sustainability

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Trans-Boundary Haze Pollution in Southeast Asia: Sustainability through Plural Environmental Governance

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Academic Editor: Marc A. Rosen

Received: 29 February 2016; Accepted: 13 May 2016; Published: 21 May 2016

Abstract: Recurrent haze in Southeast Asian countries including Singapore is largely attributable to rampant forest fires in Indonesia due to, for example, extensive slash-and-burn (S & B) culture. Drawing on the "treadmill of production" and environmental governance approach, we examine causes and consequences of this culture. We found that, despite some perceived benefits, its environmental consequences include deforestation, soil erosion and degradation, global warming, threats to biodiversity, and trans-boundary haze pollution, while the societal consequences comprise regional tension, health risks, economic and productivity losses, as well as food insecurity. We propose sustainability through a plural coexistence framework of governance for targeting S & B that incorporates strategies of incentives, education and community resource management.

Keywords: slash-and-burn; environmental governance; haze; Indonesia; plural coexistence; global warming; Singapore

1. Introduction

The world's rapidly growing population has been a long-standing cause of concern amongst both economists and environmentalists alike. There is an increasing demand for agricultural and urban spaces to sustain the ever-multiplying demographics. However, due to limited availability of space, the trend of clearing forests to make way for cultivable land has been gaining popularity [1]. One of the most perturbing methods of clearing forests is the utilization of Slash-and-Burn (S & B). The S & B method involves the felling of trees and plants, followed by setting fire to the designated area. Owing to this method's high efficiency and low cost, it has been adopted in a number of developing nations. However, the employment of S & B is not without dire consequences, the most serious of which are trans-national repercussions on the environment, economy and society [2].

Although prevalent across the globe, the practice of S & B is particularly rampant in Indonesia [1,2]. Consequently, neighboring Southeast Asian countries such as Singapore, Malaysia, Brunei and Thailand are negatively affected by S & B techniques in Indonesia [3]. In fact, the trans-boundary haze pollution due to forest fires has become significantly more evident in the recent past, with the extent of air pollution rising to record-high levels. In 1997, for example, due to haze pollution, Singapore recorded a Pollution Standards Index (PSI) level of 226, which rocketed to a reading of 401 in the mid-2013 bout of haze, as reported by BBC News (21 June 2013). These figures demand a deeper analysis of the practice of S & B and the consequences it has, not only on the country in which it is practiced, but also on neighboring nations that are affected by it.

This paper investigates the technique of S & B in a comprehensive manner—studying the reasons for employing S & B, the resulting effects of forest fires, and corrective measures to control the issue. It utilizes the treadmill of production theory to assess the extent to which S & B depletes resources from the environment and simultaneously produces wastes that are harmful to it [4]. First, it analyzes the various factors that encourage the use of S & B in Indonesia. Besides simply being a cheap and efficient method of forest clearing, S & B is also employed to facilitate peatland drainage, logging and establishment of oil palm plantations. Furthermore, weak governance in Indonesia allows for certain groups to exploit common natural resources at the cost of the environment and other sections of society. The paper then proceeds to identify the environmental, societal and economic repercussions, both direct and indirect, of S & B on the countries affected by it. Finally, the paper suggests certain measures that address the concerns surrounding S & B. The implementations of these national and trans-national recommendations would greatly diminish the dangerous impacts of S & B on the affected countries.

2. Framework

2.1. Treadmill of Production

Economic production is the vehicle on which contemporary capitalist societies run. As a result of continuous, unchecked production, a self-sustaining process called the treadmill of production occurs. The treadmill of production theory, a strand of Neo-Marxist understanding of capitalism's relationship with the environment, argues that the continuous race of production through a continuous enhancement of productive forces and practices (S & B in our case) and the need for its continued consumption create a critical interchange of "withdrawals" (extraction of resources from the environment) and "additions" (what is returned to the environment in the form of pollution and garbage). These cycles of withdrawals and additions can disorganize the biospheric systems [4].

The treadmill of production model was further elaborated to incorporate the impacts of production not just on ecological elements, but also on social and economic ones [5]. In the case of S & B, the greatest ecological withdrawal is deforestation, which results in a series of subsequent withdrawals from the environment. These occur in the form of soil erosion and degradation, global warming and climate change and threats to biodiversity. As part of the process of S & B, air pollution in the form of haze is added to the environment, resulting in a plethora of other environmental, political, social, and economic concerns, such as regional tension, health risks, economic and productivity losses and food security issues. Thus, by extracting valuable resources from the eco-system, and contributing hazardous pollutants back to it, S & B is a practice that runs on the treadmill of production.

