The Application of Adaptive Management Strategies and the Enhanced Resilience of Farms, Ranches, Forests, and Rangelands to Climate Change

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Abstract

The purpose of this paper is to evaluate the effects of climate change on the environment and how farms, ranches, forests, and rangelands can improve their resilience to it. Climate change is a problem in society, and its rising severity has ramifications within every aspect of life. Its impacts include higher temperatures, intensified drought, rising sea levels, and increased storm severity. This decreases crop yields, worsens species survival, and ultimately intensifies poverty and displacement. Awareness about understanding climate change has resulted in the development of many adaptive management strategies to overcome it. Each strategy is only applicable to certain problems and areas, and has its unique benefits and setbacks. This research paper examines the most effective adaptive management strategies by using a variety of peer-reviewed journals, credible articles, and data that are less than ten years old. The results of this research conclude that assisted migration, the rotation of livestock grazing and planted crops, and sustainable farm design efficiently improve the resiliency of farms, ranches, forests, and rangelands to climate change. Assisted migration is a strategy where qualified people move plants and animals from endangered environments to a new environment that is expected to be less impacted. Rotating crops and livestock grazing involves systematically moving crops and livestock to different areas so soil and nutrients aren't used up. Sustainable farm design encourages the construction of irrigation systems, natural features like shelterbelts, climate-resistant buildings, and efficient farming structures. Concerns regarding these strategies include the time, energy, and money needed to implement them. There is also uncertainty regarding climate change and how it can be mitigated. By examining these strategies, this review strives to identify adaptive management strategies that efficiently improve climate change resilience within farms, ranches, forests, and rangelands. It is written with a primary focus on biodiversity and sustainable farming practices, ensuring that suggested solutions are tailored to realistically align with environmental and food production needs. What management strategies can humans implement to improve agriculture's resistance to climate change?

Introduction

In 2023, the Intergovernmental Panel on Climate Change released a report on climate change. They found troubling data and speculated that the effects of climate change would be felt across the globe (IPCC, 2023). While there is uncertainty about the exact impacts of climate change, many scientists acknowledge the increasing temperatures and rising sea levels. These impacts have been evident through the rise in atmospheric greenhouse gas concentrations since

the Industrial Revolution, with most of the increase occurring in the last 45 years (Dobbins et al., 2015, p. 69). As weather patterns adversely affect agriculture, researchers must develop ways to counteract these effects to support food supply. Our review identified several strategies using facts and statistics that were less than 10 years old and came from reliable sources. The results of this review found that the best strategies to improve the resistance of farms, ranches, forests, and rangelands to climate change were assisted migration, rotational farming, and sustainable farm design. Assisted migration is a strategy where qualified people move plants and animals from endangered environments to a less endangered one. Rotating crops and livestock grazing involves systematically moving crops and livestock to different areas so soil and nutrients aren't used up. Sustainable farm design encourages the creation of irrigation systems, natural features, and efficient farming structures. This paper also examines the concerns that landhandlers demonstrate about climate change and sustainable agricultural practices. What management strategies can humans implement to improve agriculture's resistance to climate change?

Assisted Migration

Agriculture and food production is highly reliant on weather systems, requiring a constant and predictable climate. As climate change begins to disrupt the consistency of weather patterns, new strategies must arise to counteract these changes and allow agriculture to adapt to the changing environment. Plants and animals have gradually migrated and adapted to different environments over the course of millions of years. However, new projections indicate that soon, the climate will change faster than species populations are able to migrate or adapt (Twardek et al., 2023). In light of this, scientists have begun suggesting strategies that accelerate this natural process. One such strategy is assisted migration, an approach that involves the human-assisted movement of species to a new location, usually to a more climate-suitable area for the population.

There are multiple types of assisted migration, each with their own unique set of benefits and risks. The first type is assisted population migration, in which a species is relocated within their established habitat range. This approach is low risk, as the species is not taken out of its native habitat. The second type is assisted range expansion, which consists of moving a species directly outside their natural range, slightly expanding their habitat. This category poses some risk, as the species is taken out of its natural range, but is still in the same general climate or area as their natural habitat. The third and most precarious type of assisted migration is assisted long distance migration. This involves a process in which a population is relocated to an area far beyond the natural range, which cannot be accomplished without the assistance of humans (*Adapting Forests to Future Climates through Assisted Migration*, 2024).

