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Soil governance in a pandemic

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A R T I C L E   I N F O

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A B S T R A C T

COVID-19 exacerbated many threats to soil health. Long-term consequences of pandemics on soils are likely to include increased threats of contamination and exhaustion. Abrupt border restrictions and changes in demand for agricultural products will create pressure to increase crop yields and surplus animal disposal. Soils also are threatened by demand to convert agricultural lands to housing in response to pandemic-induced changes in how and where work is completed. Several governance mechanisms are outlined that support interactions between humans and soil that promote soil health during a pandemic. Maximizing soil fertility, minimizing contamination, and preventing land-use conversion are critical soil governance objectives.

1. Introduction

COVID-19 exacerbated many threats to soil health. The complex relationship between soils and human health is not well understood even though there is widespread endorsement of a ‘One Health’ approach to reduce the risk of zoonotic pandemics, such as the COVID-19 pandemic (WHO, 2021). Soils are the foundation of the food system and a key provider of the ecological goods and services human rely on to regulate, among other things, climate and water availability. In this chapter, I highlight likely long-term consequences of pandemics on soils and outline governance mechanisms that promote soil health. Maximizing soil fertility, minimizing contamination, and preventing land-use conversion are critical soil governance objectives.

Soil health is defined as “the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans” (USDA, 2021). Soil health determines the ability of soils to provide essential ecological services. The primary driver of healthy soils is soil biodiversity. Soil biodiversity is shaped by the micro-organisms (e.g. bacteria, fungi, protozoa and nematodes), meso-fauna (e.g. acari and springtails), macro-fauna (e.g. earthworms and termites), and vegetation that interact below the earth’s surface. Together they are responsible for “nutrient cycling, regulating the dynamics of soil organic matter, soil carbon sequestration and greenhouse gas emission, modifying soil physical structure and water regimes, enhancing the amount and efficiency of nutrient acquisition by the vegetation and enhancing plant health” (FAO, 2021). Polluted and degraded soils, however, can also expose humans to disease and negative health consequences. Toxins and harmful pathogens in soils can be ingested, inhaled, and absorbed by humans directly or indirectly as plants take up these components. Soils with micronutrient and trace element deficiencies, or otherwise have poor fertility, can result in malnutrition (Brevik, 2020). Soils can also be an important source of antimicrobials and antibacterial compounds used in the treatment of disease.

2. Food production

Soil health is essential to the overall resiliency of the agricultural sector during a global pandemic. The adverse effects of pandemics, however, on agricultural production have the potential to have both short-term and long-term effects on soils. These effects can be mitigated through proactive soil governance that promotes soil fertility and prevents contamination and loss of agricultural land.

Even though the overall long-term economic impact of the COVID-19 pandemic on the agricultural sector may be less than on other sectors, abrupt border closings and changes in demand for agricultural products had immediate on-farm effects. Many farmers experienced financial hardships when they no longer had access to markets for perishable goods and the labor and other inputs they needed to manage their farm operations. Consequently, many farmers are under immense pressure to do whatever is required in the short-term to improve their financial position. Farmers may attempt to increase yields through continuous cropping without allowing soils to recover or bringing marginal lands into production. While rich, healthy soils can provide a temporary bank of nutrients, marginal soils will quickly become exhausted. The loss of
access to extension and support services only compounds this problem. Farmers may not be getting the information they need to evaluate the long-term effects of these short-term gains or to consider alternative management practices.

Some farmers have also been unable to secure the labor required to perform plant production and protection measures to prevent weeds, pests, and disease (FAO, 2020). Combined with reduced access to agricultural inputs when distribution networks were temporarily disrupted, some farmers are facing higher than usual threats of crop loss from weeds, pests, and disease. Where farmers can afford and have access to herbicides and pesticides, chemicals may be applied at higher rates than usual to ‘correct’ the situation. Where soils are already depleted, this over-application will cause lasting damage.

