Agus Andrianto. "Sparking Debate over Fire Use on Agricultural Land in Indonesia." *CIFOR Forests News*, 25 Sept. 2019, <https://forestsnews.cifor.org/58756/sparking-debate-over-fire-use-on-agricultural-land-in-indonesia>.
49. "Kontribusi Sistem Agroforestri terhadap Pendapatan Petani di Kawasan Hutan Negara: Studi Kasus Parungpanjang, Indonesia." Pusat Pengkajian Pembangunan Wilayah IPB University (P4W IPB), 2021, <https://p4w.ipb.ac.id/kontribusi-sistem-agroforestri-terhadap-pendapatan-petani-di-kawasan-hutan-negara-studi-kasus-parungpanjang-indonesia/>.
50. "Palm Oil and Energy Transition in Southeast Asia." International Energy Forum (IEF), 2023, <https://www.ief.org>.
51. "Palm Oil and Rural Livelihoods." CIFOR Forests News, 2022, <https://forestsnews.cifor.org>.
52. "Palm Oil Biodiesel Program to Reduce Emissions." Reuters, 2023, <https://www.reuters.com/sustainability/palm-oil-biodiesel-program-2023>.
53. "Palm Oil Exports and Economic Growth in Indonesia." World Bank Data, 2023, <https://data.worldbank.org/indicator/NE.EXP.GNFS.CD?locations=ID>.
54. "Palm Oil Industry in Indonesia." USDA Foreign Agricultural Service, 2023, <https://www.fas.usda.gov/data/indonesia-palm-oil-industry-2023>.
55. "Palm Oil Methane Capture and Energy Production." Global Methane Initiative, 2021, <https://www.globalmethane.org>.
56. "Palm Oil Methane Emission Reduction Project." United Nations Framework Convention on Climate Change (UNFCCC), 2023, <https://unfccc.int>.
57. "Palm Oil Waste to Energy Initiatives." ASEAN Centre for Energy, 2022, <https://aseanenergy.org>.

58. "Palm Oil Bioenergy Supply Chains in Indonesia." *Journal of Renewable and Sustainable Energy*, vol. 15, no. 4, 2023, pp. 445–459.
59. "Peatland and Biodiversity Conservation in Indonesia." Conservation International, 2022, <https://www.conservation.org>.
60. "Peatland Fire Management Policies in Indonesia." CIFOR Policy Brief, 2023, <https://www.cifor.org/publications>.
61. "Peatland Fires and Haze in Southeast Asia." NASA Earth Observatory, 2021, <https://earthobservatory.nasa.gov/features/IndonesianFires>.
62. "Peatland Fires Emission Data 2015–2023." Center for International Forestry Research (CIFOR), 2023, <https://www.cifor.org>.
63. "Peatlands and Climate Change." Food and Agriculture Organization (FAO), 2023, <https://www.fao.org/peatlands>.
64. "Regulation of the Minister of Agriculture Number 43 of 2019 on Registration of Pesticide (Indonesia)." CIRS Group, 2019, <https://www.cirs-group.com/en/agrochemicals/regulation-of-the-minister-of-agriculture-number-43-of-2019-on-registration-of-pesticide-indonesia>.
65. "Restoring Indonesian Peatlands, Protecting Our Planet." United Nations Office for Project Services (UNOPS), 5 June 2022, <https://www.unops.org/news-and-stories/stories/restoring-indonesian-peatlands-protecting-our-planet>.
66. "Smallholder Palm Oil Farmers and Energy Transition." World Agroforestry (ICRAF), 2023, <https://www.worldagroforestry.org>.
67. "Sparking Debate over Fire Use on Agricultural Land in Indonesia." *CIFOR Forests News*, 25 Sept. 2019.
68. "Statistics Indonesia (BPS): Indonesia Environmental Statistics 2020." Badan Pusat Statistik (BPS), 27 Nov. 2020, <https://www.bps.go.id/en/publication/2020/11/27/969702bd7c227b224b293795>.
69. "Sustainable Biomass Policies in Asia." International Renewable Energy Agency (IRENA), 2022, <https://www.irena.org/publications>.

70. "Sustainable Palm Oil and Bioenergy." Roundtable on Sustainable Palm Oil (RSPO), 2023, <https://rspo.org/news-center>.
71. Wibowo, Andi, et al. "Assessing Agroforestry's Potential for Sustainable Food Systems in Indonesia." *IOP Conference Series: Earth and Environmental Science*, vol. 1145, no. 1, 2023, <https://iopscience.iop.org/article/10.1088/1755-1315/1145/1/012001>