Although precise predictions for the distant future are uncertain because they largely depend on the future global economy and human population, it is widely accepted by researchers and the general public that average temperatures will almost certainly rise over the coming years (IPCC, 2023). Native forest tree species are specifically adapted to the area in which they live; even populations of trees that grow in the same region may differ slightly in adaptation depending on the soil and special conditions of a certain environment within their natural range. This suggests that climate change will take a larger toll on tree populations due to the physiological stress caused by

increasing temperatures and decreased precipitation. These factors combined also make populations more susceptible to pests and diseases, further weakening their ability to survive. As climates begin to change more rapidly, the specific environment a tree species needs to thrive may shrink in availability or disappear completely. Some people may speculate that tree populations will naturally evolve to rising temperatures or naturally move northward. However, due to the current rate of human-induced climate change, tree populations would have to shift geographic location 10 to 100 times faster than previously recorded in order to keep up with the current rate of change in climate and temperatures (Sáenz-Romero et al., 2016). This cannot occur naturally and can only be achieved through human intervention.

This means that human assistance is necessary to protect specific populations. Tree populations must be moved upwards towards the poles, which is primarily done by taking seeds from natural populations, growing the seedlings in nurseries, and planting them in areas with a predicted suitable environment. These areas of migration must be selected by taking into account the tree's lifespan, reproductive, and biological needs.

A variety of studies have been conducted on the successes and limitations found in assisted migration. For example, research in Minnesota sought to examine how climate change impacted the success of bur oak and red oak trees when they were moved to different environments. The researchers feared that tree species found in the southern part of the state would be better suited for living in northern Minnesota because of the warming climate (Adapting forests to future climates through assisted migration, 2024). They hypothesized that southern Minnesota was becoming too warm for those tree species and that they would better thrive in the northern Minnesota environment. Their study found extremely high success rates of well over 93% in both species of oak within three years of being transferred from southern Minnesota to northern Minnesota. Studies like this demonstrate the real-world and potentially large-scale application of assisted migration in enhancing the resilience of forests.

Rotating Crops and Livestock Grazing

Climate change poses a significant challenge for many people as it not only causes extreme events but also affects crops and livestock. It has consistently resulted in lower crop yields and increased food insecurity. Factors such as global warming and increased greenhouse gas emissions, including nitrous oxide and carbon dioxide, contribute to climate change (Ghosh et al., 2024, p. 83). While there are agricultural practices in place that have exacerbated climate change, there are also practices that can be put in place to mitigate it. From reducing the impact of climate change to cementing food security and growing farmers' profits, regenerative agriculture and the practices it encapsulates can aid in improving everyday life for many Americans (Ghosh et al., 2024, pp. 4-5).

Crop rotation could be defined through a variety of factors; it could include expanding crop diversity, practicing polyculture farming instead of the cultivation of only one crop, and implementing a continuous growing system to reduce fallow land (Ghosh et al., 2024, p. 98). As noted in a journal article by the Union of Concerned Scientists (2017), the growth of only two crops, as is what occurs in the Midwestern United States with corn and soybeans, has led to

decreased income for farmers and an increase in nitrogen pollution in both the air and waterways of the United States. This article notes that recent research points to modified cropping systems as a solution (p. 2). This organization believes that expanding crop diversity and crop rotation can reduce soil erosion, lower greenhouse gas emissions, and decrease runoff of contaminants (Union of Concerned Scientists, 2017, p. 2). Another group of researchers in various agriculture-related fields has seen positive environmental change, noting that the implementation of crop rotation led to a significant decrease in Nitrous Oxide (Ghosh et al., 2024, p. 98). The use of crop rotation not only decreases the impact of climate change by reducing the need for artificial fertilizers and decreasing pollutants, but it can also help farmers save money and create more sustainable farm systems. However, rotating crops is not the sole regenerative agriculture practice that can aid in mitigating the impact of climate change.

