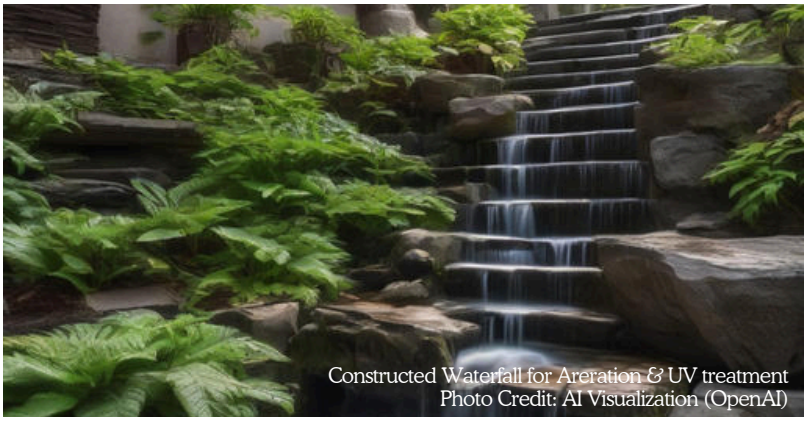

Constructed Waterfall for Areration & UV treatment
Photo Credit: AI Visualization (OpenAI)

JJSF President, Journal Editor
COMAN, Kenneth Dale (Sr.)
Graduate, Civil & Environmental Engineering
University of Maryland, USA
Written: May 2024

Abstract

This article explores the integration of permaculture principles, specifically focusing on techniques like System of Rice Intensification (SRI) and agroforestry, into traditional rice cultivation practices. Through a case study analysis of successful implementation in various regions, including Madagascar, India, and Vietnam, the benefits of sustainable rice farming methods are highlighted. By emphasizing practices such as polyculture, integrated pest management, composting, and mulching, farmers have reported increased yields, reduced input costs, and improved soil health. The article discusses the importance of agroforestry in providing shading within rice lagoon systems and its role in enhancing biodiversity and climate resilience. Overall, the findings suggest that incorporating permaculture principles in rice cultivation can lead to more sustainable and productive agricultural systems. Let us refer to this combination of wet rice field agriculture mixed with [fruit] trees ... as "Wetlands Agroforestry"

Wetlands Agroforestry

Constructed Wetlands
Photo Credit: AI Visualization (OpenAI)

Introduction

As environmental concerns and the need for sustainable agricultural practices grow, integrating permaculture principles into conventional farming is gaining attention. Permaculture, derived from "permanent agriculture," is a holistic approach to farming that emphasizes sustainability, biodiversity, and natural systems. In the context of rice production, permaculture can offer invaluable benefits, enhancing both environmental health and agricultural productivity. This document compares the research efforts in Asia and Africa, highlighting key areas of focus, challenges, and opportunities, with a particular emphasis on innovative water management techniques and notable lagoon-based permaculture projects.

What is Permaculture?

Permaculture is a design philosophy that works with natural processes to create self-sustaining ecosystems. It involves principles such as observing and interacting with natural systems, capturing and storing energy, and integrating rather than segregating different components of the ecosystem (Mollison, 1988). In agriculture, these principles aim to create food systems that are resilient, efficient, and environmentally friendly.

Benefits of Permaculture in Rice Production

Soil Health and Fertility

One of the core principles of permaculture is maintaining soil health. Conventional rice farming often relies on synthetic fertilizers, which can degrade soil quality over time. Permaculture encourages the use of natural fertilizers and organic matter, such as compost and green manure, which enrich the soil. This approach maintains the soil structure and promotes the presence of beneficial microorganisms (Altieri & Nicholls, 2005).

For instance, incorporating nitrogen-fixing plants like legumes in paddy fields can naturally replenish soil nutrients, reducing the need for chemical fertilizers.

Water Management

Rice production is fundamentally water-intensive, with traditional methods requiring large amounts of irrigation. Permaculture advocates for efficient water use through techniques like swales, ponds, and mulch, which are aimed at optimizing water retention and conservation, especially critical in regions prone to both drought and heavy rains (Fukuoka, 1978).

Slowing Down Rainwater

Implementing swales—shallow, broad ditches on contour lines—helps to capture and slow down rainwater. This technique reduces soil erosion and allows water to percolate into the ground, recharging groundwater supplies and increasing soil moisture. Swales prevent the rapid runoff that typically occurs during heavy rains, instead allowing water to be absorbed gradually into the soil, creating a more consistent and prolonged water supply for crops.

Storing Water for Dry Periods

Creating ponds and reservoirs within rice paddies is another permaculture strategy that stores rainwater for use during dry periods. These water bodies not only serve as a water source during times of scarcity but also play a role in supporting biodiversity, as they can be integrated with fish habitat.

Filterable Water Benefits

By capturing and storing water through these methods, permaculture systems often produce cleaner, filterable water. As water moves through the soil and plant roots, it undergoes natural filtration, which can significantly improve water quality, making it suitable for agricultural and even household use after further purification.