2.2. Environmental Governance

Environmental governance refers to interventions and regulations that impact the environment. It encompasses mutually beneficial actions and decisions made by the state, communities, corporations and nongovernmental organizations. Hence, these interventions can take the form of international treaties, national policies or local legislation to preserve the quality of the environment, while simultaneously ensuring the well-being of society and the growth of the economy [6]. The environmental governance can be used to recommend certain interventions to mitigate and reduce the impacts of S & B. For our paper, we have used four over-arching themes of environmental governance.

First, with the increasing interconnectedness of today's world, natural resource depletion and waste production spread across geopolitical boundaries. Capital is directed towards countries that have more lenient environmental standards, due to which, resources in these countries are exploited until another country provides easier conditions for production. This "race to the bottom" leaves countries with destroyed natural systems and deep socioeconomic inequalities [6] (p. 300). However, globalization can also aid in the restoration of such nations. With the help of the free flow of information,

better technology and the support of transnational environmental institutions, policy initiatives can be established to implement and preserve safe environmental standards.

Second, it is contended that there is a shift towards environmental governance on a "subnational level" [6] (p. 302). The decentralization of governance ensures efficient community-based resource management by those who are more knowledgeable about them, as well as concentrated efforts to protect these resources [6].

The third theme of environmental governance is market- and agent-focused instruments, which aim to favor environmentally sound practices through calculated incentives and costs. These instruments include taxes, subsidies, market incentives and certifications, amongst many other measures, that mobilize individuals to support operations that are the least harmful to the environment. Finally, scholars suggest that, since the repercussions of environmental problems are felt at the local, national, and transnational levels, there needs to be multi-level governance to address these issues [6].

3. Contributing Factors behind S & B Culture

Despite the availability of other, more sustainable alternative, methods of clearing forests (for example, slash-and-mulch, which clears forests by slashing and subsequently planting crops in the mulch, and improved fallow, whereby the land is left fallow to restore fertility), S & B is still rampant across the world. This is due to several factors that make it the most efficient method to implement, which are discussed in this section.

3.1. Perceived Relative Benefits

One of the main reasons why S & B is selected as the method of forest clearing is the perceived economic and environmental benefit of the practice. For example, S & B is often thought to be the most efficient and cost-effective method of clearing land. It is also believed to enhance soil nutrients, balance soil pH levels and soil structure, as well as reduce aluminium presence. Besides these benefits, S & B is viewed as advantageous because it prevents growth of weeds and incidence of pests and diseases [2,3,7–10].

In comparison, however, the alternatives to S & B are perceived as more expensive and as resulting in fewer benefits. Burning assists in the production of ash fertilizer and also aids the eradication of pests and diseases, without which there would be lower crop output or late crops, and higher labor costs. As a result, income would be reduced and poverty would increase [3]. However, it is important to note that these benefits appear to outweigh the costs since they only take into consideration short-term benefits and costs. Greater, long-term costs, both ecological and social, are often ignored, resulting in a misguided perception that S & B is more advantageous than it is harmful [2,11].

3.2. Logging

Logging refers to the extraction of timber from forests. The result of logging often acts as a catalyst to forest fires. For instance, logging leaves behind easily combustible litter on the forest floor. It also leaves behind an open canopy, which then creates drier conditions and permits the growth of extra-combustible vegetation beneath, thus increasing the risk of fire [12–14]. Furthermore, when trees in dense tropical forests are felled, the intertwined roots and vines uproot other trees as well, exacerbating the extent of the aftermath of logging [15]. Logged forests are much more susceptible to fires in comparison to unlogged forests since logging translates into more forests burned and more crown fires [16]. On the other hand, unlogged forests experience less damage, and therefore, are only susceptible to small-intensity surface fires. Evidence of this can be seen in the case of Kalimantan, where 97% of logged forest and peat were destroyed by fire, as compared to 11%–17% of unlogged forest [16].

Another related factor that encourages logging, and subsequently fires, is the construction of roads and irrigation canals, which pave the way for further illegal logging. With this infrastructure in place, people can now access the once-inaccessible forests and peatlands to obtain and transport

timber illegally, or even to develop the land for economic purposes. Indeed, as a result, illegal logging rates rose by 44% from 1997 to 2000 [15].