In terms of another method that falls into the category of regenerative agriculture, rotational grazing and its use are also known to have benefits for both farmers and the environment. One common practice that hurts the biodiversity and ecosystems of rangelands and ranches is overgrazing. Overgrazing occurs when animals are allowed to graze continuously in a field or pasture without allowing enough time in between grazing for plants to fully regrow (Ehlert, 2025). This can have a variety of negative effects, including a decrease in soil fertility and the replacement of edible grasses with inedible weeds (Ehlert, 2025). However, the most notable aspect of farming that is significantly impacted by overgrazing is the livestock. When forage is overgrazed and not allowed to fully regrow, it can cause livestock to lose weight, experience poorer body conditions, and see a decline in breeding rates, leading to a negative impact on farmers and ultimately everyday citizens (Ehlert, 2025). While it does have many negative impacts, overgrazing can be mitigated through the use of rotational grazing. Rotational grazing can help minimize damage from man-made products and improve the ecological function of the soil. A 2020 review article about Livestock Production and the Functioning of Agricultural Ecosystems noted the use of pyric herbivory (PH) and adaptive multi-paddock grazing (AMP) as a form of rotational grazing in farms (Teague et al., 2020). Each system uses adjusted grazing periods and locations, all of which are changed by farmers or stockmen (Ehlert, 2025). While money and management are necessary for both PH and AMP, the economic and environmental benefits will help the farmer in the end. Along with the reduction of greenhouse gases into the air, managing grazing will allow the grass more time to grow back after being eaten. This means that farmers will have a steady source of feed and will not need to buy more. The decisions people make regarding livestock and their grazing significantly impact climate change and the effects it has across the world.

A wide variety of farms, ranches, and rangelands were created with the purpose of productivity instead of sustainability; however, through changing the practices they exercise, farmers can help restore the environment and make more money at the same time. Regenerative agriculture improves the health of livestock, reduces carbon emissions, and ensures farmers don’t have to buy man-made fertilizer or fodder. From protecting the world from climate change to increasing farmers’ profits and reducing food insecurity, regenerative agricultural practices can improve the lives of everyone across the globe.

Sustainable Farm Design

With climate change posing a significant threat to the success and security of farms worldwide, farmers must learn to adapt. Farms are vital to society because they generate food, stimulate the economy, create jobs, care for the land, and can even improve the environment. Unfortunately, they play an extensive role in the emission of greenhouse gases; in Canada, 12% of its greenhouse gas emissions come from agriculture (Laforge et al., 2021). Improving farm efficiency and sustainability can significantly mitigate many negative environmental impacts associated with farming, causing positive impacts across the globe. One of the most effective strategies to achieve this is by implementing sustainable farm designs like recreating natural features, building water management systems, and engaging in vertical farming.

A simple approach to sustainable farming involves recreating the natural environment. Nature has advantageous features to farmers, primarily landscapes like prairie strips and riparian buffers, and agroforestry practices like shelterbelts and hedgerows. Prairie strips are sections of farmland with native vegetation. Root systems anchor soil and shield it from erosion by wind and water. Prairie strips also absorb excess nutrients and trap sediment, improving water quality and preventing pollution. A 2017 study examined differences in cropland with and without prairie strips and found that farms that replaced 10% of their cropland with prairie strips saw better biodiversity. It found a 37% reduction in runoff, 4.3 times greater phosphorus concentration, and 20 times more retained soil (Schulte et al., 2017). Despite concerns about replacing cropland, the study noted that crop production took minimal damage. Riparian buffers are areas of vegetation along a body of water serving as barriers between water and possible pollutants. Several studies found that woody riparian buffers 18 meters in length had 100% sediment trapping efficiency, a total nitrogen removal of almost 90%, and about 93% total phosphorus removal (Kumwimba et al., 2024). Shelterbelts and hedgerows serve similar purposes on farms; they protect crops from wind erosion and enhance biodiversity by serving as a safe habitat. A 2021 review article noted 14 crops that saw significant yield increases using shelterbelts, primarily strawberries, millets, and green beans, with average yield increases of 56%, 44%, and 40%, respectively (Smith et al., 2021). The natural features in this paragraph have been proven to reduce pollution and erosion while increasing soil health and biodiversity, having an overall positive impact on farming.

