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Australia: Soil Salinity in Australia and its Effect on Agriculture and Wildlife

The sixth largest country in the world, the Commonwealth of Australia occupies the mainland of the Australian continent (Mattyasovszky). The continent is surrounded by the Indian and Pacific Oceans and located in the Southern Hemisphere. The country is 7.692 million square kilometers but only 10% of the land is habitable. In 2017, the population was recorded to be 24.6 million. With 18% of its land mass classified as desert (receiving an average rainfall of less than 250 mm a year), the Australian continent is the driest inhabited continent on the planet (Richards). As the inner part of Australia is desert, most of the population lives on the coasts, 80% on the southeastern coasts. Even the inhabited areas are dry and hot with an average annual rainfall of 412.8 mm (Bureau of Meteorology). The weather can be extreme and unpredictable; the yearly rainfall can occur in one day or spread out in small increments throughout the year. One year they can have an extreme drought, while the next year has record rainfall with flooding.

Australia is a wealthy country with a good educational system. Their primary and secondary education, overall, is 13 years long and followed by tertiary education, which can be higher education (such as universities) or vocational education and training (VET). The Australian Qualifications Framework (AQF), allows the educational system to link schools under one national system. The AQF is a government-authorized and nationally accredited program designed to prepare its citizens for further study or going into the workforce (Australian Government).

The largest sector of the workforce is the service industry, which employs 79% of workers in Australia and accounts for 70% of the gross domestic product (GDP). Manufacturing is also important, as is the professional, scientific, and technical industry (Lang'at). Agriculture directly employs only 2.5% of the labor force and contributes 3% of the GDP. In 2016-17, agriculture brought in $60 billion and $45 billion in exports. The importance of farming has grown steadily over the past four decades, exceeding the growth of all other sectors (National Farmers' Federation).

In spite of its small contribution to the GDP, agriculture has other significance to Australia. Notably, more than 90% of the country's food supply is produced by its farmers (National Farmers' Federation). Very little of their food supply is imported, so they are very self-reliant. 99% of their farms are owned locally by Australians. Farmers are also important as land managers, managing 48% of Australia's total land mass (National Farmers' Federation). Because of their importance to the economy, farmers' practices were not regulated with regard to their environmental impact. Historically, the negative impact of these practices was ignored. However, in the early 2000s, the effects of deforestation and degradation became too prominent to be ignored (Nations Encyclopedia).

Australia's problems with land degradation began in 1788 with colonization by Europeans. Immediately, the settlers started clearing the vegetation for agriculture. Shortly after, Australia's new government introduced the Crown Lands Alienation Act, intended to increase colonization and access to land. It

required landholders to develop their land for agricultural uses, which led to the rapid and extensive deforestation of eastern Australia. In the 1920s, deforestation shifted to western Australia. By the 1980s, almost 40% of Australia's forests had been degraded by the rapid clearing. Land degradation continues; currently, about half of Australia's forests are gone or critically damaged (Bradshaw).

Besides the obvious loss of trees, the land clearing and farming conducted by Europeans contributed significantly to a bigger problem: soil salinity. This problem is the accumulation of salts in the soil surface and groundwater. Australia naturally has a saline environment, developed over thousands of years due to rock weathering and salt from the sea being carried onto land by winds and falling in rain. The water/salt balance was maintained until European settlers cleared trees and planted non-native crops. The native vegetation had adapted to be salt-tolerant; they developed deep roots and a high demand for water. The Europeans replaced the native vegetation with shallow-rooted crops that did not need as much water (Murphy). When rain falls, the water moves into the soil; if the plants do not absorb it, the water seeps down into the groundwater. As a result, the water table rises, bringing salt with it. When the water table nears the soil surface, it deposits water and salt into the soil. The water evaporates, leaving behind salt. The same process occurs when crops are irrigated. Excess water seeps down into the groundwater and raises the water table, leading to deposition of salt in the surface layers of soil (Dixon et al).

Soil salinity has many devastating effects on Australia. When land is cleared or salt-sensitive plants die out due to the increased salinity, erosion occurs. This further compounds the salinity problem by bringing the soil surface closer to the level of the water table (Dixon et al). The high water table also increases the risk of flooding, as rainfall cannot be absorbed into the ground. Another impact of salinity is the effect on water quality. Fresh rivers are becoming salinated, contaminating Australia's source of water for drinking and irrigation (Queensland Government).

One of the most catastrophic results of soil and water salinity is a decrease in agriculture production. Salty soil prevents the movement of water into the plants through osmosis, so the plants become severely dehydrated. Even if the affected crops do not die, the crop yield is diminished. Salinity has an impact on any vegetation (crops, pastures, and trees) by decreasing nitrogen absorption, thereby halting reproduction and growth (Queensland Government). All of this occurs at a great expense to Australia. Over one million hectares of farmland have already been severely degraded by salinity, and another 2.8-4.5 million hectares are at immediate risk. Of Australia's inhabitable land, 1.3% has been lost, and 3.6-5.9% is greatly threatened. The financial cost of such agriculture loss was at least $519 million in 2014 and is continually increasing (George and Simons).