3.3. Oil Palm Plantations

Oil palm is a valuable cash crop for its oil is used as fuel for vehicles, as cooking oil and in cosmetics [15]. Indonesia's climate and soil are suitable for the growth of oil palm, which contribute to its high output and whole-year harvest schedule [13]. Farmers are compelled to grow oil palm to reap the most economic benefits possible from shrinking farm acreage [3]. Forest areas burnt during the 1980s' fires expedited their development into plantations via burning [16]. Since fire is the cheapest and fastest means of clearing land, it was found that 80% of the forest fires were deliberately ignited by plantation companies, and the other 20% by farmers [3,13]. Rapid development in the oil palm sector during the 1990s led Indonesia to expand oil palm plantations to become the world's biggest producer of palm oil, producing 51% of worldwide yields [13,16]. Between 1990–1997, land designated for oil palm plantations doubled to 2.5 million hectares and was projected to increase to 5.5 million hectares by 2000 [17]. With the issuance of Presidential Decree no. 80/1999 in July 1999, 2.8 million hectares of peatlands were targeted for conversion into cash crop estates, the majority being oil palm estates. Logging and oil palm processes can interact [17]. For instance, forestry companies tend to be interested not only in logging but also in the oil palm sector. As a result, logged forest areas are usually converted into oil palm plantations via S & B.

3.4. Government Corruption and Weakness

Many plantation companies from Indonesia, Malaysia and Singapore establish and maintain political connections with Indonesian government officials to receive concessions and face fewer red-tape barriers, such as attaining necessary certification and rights for clearing land more easily and quickly. Government officials are also motivated towards corruption and encouraging S & B due to low pay, a desire for side-line benefits or high cost and difficulty of monitoring and enforcing laws [10,13]. For instance, former Minister of Trade and Industry, Bob Hasan, has been known to channel funds from public avenues such as the Reforestation Fund for private businesses. In addition, 60 million hectares of forests are concentrated in the hands of about 500 companies with logging rights; Barito Pacific Group alone has access to 5.5 million hectares of forest and owns the largest pulp mills worldwide [17]. When interests collide, company representatives settle them with administrative officials under the table [13]. The Ministry of Environment also has weakened authority due to lack of branches in provincial regions. Although an agency called BAPEDAL (Badan Pengendalian Dampak Lingkungan) was set up to counter this issue, it has not shown success. Provincial officials also do not necessarily adhere to state policies on S & B and in fact often disregard them for private interests [17].

As a result, state policies serve little or no disincentive against rule breaking. Perpetrators do not fear punishment and continue violating the rules, establishing a norm of rule-breaking which influences others to do the same, making punishment of rule breakers difficult and inducing officials to either overlook or even aid rule breaking. For instance, Presidential Decree Keppres no. 32/1990 and Indonesian Government Regulation no. 26/2008 curbs the establishing of oil palm plantations on peat extending more than three meters underground, yet a quarter of plantation companies continue violating the rule. In addition, Duta Palma, an Indonesian plantation company, escaped investigation despite extensive history of illegal S & B due to relations with the Indonesian military [13]. Moreover, despite suspending land clearing licences, most companies responsible for the 1997–1998 forest fires continued illegal S & B, even pushing the blame onto one another or to accidents [16].

4. Consequences

While on one hand it appears to be an advantageous practice, S & B has severe consequences, on the other. These can be understood in terms of the treadmill of production theory, with intensive withdrawals of natural resources from the environment, along with large-scale additions to it. This

section analyzes the effects of the withdrawals and additions caused by S & B on the environment, society and economy.

4.1. Withdrawals: Deforestation

The most obvious consequence of S & B is the large-scale removal of forests or deforestation [11,15]. Deforestation incurs heavy environmental costs, including soil erosion and degradation, water pollution, desertification, global warming and climate change, vulnerability to natural disasters such as floods, and threats to biodiversity [15]. The impacts last for a long time even after the area is replanted. Subsequent trees and plants growing in deforested areas may store less carbon than before [7]. Less water permeates the soil after deforestation, reducing the rate of replenishing groundwater. Fewer plant roots store sulphur, causing more sulphate ions to enter the atmosphere and fall as acid rain, damaging vegetation, land and marine life [15]. The impacts of the large-scale deforestation that occurs as a result of S & B are far-reaching and long lasting, as described below.

4.1.1. Soil Erosion and Degradation

A direct consequence of deforestation is the increased rate of surface runoff, which speeds up soil erosion and degradation. Soil erosion refers to movement of soil particles via wind or water from one location to another [15]. As a result, soil nutrient levels and density structure are permanently altered, thereby degrading soil productivity. Furthermore, with S & B, forest canopy is opened, exposing soil directly to weather elements such as wind, rain and sunlight. This increases the ease with which soil dries up and is blown or washed away. Soil temperatures and acidity levels are also affected. Higher soil surface temperatures expedite nitrogen loss into the air as well as biomass decomposition [9]. Higher temperatures and soil acidity increases phosphorus sorption, further exacerbating the limited availability of soil phosphorus and negating subsequent effectiveness of adding more fertilizer to increase phosphorus availability [18–20].