In the wake of climate change and its reduction of water availability through inconsistent weather patterns and more evaporation because of warmer temperatures, it is more important than ever to efficiently use water resources. The best ways to do this are through irrigation techniques, effective water harvesting and storage, and contour farming. Irrigation involves controlling the flow of water through a farm, usually by making channels that carry water from wells, canals, rivers, and other sources of water. It allows farmers to manage water efficiently, resulting in better crop yields and less wasted water. It is widely acknowledged that irrigation is extremely efficient and effective, especially regarding agriculture. Another excellent way to use water efficiently is through rainwater harvesting and storage systems. These typically use gutters and downspouts to catch and filter rainwater, then transport it into a storage tank. After a meticulous study was conducted on successful water harvesting implementation, researchers concluded that cropland in Uganda, Burundi, Tanzania, and India could have an increase in crop production between 60% to 100% if they implemented such water harvesting strategies (Piemontese et al., 2020). The lack of wasted water allows for greater crop production and greater

efficiency with Earth's natural resources. Contour farming, simply farming in accordance with the natural shape and curves of the farmland, was also identified as an excellent source of water management. Contour farming as a whole manages water significantly better than traditional farming and allows for excellent soil health. Several studies in the USA, China, and India found that farmers can see 50-60% reductions in soil erosion, as well as substantial improvements in crop yield simply by farming in alignment with the land's natural contours (Choudhary et al., 2024). These practices can have massive impacts on farmland by improving water management and soil health while reducing runoff and pollution, resulting in a prosperous and sustainable farm.

The extensive urbanization of society means that available space for agriculture is declining. An advanced method of farming called vertical farming has grown in popularity to combat this loss of land. Vertical farming is a form of farming where farming grows vertically, rather than horizontally. In this way, farmers can produce more food than traditional farming using the same amount of land or even less. Vertical farming allows farmers to use an average of 98% less water and 99% less land than traditional farming (Funk 2023). It also requires much fewer pesticides, reducing the amount of greenhouse gases that are emitted into the atmosphere. Vertical farms effectively grow greens like spinach, lettuce, kale, mint, and basil. It typically employs a hydroponic system, which involves growing crops using water-based nutrients instead of soil. Hydroponic plants have roots that are exposed to the air so they can get the oxygen and sunlight they need to photosynthesize. The proximity in which crops grow allows for greater plant yield, less wasted water, less space used, and flexible growing locations. This allows farming to be less impacted by climate change while reducing the use of pesticides and the release of greenhouse gases, contributing to the decline of climate change as a whole.

Counter Arguments

Climate change adds pressure on farmers as they are expected to change their practices in order to become more sustainable (Cano et al., 2024). Many of them fear the time, money, and effort that are required to implement these strategies. However, many organizations, both government and private, provide ample education and incentives. Notable organizations that strive to achieve agricultural sustainability are the National Sustainable Agriculture Coalition (NSAC), the Sustainable Agriculture Research & Education (SARE) organization, and the CARE program. NSAC works to create federal policy that encourages sustainable agriculture, especially in rural communities (NSAC, 2023). Similarly, the CARE program seeks to spread ethical agriculture in less developed areas across the world (CARE, 2021). The SARE fights to advance sustainability involvement and knowledge across the United States through competitive grants and an education program. There are often tax breaks and government subsidies, as well as government programs like the Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program (CSP). Both these programs are offered by the U.S. Department of Agriculture (USDA), with hundreds of programs and practices to encourage sustainability (USDA 2025a). They offer financial and technical assistance to land handlers who choose to implement certain sustainability practices (USDA, 2025b), helping quell fears about expenses and effort involved in adaptive management strategies. Government policies play a consequential part in helping farmers change to more sustainable practices. Through the various programs provided by the

United States, as well as the communication between growers and policymakers, farmers can get the support they need to help save the environment (Morrison, 2023).