The results of agricultural loss due to salinity are not only financial; there is also a tremendous loss of biodiversity, the variety of life. Salinity's effects on vegetation are fairly easy to demonstrate. In a study of ground plants of southern Australia, researchers showed that 86% of ground plants in salinized areas were non-indigenous, mostly weeds. In contrast, only 31% of the ground plants in unsalinized areas were non-indigenous, approximately three times less than salinized areas. The effect on trees was similar. In salinized woodlands, 85% of trees exhibited symptoms of dieback, versus 34% of trees in unsalinized woodlands. The land most affected by salinization was in areas already depleted by clearing (Briggs and Taws).

Salinity's effects on terrestrial life are more difficult to quantify. Aside from an obvious loss of habitat from land clearing, there is increased salinization in the soil, which leads to further loss of trees. Tens of millions of animals are lost each year because of land clearing. In Queensland and New South Wales alone, land clearing kills over 50 million animals each year (Finn). Largely as a result of land clearing, Australia has become the country with the highest mammal extinction rate in the world. Since European settlement in the late 1700s, 30 endemic mammals are known to have become extinct. Worldwide, over the last four centuries, one-third of all mammalian extinctions have happened in Australia (Australian Wildlife Conservancy). The extinction rate is especially disturbing because Australia is one of the most biodiverse nations, approximately 600,000 species, more than other developed countries (Chapman).

The loss of agriculture and biodiversity in Australia due to salinization has become a crisis. Since the 1980s, when the media drew attention to the land degradation problem, there have been attempts to remediate the damage. The National Landcare Program was instituted to promote new cultivation methods, extensive tree planting, new engineering solutions, and changes in production systems. Through the Landcare movement, more than 5,400 Australian groups have become involved, with 90% of Australia's farmers taking an active role. The government has put millions of dollars into this program, realizing the importance (Veevers et al). Since Australia's government and farmers have such high stakes in this agricultural issue and are already working hand-in-hand, they should be open to improving current methods and trying new ones.

One way to improve a process already underway involves desalination plants. Australia has been using desalination plants to convert seawater into potable water. The plants use reverse osmosis to achieve this, and 50-70% of the cost is for the energy used. As the source of energy is fossil fuel, the process produces large amounts of CO_2 (Australian Water Association). Shifting the source of water for this technique from seawater to less salty groundwater would require less energy, cost less, decrease the amount of CO_2 produced, and lower the water table. The resulting freshwater can be used for drinking but also for crop irrigation. Any seepage of excess irrigation would be less salty than what is currently being used and may decrease soil salinity. Furthermore, if the water table lowers too much, the water can be desalinated and then pumped back into the aquifer through bores. Another improvement to the desalination plants would be to switch from fossil fuels, such as coal, to solar power. Solar power reduces the cost of power production by more than 50% compared to coal (Berke). With these improvements, desalination plants could become more cost-efficient and potentially greatly decreased soil salinity without CO_2 emissions.

Replanting native vegetation is a common method for reducing salinity. Australian native plants are adapted to have deep roots and a high water requirement. Because of these characteristics, they are able to absorb rainwater and excess irrigation, thereby maintaining optimal water table levels. One such type of native plant is saltbush, a perennial plant used as feed for livestock. This plant is salt-tolerant, suitable to grow in areas of high salinity. There are many benefits from planting saltbush that counteract the downfalls of high salinity. First, it can improve farmland that has been damaged by salinity and can make it productive again. The economic impact of the saltbush's soil rehabilitation is an increase in profitability up to 24%; this is maximized by planting the bush in 10% of a farm's land. Saltbush also provides food and a source of shelter for animals that have lost their habitats through deforestation. Furthermore, scientists have shown that many types of grasses and flowering plants thrive in the soil around saltbush plantings. The same researchers also demonstrated increased biodiversity around concentrated areas of

saltbush, including threatened species. Because of the tremendous environmental benefits, Australia's government should offer incentives such as tax cuts to farmers who plant 10% of their land with saltbush species (Lancaster). If every farmer were to comply, this plan could have a significant impact on soil salinity.

Finally, to manage the problem of salinity in Australia, practices that contribute to salinization must be minimized or stopped. This includes deforestation and over-irrigation. In most Australian states, land clearing has nearly halted; the exception is Queensland, where previously strict laws prohibiting land clearing were lifted. As a result, in the year 2015-16, land clearing increased by 33%, with 400,000 hectares of wooded areas lost (Robertson). Strict legislation should be restored to penalize farmers and other landowners for such deforestation. Regarding irrigation, farmers need to prevent over-watering of crops and pastures. This could potentially be accomplished through soil monitors that measure the amount of moisture in the soil and planting crops that do not require as much irrigation.

Ultimately, this problem will require a multi-faceted approach. The problem of salinity is a complicated one that has evolved over time. Solutions will undoubtedly be just as complicated and require many areas of expertise. A group of experts in various fields, such as hydrology, geology, botany, ecology, zoology, and engineering should convene to discuss and research these and other novel ideas.

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