Beyond a certain extent of soil erosion, when topsoil productivity decreases by at least 10%, desertification occurs. Deserts or dust bowls are created or expanded as a result. Eroded soil particles get washed into water bodies and cause water pollution via eutrophication or clogging of rivers, lakes and streams. Soil particles may contain herbicide and pesticide remnants, which may be consumed by marine life and possibly kill them [15,19].

4.1.2. Global Warming and Climate Change

Through S & B, trees and plants that absorb and store carbon are cleared out faster than they can grow back [15]. This reduces forests' capacity to absorb human carbon emissions, leading to substantial release of greenhouse gases such as carbon dioxide and methane which enhances the greenhouse effect and accelerates global warming, changes in precipitation, and climate change [2,11,15,21]. Indonesia ranks highest in carbon dioxide emissions from peatland degradation, approximating 900 million tons annually, as draining large areas of peatland causes the peat to decompose into carbon dioxide [22].

Large-scale deforestation can alter regional weather and even climate. With reduced forest canopy, this results in higher ground temperatures and lower humidity [23]. Coupled with reduced transpiration of plants, local rainfall decreases. This makes forests drier and more susceptible to fire [15]. Beyond thirty years, the local climate may change irreversibly such that forests can no longer return or be sustained and may be substituted by less diverse tropical grassland [15,21].

In a vicious positive feedback loop, climate change threatens forests further by increasing susceptibility to insect and pest species that kill more trees. Thus, forest fires are more likely to recur with greater frequency and intensity than before [15]. Climate change also exacerbates peatland degradation by inducing thawing of peatland usually under permafrost conditions during higher temperatures in warmer seasons, causing peat decomposition into large amounts of carbon dioxide and methane.

4.1.3. Threats to Biodiversity

About half the world's known species are housed in tropical forests alone [15]. In fact, Indonesian rainforests have been hailed as biodiversity hotspots [2]. The destruction of vegetation and habitats of native creatures by S & B threatens their livelihood and survival, and pushes them towards the brink of extinction [11,15]—for instance, exclusive orang-utan communities [2,10]. Species that cannot withstand sudden changes in environment, fires or high temperatures, or those that require very specific conditions for survival, are especially likely to be affected [14,23]. They may be unable to withstand prolonged lack of food and water, escape from the fires, or migrate to new homes [14]. Burning also destroys seeds and roots of vegetation, which impedes regeneration [9].

Thus, biodiversity in post-S & B habitats tend to be substantially lower than pre-S & B habitats [23]. With species endangerment or extinction, decreased diversity of genetic resources lowers species' adaptability in response to changing environments, which, in turn, lowers their likelihood of survival further. Thus, a vicious downward spiral is created. Significant loss of many undiscovered plant and animal species which possess medicinal and healing properties, or other attributes that contribute to much-needed products and services, may result [2]. Potential for raising food production and for developing more hardy and nutritious species of crops and animals is also impeded [15]. Moreover, S & B facilitates intrusion of invasive species such as bracken [9,23]. It was also found that post-burning, easily managed weeds (such as wide-leaf annuals) tended to be replaced by harmful perennials [24].

4.1.4. Peatland Drainage

Indonesia has the biggest area of peatlands worldwide, approximating 27 million hectares [12]. Peatlands store water, absorb atmospheric carbon dioxide and house diverse species of plants and animals, including the endangered Sumatran tiger and orang-utan. The problem arises when forestry and plantation corporations drain peatlands for growing oil palm and logging valuable timber. The incidence of this is ever-increasing, with at least half of all the new, projected oil palm plantations being established in peatlands [13]. Another cause for concern is the poor planning of trans-migration programmes, which led to the further degradation of peatlands. Forests were cleared to construct a 4,400 kilometres canal network. The canal was built to assist crop irrigation and soil drainage during dry and rainy seasons, respectively; however, it also drained excessive peatland moisture into the sea, resulting in low water tables which kill vegetation and reduce capacity to absorb water. As a result of this, the peatlands have dried up and become susceptible to fires during the dry season, as evidenced in the 1997 forest fires. Moreover, peat fires seethe underground for years and reignite during dry conditions [12,14].