Relation to Professional Initiatives

The practice of sustainable agriculture has massive positive implications worldwide. Many official initiatives regarding the improvement of agriculture and sustainability across the globe are more likely to be achieved by implementing the adaptive management strategies described in this article. In 2015, the United Nations established seventeen goals that all member nations adopted in hopes of a more stable world by 2030 (United Nations, n.d.). Adaptive management strategies that enhance the resilience of agriculture to climate change are linked with all seventeen goals, but they most directly relate to goal thirteen. This goal, entitled the "Climate Action" goal, encourages countries to take urgent action to mitigate climate change and the effects it has on the world (Filho et al., 2023). Assisted migration, crop and livestock rotation, and sustainable farm design all reflect this goal by reducing the contributions of agriculture to climate change and improving agriculture's resistance to the effects of climate change. Similarly, the USDA's Agriculture and Food Research Initiative (AFRI) is a program that offers grants to support research and education opportunities in six priority areas (USDA 2024). All priority areas are positively impacted through sustainable agriculture, but sustainable agriculture most directly relates to the Bioenergy, Natural Resources, and Environment priority area. The adaptive management strategies identified in this paper help to effectively manage natural resources, reduce the emission of greenhouse gases, enhance ecosystems, and improve resilience to climate change.

Conclusion

Assisted migration, crop and livestock rotation, and sustainable farm designs are adaptive management strategies that can improve farm, forest, ranch, and rangeland resistance to climate change. Adopting these strategies means crops and livestock will be able to thrive, improving food production and quality. The environment is positively impacted through water, nutrients, and species conservation, as well as less pollution. Ultimately, these strategies contribute to the reduction of carbon emissions and encourage the use of renewable energy. If farmers fail to adapt, crop failure is at a greater risk because climate change could drastically change weather patterns. This would raise food prices and cause massive food instability. Furthermore, pests and pollution would devastate the environment, harming soil and water quality. Considering that this extra effort can reduce the progression of climate change, these strategies can be the difference between a stable environment and the complete unraveling of an ecosystem.

References

Adapting forests to future climates through assisted migration. (2024). Umn.edu; University of Minnesota Extension. https://extension.umn.edu/creating-climate-ready-woodlands/assisted-forest-migration

Cano, A., & Campos, B. C. (2024). Drivers of farmers' adaptive behavior to climate change: The 3F-SEC framework. *Journal of Rural Studies*, *109*. https://www.sciencedirect.com/science/article/pii/S0743016724001475.

CARE. (2021). *Achieving Food and Nutrition Security & Resilience to Climate Change: Annual Report*. CARE. http://www.jstor.org/stable/resrep54776.

Choudhary, R., Sharma, S., & Gautam, S. K. (2024). *Contour farming and strip cropping for soil protection*. In *Soil Conservation Techniques and Erosion Control* (pp. 112–130). Golden Leaf Publishers. https://doi.org/10.61887/glp.2024.24

Dobbins, J., Solomon, R. H., Chase, M. S., Henry, R., Larrabee, F. S., Lempert, R. J., Liepman, A. M., Martini, J., Ochmanek, D., & Shatz, H. J. (2015). Climate Change. In *Choices for America in a Turbulent World: Strategic Rethink*. 69–84. RAND Corporation. http://www.jstor.org/stable/10.7249/j.ctt17mvhfj.13

Ehlert, K., Menendez, H., Bachler, J., Dagel, A. (2025). *The Lasting Effects of Overgrazing on Rangeland Ecosystems*. South Dakota State University Extension. https://extension.sdstate.edu/lasting-effects-overgrazing-rangeland-ecosystems

Etterson, J. R., Cornett, M. W., White, M. A., & Kavajecz, L. C. (2020b). Assisted migration across fixed seed zones detects adaptation lags in two major North American tree species. *Ecological Applications*, *30*(5). https://doi.org/10.1002/eap.2092

Leal Filho, W., Wall, T., Salvia, A. L., Dinis, M. A. P., & Mifsud, M. (2023). The central role of climate action in achieving the United Nations' Sustainable Development Goals. *Scientific Reports, 13*, Article 20582. https://doi.org/10.1038/s41598-023-47597-7

Funk, B. (2025, May 13). *Vertical farming: Everything you need to know*. Eden Green. https://www.edengreen.com/blog-collection/what-is-vertical-farming

Ghosh, S., Saha, A., Kumar, S., Pathania, S. (2024). *Regenerative Agriculture for Climate Change Mitigation and Food Security*. 88-133. Springer Nature. https://doi.org/10.1007/978-981-97-6691-8_4

IPCC. (2023). Synthesis report of the IPCC Sixth Assessment Report (AR6) Summary for Policymakers. In IPCC. Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_SPM.pdf

Kumwimba, M. N., Akter, S., Li, X., Dzakpasu, M., Ifon, B. E., Manirakiza, B., Muyembe, D. K., Zhang, Y., Huang, J., & Guadie, A. (2024). Nutrient and sediment retention by riparian vegetated buffer strips: Impacts of buffer length, vegetation type, and season. *Agriculture, Ecosystems & Environment*, *369*, 109050. https://doi.org/10.1016/j.agee.2024.109050

Laforge, J., Corkal, V., & Cosbey, A. (2021). *Farming the Future: Agriculture and climate change on the Canadian Prairies*. International Institute for Sustainable Development (IISD). http://www.jstor.org/stable/resrep40460.