The financial hardship caused by the pandemic may prevent other farmers from planting a crop because they cannot afford seed and other inputs. In these situations, the risks of soil loss due to erosion and the spread of invasive species increase. Some farmers, who were already operating on the margins, will exit the industry as a result. This fact combined with labor shortages may increase the average farm size and the adoption of farming techniques that rely on chemical inputs and monocultures. Another long-term effect of pandemics on food production likely will be an emphasis on building robust, domestic supply chains. Regions that are not net importers of food experienced shortages and price increases during the COVID-19 pandemic that raised food security concerns. Increasing domestic production, while an obvious response to these shortages, poses risks to soil health if the expansion of domestic production does not consider soil fertility. Incentives to grow domestically may result in increased production on marginal lands or the overuse of farming techniques that impair soil fertility.

### 2.1. Food production governance recommendations

Soils offer an important tool of resiliency for the agriculture sector and domestic food security during a pandemic when soils are healthy. Therefore, much of the governance mechanisms that are recommended to protect soil health in a pandemic are proactive.

To begin, global efforts are urgently needed to prevent land degradation. The world has lost about 33% of its arable lands due to soil pollution and erosion. (Cameron, 2015). Land Degradation-Neutral Targets (LDN) are, therefore, urgently needed to slow and even reverse this unsustainable rate of loss (Boer and Hannam, 2021). The United Nations Convention to Combat Desertification (UNCCD) has created a conceptual framework for LDNs that would allow countries to tackle land degradation using mechanisms similar to what has been employed for climate change – nationally determined targets implemented through domestic legislation and policies.

At a more local level, policymakers can promote sustainable soil management through the adoption and implementation of the FAO’s Voluntary Guidelines for Sustainable Soil Management (VGSSM) (FAO, 2017). The VGSSM outlines ten priorities for sustainable soil management that aim to restore and rehabilitate depleted soils and prevent soil contamination and soil loss. They are:

- Minimize soil erosion
- Enhance soil organic content
- Foster soil nutrient balance and cycles
- Prevent, minimize and mitigate soil salinization and alkalinization
- Prevent and minimize soil contamination
- Prevent and minimize soil acidification
- Preserve and enhance soil biodiversity
- Minimize soil sealing
- Prevent and mitigate soil compaction
- Improve soil water management

The emphasis on farm nutrient cycling through the maintenance of soil organic matter, manure use, and beneficial crop rotations recognizes that farmers are vulnerable if they over-rely on imported chemical fertilizers and access to these inputs are restricted through border closures.

Farmers who rely on imported chemicals to manage pests and pathogens are similarly vulnerable to border closures. Policymakers can prepare for a pandemic by mandating the adoption of Integrated Pest Management and Integrated Disease Management (IPM/IDM) practices. IPM/IDM uses multiple techniques to maintain the population of pest/pathogen species below levels sufficient to cause economic injury through crop damage while minimizing harm to humans, animals, plants, and the environment (Clano and Mukerji, eds., 2007). For IPM/IDM mandates to be effective, farmers will need access to information, tools, and advisory services to assist with pest monitoring and decision-making.

Policies that bolster the financial security of farmers, including access to credit and insurance, are equally important to protecting soils during a pandemic. Farmers are especially vulnerable to border closures and demand changes because of the duration and inflexibility of their production cycles. Not only is it near impossible for farmers to pivot to new markets or products once the annual production cycle has begun, farmers are unable to minimize financial losses because the majority of their expenditures are invested early in the production cycle. Economic constraints, therefore, can foster short-term decisions to relieve immediate financial pressure that negatively impact soils (Bartkowiak and Bartke, 2018).

Policies that provide landowners with secure land tenure likewise promote long-term decision-making in favor of sustainable agricultural practices (Richardson, 2018). Farmers who know that they will reap the benefits of investments in soil health are more likely to make these investments even where their decisions may not provide immediate benefits.

### 3. Carcass disposal

Soil health can be undermined by the improper disposal of animals culled during global pandemics. During the COVID-19 pandemic, mass culling of animals occurred for two reasons. Market disruptions due to decreased consumer demand, global trade restrictions, and workforce illness and absenteeism created market surpluses (Hayes et al., 2021). Animals were also culled to prevent the transmission and mutation of the virus through animal vectors. Denmark, for example, euthanized almost 20 million minks after mink directly infected farmers with COVID-19 (Mallapaty, 2021). Few countries, if any, have the capacity to implement the preferred option, off-farm incineration, for the volume of animals that will likely be culled in a global pandemic. On-farm disposal through burning, burial, or composting will be used in future pandemics.