4.2. Additions: Trans-Boundary Haze Pollution

Haze refers to "a high concentration of particulate matter" [16] (p. 70). S & B creates forest fire emissions that are transported by wind and rain to other countries [16] and can be exacerbated by dry weather or drought from the El-Nino Southern Oscillation (ENSO) [12]. In the Indonesian forest fires of 1997–1998, haze affected not only Indonesia but also neighboring countries such as Malaysia, Thailand, and Singapore [12]. In Kuching, Sarawak in Malaysia, the Air Pollution Index (API), registered an all-time high of 849 [16]. Concentrations of sulphur dioxide (SO_2), carbon dioxide (CO_2), methane (CH_4) and particulate matter (PM_{10}) exceeded baseline concentrations by at least ten times, five times, two times and twenty times, respectively [7]. In Singapore, haze in 1994 and 1997 from forest fires resulted in prolonged high levels of PM_{10} at 150-180$\mu g\ m^{-3}$ [7] as well as a fifty percent spike in carbon monoxide (CO) concentrations [25]. Haze results in negative outcomes for the environment. It inhibits photosynthesis, reducing forests' ability to absorb carbon, which worsens global warming [7]. Furthermore, it has greater risks on society and the economy.

4.2.1. Regional Tension

Haze issues have led to political tension between Indonesia and its neighbors such as Malaysia and Singapore. For instance, while Malaysia and Singapore alleged to help Indonesia fight against its forest fires, Indonesia was also censured for its persistent lack of improvement in instituting fire control and measures. In turn, Indonesia held trans-national firms responsible for unrestrained illegal logging, which left its forests vulnerable to destructive blazes. As reported in popular Dailies, in 2013, Agung Laksono, the in-charge Minister, in response to the haze episode, then criticized Singaporeans for being immature and childish, rousing widespread anger. The Indonesian president, Susilo Bambang Yudhoyono, had to express remorse on behalf of Indonesia to right the repercussions faced by neighboring countries.

4.2.2. Health Risks

The health of approximately seventy-five million people is affected by haze each year [13]. Haze contains $PM_{2.5}$ that contains toxic trace metals such as copper and chromium; inhalation can result in cancer, for every 1 in 200 people [12]. Each 10μg m^{-3} increase in particulate matter is associated with increased lung cancer risk by 8% [12]. $PM_{2.5}$ particles are also miniscule enough to penetrate the lungs deeply, increasing risk of respiratory-related diseases such as bronchitis and asthma. Indeed, inhalation accounts for 70% of $PM_{2.5}$ in the lungs [12]. All in all, haze is associated with respiratory disease, associated hospital admissions, risk of cancer, eye conditions, as well as death [10,12,14].

People residing or working in haze-affected areas, such as fire-fighters and plantation workers, are especially prone to health risks. It was found that concentrations of $PM_{2.5}$, trace metal and nitrated polycyclic aromatic hydrocarbons (PAHs) were highest in areas nearest to peat fires, such as Sumatra and Kalimantan, with severe health consequences. Even outside of Indonesia, the health impacts of haze are strongly felt. For example, in Singapore, the 1997 haze saw a 12% increase in respiratory illnesses and a 19% rise in occurrence of asthma [1,26]. During the same period in Malaysia, the number of respiratory patients increased from 250 per day to 800 per day [26,27]. Simultaneously, there was a huge increase in occurrence of asthma, bronchitis and conjunctivitis across Malaysia [27,28]. The total cost of health damage in Malaysia was approximately RM 129 million during the 1997 haze [27]. Peat fires that smoulder emit especially high amounts of $PM_{2.5}$ [12]. S & B produces gases such as CO and hydrocarbons that contribute to ozone formation [29]. Ozone pollution can cause lung damage and inflammation, and respiratory diseases. Ozone is also the main constituent of smog, which increases eye and throat discomfort as well as the risk of illness [14].

4.2.3. Economic Tensions

Haze pollution and health risks have various ripple effects including hampering economic productivity in affected Southeast Asian countries, especially Singapore and Malaysia [10,13]. More people fell ill due to haze, amounting to heftier medical fees and work absenteeism, which translated to work productivity loss. Additional impacts were seen in the form of declining tourism and recreation in haze-affected areas, which affected performance of businesses [10]. Schools and businesses were shut; flights were delayed or cancelled [10,30]. Kalimantan even experienced lack of food and water [14].

For Singapore, losses incurred from the 1997 haze amounted to US$163.5–US$286.2 million. Greatest loss occurred in the tourism sector, amounting to US$136.6–US$210.5 million. Recreation suffered due to poor scenery and visibility, amounting to costs of US$23.2–US$71.2 million. Health losses amounted to US$3.8–US$4.5 million. Businesses, especially retail and food-and-beverage sectors, suffered as most people stayed indoors during the haze and did not leave their homes longer than necessary [10]. Table 1 summarizes the total damage costs in Singapore due to 1997 haze [30] (p. 182). Indonesia also incurred heavy losses amounting to US$20.1 billion, approximately 50% of its government income in 1997. Its tourism sector declined since tourist hotspots were affected by fire and haze [2]. For instance, most of Kutai National Park in East Kalimantan was burnt [17]. Also in 1997,

an Indonesian air flight carrying 234 people on board crashed due to poor visibility from haze, and remains to-date the deadliest aviation disaster in Indonesian history [17].