Morrison, R. (2023, Oct 26). *11 ways farmers are adapting to climate change*. Earth.Org. https://earth.org/11-ways-farmers-are-adapting-to-the-unpredictability-of-climate-change/

National Sustainable Agriculture Coalition. (2023, April 11). *About Us - National Sustainable Agriculture Coalition*. National Sustainable Agriculture Coalition. https://sustainableagriculture.net/about-us/

Piemontese, L., Castelli, G., Fetzer, I., Barron, J., Liniger, H., Harari, N., Bresci, E., & Jaramillo, F. (2020). Estimating the global potential of water harvesting from successful case studies. *Global Environmental Change*, *63*, 102121. https://doi.org/10.1016/j.gloenvcha.2020.102121

Sáenz-Romero, C., Lindig-Cisneros, R. A., Joyce, D. G., Beaulieu, J., St. Clair, J. B., & Jaquish, B. C. (2016). Assisted migration of forest populations for adapting trees to climate change. *Revista Chapingo Serie Ciencias Forestales Y Del Ambiente*, *XXII*(3), 303–323. https://doi.org/10.5154/r.rchscfa.2014.10.052

Schulte, L. A., Niemi, J., Helmers, M. J., Liebman, M., Arbuckle, J. G., James, D. E., Kolka, R. K., O'Neal, M. E., Tomer, M. D., Tyndall, J. C., Asbjornsen, H., Drobney, P., Neal, J., Van Ryswyk, G., & Witte, C. (2017). Prairie strips improve biodiversity and the delivery of multiple ecosystem services from corn–soybean croplands. *Proceedings of the National Academy of Sciences of the United States of America*, *114*(42), 11247–11252. https://www.jstor.org/stable/26488949

Smith, M. M., Bentrup, G., Kellerman, T., MacFarland, K., Straight, R., & Ameyaw, Lord. (2021). shelterbelts in the United States: A systematic review of producer-reported benefits, challenges, management activities and drivers of adoption. *Agricultural Systems*, *187*, 103032. https://doi.org/10.1016/j.agsy.2020.103032

Teague, R., Kreuter, U. (2020). *Managing Grazing to Restore Soil Health, Ecosystem Function, and Ecosystem Services.* Frontiers in Sustainable Food Systems. https://www.frontiersin.org/journals/sustainable-food-systems/articles/10.3389/fsufs.2020.534187/full.

Twardek, W. M., Taylor, J. J., Rytwinski, T., Aitken, S. N., MacDonald, A., Van Bogaert, R., & Cooke, S. J. (2023). The application of assisted migration as a climate change adaptation tactic: An evidence map and synthesis. *Biological Conservation*, *280*, 109932. https://doi.org/10.1016/j.biocon.2023.109932

Union of Concerned Scientists. (2017). *Rotating Crops, Turning Profits: How Diversified Farming Systems Can Help Farmers While Protecting Soil and Preventing Pollution*. Union of Concerned Scientists. http://www.jstor.org/stable/resrep17250

United Nations. (n.d.). *The 17 Goals | Sustainable Development*. United Nations. https://sdgs.un.org/goals

USDA. (2024, September 11). *Agriculture and Food Research Initiative (AFRI)*. National Institute of Food and Agriculture. https://www.nifa.usda.gov/grants/programs/agriculture-food-research-initiative

USDA. (2025a). *Conservation Stewardship Program*. Natural Resources Conservation Service. https://www.nrcs.usda.gov/programs-initiatives/csp-conservation-stewardship-program

USDA. (2025b). *Environmental Quality Incentives Program*. Natural Resources Conservation Service. https://www.nrcs.usda.gov/programs-initiatives/eqip-environmental-quality-incentives