On-farm disposal can contaminate soils with chemicals and pathogens. Contamination can impair plant growth, leach into groundwater, contaminate run-off, and be consumed by animals who may come in contact with the soil or plants grown in that soil. Soils will also be removed from productive use during disposal processes. In some instances, soils may need to be permanently removed from production if the contamination involves a persistent pathogen or pollutant.

Sources of contaminants can include any heavy metals that have accumulated in the carcass and veterinary drugs that have not cleared the animal’s system. For smaller animals, asphyxiation using a chemical foam is often used where large amounts of animals must be killed quickly. These foams may contain PFAs (per- and polyfluoroalkyl substances) which are considered a Persistent Organic Pollutants (POPs) (Benson et al., 2007). POPs can be harmful at extremely low levels (Farnese, 2018). These foams will contaminate the carcasses and enter soils.

1. See e.g. European Union (2009) Directive 2009/128/EC on the sustainable use of pesticides (Council of Europe, 2009).
Viruses, bacteria, parasites, and prions can be released from carcasses during disposal and contaminate soils. Some of these pathogens may be naturally occurring in healthy animals, such as e.coli. The presence of pandemic-related pathogens may be the reason why the animals have been culled. Reactivating pathogens quickly before they can contaminate soils is essential to effective and safe disposal. Deactivation, however, is not possible for all pathogens. Prions, for example, are persistent and there is no known way to remove them from contaminated soils. Anthrax is another pathogen that has proven very difficult to manage once soil has been contaminated.

Contamination risks vary depending on the disposal method. Burning, places the carcass within a bed of combustible material. Although a generally effective way to inactivate most pathogens, burning is slow, expensive, and risks contaminating soils through ash deposits at the burning site and elsewhere through airborne ash dispersal. The use of accelerants, such as diesel, and including materials other than clean wood, such as tires, painted wood, and plastics in the burning pyre, exacerbates soil contamination (Miller et al., 2020).

Deep burial relies on anaerobic decomposition to dispose of carcasses. Animals are placed in pits 3-5m below ground and covered with soil. Overtime the animal breaks down and slowly is absorbed into the soil and potentially any nearby groundwater. This process can be an effective method to reduce contaminates depending on the overall health of the soils where the animals are buried. Already degraded soils will not have the requisite microorganisms to facilitate effective filtration. There is also the risk of methane gas build up, which can pose an asphyxiation and/or combustion hazard in addition to being a harmful greenhouse gas (Miller et al., 2020).

Above ground burial creates mounds of carcasses, covered by soil and planted with vegetative material to prevent erosion. Mounds are built on top of a shallow trench that is half filled with a carbonaceous material to direct surface water away. While this method is fast and cost effective because heavy equipment is generally not required. Improper burial, however, can result in the mounds being scavenged or animal carcasses unburying themselves as escaping methane gas causes the carcasses to bloat. Where available, the FAO recommends this method for small and medium farms with less than 5000 poultry, 128 pigs or 25 cattle because the animals are often decomposed within a year. The mounds can then be leveled and farmed. If the carcasses contained heavy metals, those metals may remain in the soils as contaminant (Miller et al., 2020).

Finally, carcasses can be composted in layers of carbon material. Composting uses high temperatures to facilitate decomposition. Once the carcasses are broken down, the compost can be tilled into the soil. As with all these disposal methods, soil contamination is a concern. This process can also take more time than above ground burial and requires significant skill from the farmer to ensure that the compost pile reaches the desired temperature, does not release odors, leach through stormwater, or attract scavengers.

3.1. Carcass disposal governance recommendations

To minimize the effects of carcass disposal on soil health and to maximize the return of areas used in disposal to productive uses, policymakers need to provide farmers with site-specific information in anticipation of a pandemic. Farmers often have a comprehensive understanding of soil types and ground and surface water sources on their farms. Policymakers can supplement that understanding with information about the role of soil type, soil depth, soil depth to ground water, and seasonal variations on pathogen activation and contaminant filtration. Farmers could also benefit from specific recommendations of preferred disposal methods to be used in their regions that outline requirements for distance from waterways and designs and materials to be used in compost mounds, burial mounds, and burial pits. Ideally this advice would come from extension agents familiar with the local area, but information can also be provided through websites, social media, etc. for farmers to readily access when needed.