Table 1. Summary of the total damage costs in Singapore due to the 1997 Haze.

Impacts of Haze Damages	Upper Bound Estimation (US$)	Lower Bound Estimation (US$)
Health damage (cost of illness, loss of earnings or productivity, preventive expenditures *etc.*)	4 517 629	3 776 708
Loss to tourism	210 449 067	136 577 290
Loss in visibility and views	71 137 941	23 057 133
Loss in recreation activities	94 170	94 170
Damage costs per person	95.39	54.50
Damage costs per household	369.90	211.31
% of 1996 Gross Domestic Product (GDP)	0.32	0.18

These calculated losses are likely to be below the actual true costs since not all costs can be fully taken into consideration [10]. The economic costs that countries incur comprise of private costs that are usually taken into account, such as damages and loss of economic goods and services [2]. However, social costs or negative externalities such as loss of forests and corresponding ecosystem services are usually overlooked.

4.2.4. Food Security Issues

Food security is the state whereby most or all people in a population can get healthy food on a daily basis. S & B relates to food security via net primary productivity (NPP) and the role of producers (usually trees and plants). NPP refers to "the rate at which producers use photosynthesis to produce and store chemical energy, minus the rate at which they use some of this stored chemical energy through aerobic respiration" [15] (p. 61). In other words, only biomass stored in producers, represented as NPP, is available as nutrients for consumers; NPP is thus the limiting factor for survival. Housing huge quantities and species of producers, tropical rain forests are very high in NPP. In S & B, NPP decreases significantly which translates into decreased nutrients available for consumption and use.

NPP is affected by soil productivity. With decreased soil phosphorus availability, duration of yearly harvests may be reduced and the soil becomes less fertile over time, especially if S & B episodes recur [20]. This translates into inadequate and unstable food supplies, threatening the food security and livelihood of farmers, their families and businesses [11]. Reduced soil phosphorus availability is further compounded by crop harvesting which clears away plant material that constitutes sources of phosphorus, as well as erosion in agricultural systems and deforested areas.

5. Sustainability through Plural Environmental Governance

The complex nature of the issue needs integrated environmental efforts which we call "plural environmental governance" (Figure 1). It involves, among other initiatives, intervention based on globalization, decentralized environmental governance, market and agent focused instruments of environmental governance, and cross-scale environmental governance. These have been expanded below.

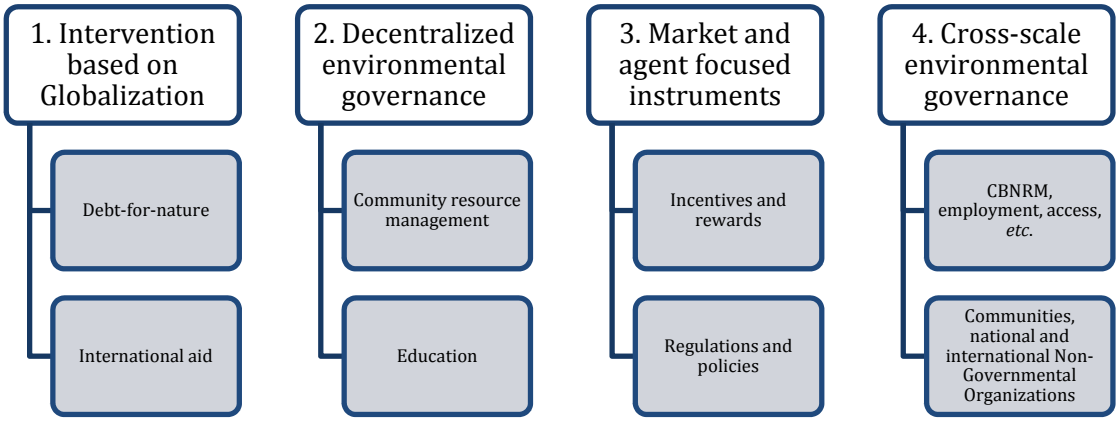

Figure 1. Plural environmental governance

5.1. Intervention Based on Globalization

To monitor S & B activity, research on haze prevention, techniques to spot burning and to interpret patterns of fire is required, yet it has not been sufficiently addressed and included in preventive costs. Incentives such as international aid for governments to invest in research are warranted. Countries affected by haze from Indonesia's forest fires can offer Indonesia aid equivalent to the maximum damage each of them incurred [10]. Singapore also provides Malaysia and Indonesia satellite data to aid in haze research, courtesy of the Center for Remote Imaging, Sensing and Processing (CRISP) at the National University of Singapore. Another suggestion is debt-for-nature swaps or conservation concessions, whereby countries receive financial aid or have their debts waived in return for preserving forests and natural resources [15]. Research can be conducted on means of determining economic value of ecosystem goods and services, as well as cost-benefit analysis, so that economic products can be optimally priced to include social costs, and to maximize land use among competing economic activities. Research on ENSO permits understanding of its characteristics and patterns of occurrence, which influence effectiveness of S & B policies. Research on potential techniques includes remote sensing, air quality modelling, and Geographical Information Systems (GIS). Adopting a combination of these techniques in parallel, coupled with land ownership records, help in regulating S & B activities as they can help pinpoint perpetrators and hold them responsible. However, they require consistent monitoring and precise, accurate data. Furthermore, adopting techniques in isolation may not depict actual situations completely and accurately [10].

5.2. Decentralized Environmental Governance

5.2.1. Community Resource Management

Forests are ideal for management by local communities, due to their clear boundaries, making it possible to determine rights of access and to monitor usage. For instance, illegal or inappropriate S & B is easily spotted, hence the perpetrator is more likely to be caught and punished. In communities where people have known each other for long, complex interpersonal relationships are established, which facilitate development of shared community norms and expectations. Violation for personal gain would cause the perpetrator to risk heavier losses such as losing respect and trust or being ostracized, which could threaten his future survival within the group. As a result, individuals are motivated to refrain from unacceptable S & B. Moreover, local communities are likely to have adequate knowledge of forest resources and to be highly dependent on forest resources for survival. Hence, they are concerned about its overexploitation; this culminates in a participatory style of creating rules agreed upon by everyone, such that rules are perceived as fair and adhered to voluntarily [18,31]. Complex relationships, coupled with shared norms and adequate knowledge of forest resources,

facilitate knowledge transmission throughout social networks via word-of-mouth, which is perceived as more credible and persuasive, thereby more influential in decisions involving S & B. Key strengths of community resource management lie not only in its potential to induce voluntary compliance to S & B regulations but also to enhance the spread of and perceived efficacy of S & B alternatives, thus increasing adoption rates.

5.2.2. Education

People can be educated on the long-term outcomes of S & B, ways of regulating S & B activities and emissions, as well as fire-free alternatives [10,15,32]. Such information can be disseminated via formal channels such as national media, or via informal channels such as word-of-mouth from community members [11]. To be effective, it is important to customize information to make it understandable, credible, personally relevant, motivating, and attention capturing for intended parties. Examples include emphasis on on-going losses and costs incurred from S & B, keeping information simple, direct and relevant, using striking and tangible images of S & B costs to evoke moderate fear, and pairing them with strategies to reduce the fear. These strategies would include adopting alternatives, strategies to increase perceived self-capability of executing alternatives by emphasizing the ease of grasping new technology, and strategies to ease the transit to alternatives by lowering costs and providing on-site guidance [18,33]. Elicit public commitment to phasing out S & B by signing a statement to do so, broadcasting the names of participating individuals and corporations on national television (with prior consent sought), and so on. This reduces likelihood of detraction as they now are motivated to uphold a positive public image of walking the talk and to maintain self-esteem [33]. Note that eventual adoption of S & B alternatives can be influenced not just by individual attributes e.g., level of education, but also by farm characteristics such as size and type of crop grown, and by institutional factors such as land ownership policies [11].

5.3. Market- and Agent-Focused Instruments of Environmental Governance

5.3.1. Incentives and Rewards

Perpetrators are usually aware of costs of no-burning and benefits of S & B accruing to self, but not the costs of S & B and benefits of no-burning that accrue to society. As a result, they perceive benefits of S & B as overriding its costs [11]. Incentives in the form of regulations, taxes, rewards, and so on serve to correct this misguided perception. The purpose is to increase perceived costs and reduce perceived benefits of S & B, as well as to increase perceived benefits of S & B alternatives [18]. Note that S & B alternatives should address not only environmental needs and concerns but also that of parties involved [3].

Rewards and assistance can be provided to parties that comply with S & B regulations or those that are willing to incorporate fire-free alternatives. For instance, rural communities can receive funding or other rewards if bigger-than-permitted fires have not occurred in the vicinity in any particular year, providing them with an impetus to control fires and to report violations. Companies, especially smaller ones, can receive government funds and subsidies in areas of technology adoption, training and consultation in forestry management [10]. An international fund can be set up to help farmers in developing countries adopt more sustainable fire-free alternatives for land clearing and agriculture [15]. In addition, alternative employment may be offered to farmers to pull them out of poverty [2].