The timing of the advice provided to governments is important. In a global pandemic, especially where culling is being used to prevent the spread of infectious diseases, farmers may be asked to euthanize and dispose of their herds and flocks in a very short timeframe. The risk of the spread of infectious diseases from carcasses is likely the greatest while the carcasses are temporarily being stored before disposal. At that time, pathogens can be shed when bodily fluids are released, to the areas where the carcasses are stored. Shed pathogens may contaminate run-off or be dispersed through the air during temporary storage. Carcasses are also extremely vulnerable to be scavenged by birds and other animals during temporary storage.

The provision of this advice in advance of a pandemic is also important because safeguards that are normally in place to protect the environment, such as permitting, cannot be relied upon. As the COVID-19 pandemic has demonstrated, global pandemics will trigger legislation that allows governments to have extraordinary powers during emergencies. Existing regulations to prevent soil contamination and the release of contaminants into the air and waterways may be suspended. Farmers need information about the risks of disposal so that they can select, in advance, the best method for disposal and place to locate a disposal site on their land.

All farms involved in animal production should be required to have a site-specific plan and sufficient space for the safe on-farm disposal of all their animals. During a pandemic, moving animals off the farm for disposal is likely not practical. Given the scale of culling that may be required, off-farm disposal through incineration or landfilling is not practical. Transportation may also be prohibited if the carcasses are a disease vector. Requiring farms to have such a plan should be no more burdensome than plans that are often required for the handling of agricultural chemicals.

Policymakers should consider prohibiting farmers from locating large-scale operations in areas unsuitable for safe, on-farm disposal. For example, only small farms should be located on lands where water tables are high and above ground disposal using burial mounds or composting is not possible. Continuing to allow small farms to operate in these areas is only justifiable if they assured access to off-farm disposal during a pandemic.

Ongoing monitoring of disposal sites until disposal is complete should be mandated and the area should not be brought back into production until the risks to animal, plant, or human health have been mitigated. Farmers should be required to maintain records of the location and disposal as well information to verify that all health risks at the disposal site had been mitigated before the site was returned to production. Where disposal results in the release of POPs or persistent pathogens, such as prions or anthrax spores, the location of those sites should be reported to the government and permanently marked to inform future land-users.

Finally, compensating farmers for the culled animals and loss of productive areas is also recommended to encourage proper disposal and reduce the risk of contamination. Managing carcasses is a very expensive part of responding to an infectious disease threat (Miller et al., 2020). Often it is not just the carcass that needs to be disposed of, but also anything associated with the carcass that may be contaminated such as litter and bedding, feed, manure and animal products like milk, wool, and eggs. Without compensation, many farmers may not be able to afford to properly dispose of culled animals and will choose the least costly option despite the contamination risks.

4. Land conversion

Soil loss because of rural land conversion for suburban and country residential housing may be a lasting consequence of the pandemic. The COVID-19 pandemic shifted how and where work was completed. Many workers who passed the pandemic at home will likely continue to work from home some or all the time (Bick et al., 2020). The need to commute
daily may be replaced by a combination of primarily working from home and less frequent trips to the workplace. In addition, the 1-hour commute time that typically limits the distance most people will live from their workplace, will disappear. If this prediction is accurate, soils may suffer as those moving from the city seek less dense housing in rural areas.

Reducing the frequency of commutes will continue a trend of suburbanism. The typical North American suburb, for example, is often defined by new construction of single-family homes (Forsyth, 2012). Green spaces, including forests, wetlands, and agricultural lands are cleared and converted for suburban expansion. As a result, soils and the ecological goods and services they provide are lost.

Perhaps worse than suburbs is the preference for country-residential development especially among high-income earners. With country-residential land-use, homeowners build large homes on small 1-50 acre lots. While it is true that the percentage of green space lost can be less than the suburban development, the productivity and health of that green space is significantly undermined.