5.3.2. Regulations and Policies

At present, a complete ban on burning is not feasible as it can increase farmers' poverty. In addition, it is not possible to monitor every single violation since farmers are likely to burn smaller areas at a time that are not so easily detected. The initial ban on burning in 1984 had to be renewed in 1997 due to lack of adherence [3]. Regulating S & B is more feasible in mitigating its negative environmental impact than complete bans. To be effective, perceived probability of being penalized

and severity of penalties need to be sufficiently high [18]. Thus, laws and regulations pertaining to S & B need to be consistently and rigorously implemented. An example could be imposition of strict conditions for granting forestry licenses. Another suggestion is to build fire-fighting capability in advance, adopt the newest technology to minimize emissions, pay a deposit in advance to cover potential future costs of pollution and buy insurance [10]. Perpetrators can also be made liable to foot damages in the event of loss from fire, regardless of extenuating circumstances, to increase adoption of precautionary measures.

Authorities would also need to punish illegal logging severely [15]. A tax on land clearing, proportionate to acreage of land owned, can be made mandatory on forestry and plantation companies, to cover costs of land clearing undertaken by a central state agency; this would lower companies' need or inclination to resort to S & B, as S & B would then constitute an additional cost. For this tax scheme to work, the state agency in charge needs to be highly responsive to requests and to clear land efficiently [2]. Corruption within the government needs to be stamped out. The Indonesia Corruption Watch investigates cases of corruption whereby government officials have illegal connections with forestry and plantation companies, or enjoy private benefits from such collusions, and prosecutes perpetrators [13]. To systematically eradicate corruption at all levels, from top management to provincial branches, greater transparency of government rules and operations, as well as efficient and effective communication and cooperation among different agencies and levels of government, are required.

To emphasize costs of S & B, given that losses usually matter more than equivalent gains, the media can publicly blacklist identities of companies that violate regulations; the government can release actual costs of S & B, breaking it down into subcomponents such as private and social costs [10].

Burning of smaller areas one at a time can be regulated [3]. During dry seasons or impending drought, burning can be prohibited, requiring farmers and companies to adopt fire-free alternatives such as grinding and mulching [10]. Incentives to do so require that parties do not incur associated losses such as smaller yields. Therefore, farmers' views need to be adopted to understand more clearly perceived barriers and costs to adopting fire-free alternatives. In addition, consistent, rigorous monitoring and enforcement tends to be more feasible for company operations but less so for individual farmers [3].

6. Conclusions

S & B is a complex phenomenon, with multiple interacting factors and consequences that vary across people, situations and time [18]. We have used the treadmill of production theory to unpack the causes and consequences of this practice and proposed a plural environmental governance model to formulate potential solutions. As discussed, potential interventions warrant multi-faceted, multi-disciplinary approaches adopted in parallel, which underlies the essence of a plural coexistence framework. Scholars delineate a community-based forest program that incorporates all three strategies of incentives, education and community resource management [33]. The program aims to resolve issues of S & B in Indonesia while providing participants with employment and access to forest assets to help them rise above poverty. Various stakeholders such as communities and national and international Non-Governmental Organizations (NGOs) collaborate to ensure its long-term feasibility. Under this program, participants apply for licenses to manage the forests, which are certified by the Forest Stewardship Council (FSC). Participants also undergo training on knowledge and skills in forestry management and the FSC-certified wood market, with emphasis on the ecological value of forests. Rules regarding eligibility for the program and production of FSC-certified wood are specified, such as the allowed maximum width and number of trees to be cut. With that, each group of farmers allocated to a plot of forest decides among themselves the specific areas to cut and submits the decision to a local cooperative for compiling the harvest schedule. Upon wood production, farmers receive partial payment, with the remaining payment pending receipt after sales. Participants also receive additional income in the form of dividends. Throughout the various processes of license application,

training, and wood production, participants engage in much social interaction with other community members, which fosters a sense of belonging, collective security, as well as responsibility towards the group. Such a system has the potential to draw more people in to expand its scope of influence because of the embedding of incentives and education within the context of the community, which targets many S & B factors in parallel.

Acknowledgments: This research was supported by Nanyang Technological University's Undergraduate Research Experience on Campus (URECA) program and a Tier-1 grant from the Ministry of Education, Singapore. The authors would like to thank the reviewers for their helpful comments.

Author Contributions: Md Saidul Islam conceptualized and designed the research. Yap Hui Pei and Shrutika Mangharam wrote the paper and analysed the data. All authors have read and approved the manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

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