Country residential development cuts off the connectivity of these spaces that can prevent soils from providing effective water catchment and purification functions. Likewise, agricultural lands that are converted to country-residential are almost entirely shifted out of agricultural land-uses, except, perhaps the odd hobby farm. Homes in the country are often not connected to central wastewater facilities and soil contamination risks increase from the improper use and maintenance of septic systems. Loss and contamination of productive agricultural soils can have a significant impact on the food security potential and water management of the region.

Land conversion is also a concern because soils are an important source of antimicrobials and antibacterial compounds, most of which have yet to be identified (Rappé and Giovannoni, 2003). It may well be the case that the cure to a future pandemic exists undiscovered in soils. The recent discovery of a family of bacteria that are active against multidrug resistant pathogens highlights why land conversion, before the microbial diversity of soils is understood, is unwise (Hover et al., 2018).

4.1. Land conversion governance recommendations

That land-use is a key driver of soil health is undisputable. Regulating land-use change, therefore, is an obvious response to protect soils from the harmful effects of future pandemics. Existing limitations of land-use planning norms, however, make this response difficult to implement.

Mandatory planning regulations for rural municipalities are typically a fraction of what is required of urban municipalities even though rural lands are subject to increasing land conversion pressure. At times, rural areas that abut large urban areas are the exception to the focus on urban planning. The pressure to convert rural land-uses to urban land-uses can be so overwhelming that some governments have imposed land-use restrictions to protect valuable agricultural lands and other greenspace in the immediate areas surrounding dense urban areas. These initiatives should be lauded and replicated, but existing initiatives may not be sufficient if they do not consider that 1-hour limit on commuting may no longer exist.

To the extent that law has been effective in preventing the degradation of the natural world outside municipal planning processes, the focus has been on “special places.” Preferred features, such as flowing rivers and lakes, are subject to a myriad of regulations aimed at their protections while other features, such as soils, are ignored and sometimes are the target of active conversion. In addition, areas of exceptional beauty or cultural significance may be protected through the designation of protected areas such as National Parks. These approaches are selective thereby leaving important ecological features, including healthy soils, at risk.

Alternatively, planning on a landscape scale recognizes the importance of everyday spaces where the most vulnerable soils exist. Landscape encompasses both the uses of land and the natural and cultural elements in the area such as buildings, forests, and agriculture. Human movement is likewise determined by landscapes. Landscape is a useful scale to mitigate the impacts of pandemics on soils because it is at this scale that humans interact daily with natural processes (Forman, 1995). These interactions create observable patterns on the land and therefore appropriate interventions can influence the critical ecological goods and services provided by soils on which humans and ecosystems rely. Adopting a landscape approach will also be critical to achieving LDNs because this approach overcomes the challenges of soil protection that arise due to the complexity of soil functions and its interaction with air, water, and terrestrial life (Heuser, 2021).

The German Nature Conservation Act offers a promising mechanism to implement a landscape approach in land-use planning that may mitigate some of the negative consequences of land conversion. The legislation aims for impact neutrality by mandating restoration elsewhere to offset for every negative impact on nature. The cost of offset activities may prove to be an important incentive to avoid negative impacts (Flasbarth, 2017).

5. Conclusions

COVID-19 has highlighted the need for soils to be treated with the same urgency as climate change and the loss of biological diversity. To prepare for future pandemics, it is vital that policymakers act proactively to safeguard soil health. That existing regulations to prevent soil contamination and loss will be enforced cannot be assumed during a pandemic. Regulations may be suspended under emergency powers or not enforced due to mobility restrictions. Therefore, healthy, fertile soils are needed to buffer the negative consequences of pandemics on food production and to prevent land-conversion.

By adopting Land-Degradation Neutral targets, soil health can be prioritized in advance of a pandemic to promote resiliency. Likewise, the FAO’s Voluntary Guidelines for Sustainable Soil Management and the use of Integrated Pest and Disease Management techniques offer useful measures to promote soil health. In the long-term, planning at the landscape scale can help consider suitable places for urban and suburban expansion to avoid the unplanned loss of prime agricultural soils.

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