Biodiversity

Permaculture promotes biodiversity, which can lead to healthier ecosystems and more resilient crops (Holmgren, 2002). In rice production, integrating different plant species and livestock creates a balanced and diverse system. This diversity helps control pests and diseases naturally, reducing the reliance on chemical pesticides. Agroforestry, for example, involves planting trees alongside rice fields, providing shade, habitat for beneficial insects, and additional income through timber or fruit. Such systems enhance the overall resilience of the farm.

Economic and Social Benefits

Implementing permaculture strategies can lead to economic benefits for farmers. Reduced reliance on chemical inputs lowers production costs, while diverse crop systems can provide multiple income streams. Additionally, permaculture practices often require less labor-intensive methods, making farming more accessible for small-scale and marginalized farmers (Mollison, 1988).

Case Studies

System of Rice Intensification (SRI)

The SRI method, which incorporates several permaculture principles, has shown significant benefits in various regions. By planting younger seedlings, reducing planting density, and improving water management, SRI methods enhance root growth and increase yields with fewer inputs (Uphoff, 2003).

Integrated Rice-Duck Farming

In countries like Japan and the Philippines, farmers have successfully integrated ducks into rice paddies. Ducks help control pests and weeds while providing natural fertilizer through their droppings. This method has improved yields and reduced the need for chemical inputs (Gopalakrishnan et al., 2013).

Agroforestry

The practice of integrating trees into rice lagoon systems for shading is often referred to as "agroforestry." Agroforestry involves the intentional combination of trees and shrubs with crops or livestock to create a more sustainable and productive agricultural system.

In the context of rice cultivation, incorporating trees around or within the rice fields can provide several benefits, such as shading the rice plants, reducing water evaporation, improving soil health through root systems, attracting beneficial insects, and providing additional sources of income or nutrition.

Agroforestry practices in rice cultivation can help enhance biodiversity, improve resilience to climate change, and promote more sustainable and holistic land management. The integration of trees in rice lagoon systems is one of the ways farmers can implement agroforestry principles to create more diverse and resilient agricultural landscapes.

Notable Wetland Permaculture Project

Koh Rong Island, Cambodia
Project Name: **Song Saa Reserve**
Overview: The Song Saa Reserve on Koh Rong Island is an impressive large-scale permaculture project that integrates rice paddies with water lagoons and diverse agroforestry systems. This project forms part of Song Saa's effort to create a sustainable community and ecosystem while focusing on responsible tourism and agriculture.

Figure 1: Song Saa Master Plan
Photo Credit: https://songsaareserve.com/

Key Features:
• Integration of rice paddies with naturally-occurring water lagoons.
• Planting of native trees and fruit-bearing species within the lagoon system.
• Utilization of nutrient-rich water from the lagoons to irrigate rice fields.
• Cultivation of edible aquatic plants and fish to enhance productivity and biodiversity.

Benefits:
• Improved water retention and soil health.
• Enhanced biodiversity and resilience of the agro-ecosystem.
• Provision of multiple income streams from rice, fruit, and fish.

Quote from the Song Saa Project Website:
"Considerable work has been devoted to the development of an effective strategy for the restoration of rainforest at the Song Saa Reserve. Key to this has been an appreciation that rainforest restoration is about more than just 'planting trees' and requires an understanding of a range of disciplines. This entails uniting biology, soil and social science, hydrology and biodiversity conservation in a strategy that ensures the greatest opportunities for restoration success."


Figure 2: Tree Conservancy in Cambodia
Photo Credit: https://songsaareserve.com/


Figure 3: Lagoons of Song Saa
Photo Credit: https://songsaareserve.com/

Song Saa Reserve Website. (2024, 16 May). One-Million Trees Programme. https://songsaareserve.com/beyond-sustainability/1-million-trees-programme/

Notable Wetland Permaculture Method

Mekong Delta, Vietnam
Project Name:
VAC Farming System (Vuon-Ao-Chuong)
Overview: The VAC farming system in the Mekong Delta is a traditional Vietnamese farming method that epitomizes the principles of permaculture. 'VAC' stands for garden (Vuon), pond (Ao), and livestock pen (Chuong), representing the integration of diverse agricultural practices including rice and tree cultivation combined with aquaculture.

Key Features:

- Rice fields are constructed around water lagoons (ponds) that are stocked with fish.
- Trees, such as coconut, banana, and fruit trees, are planted around and within the rice fields.
- Duck and other livestock are integrated into the system, contributing to pest control and soil fertility.

Benefits:

- Efficient use of land and water resources.
- Natural pest control and reduction of chemical use.
- Diversified and stable sources of food and income for local farmers.

Quote from Permaculture News on VAC:
"The typical VAC garden-farm in a coastal area is from 2000-5000 square metres. It is bordered by a row of Casuarina equisetifolia which acts as a windbreak, hinders drifting sand and filters salt. Other timber trees and rattans are densely planted on mounds built up around the garden as protection. Within the garden a variety of fruit trees is grown, such as bananas, mulberries, figs, papaya and citrus, plus tuber crops such as sweet potato, arrowroot and jicama. Fish and prawns are raised in brackish ponds and canals. The most common forms of livestock raised are buffalo, cattle, pigs and poultry, especially ducks."

Permaculture News Website. (2008, October). Vuon – Ao – Chuong – The Traditional Vietnamese Farm. https://songsaareserve.com/beyond-sustainability/1-million-trees-programme/

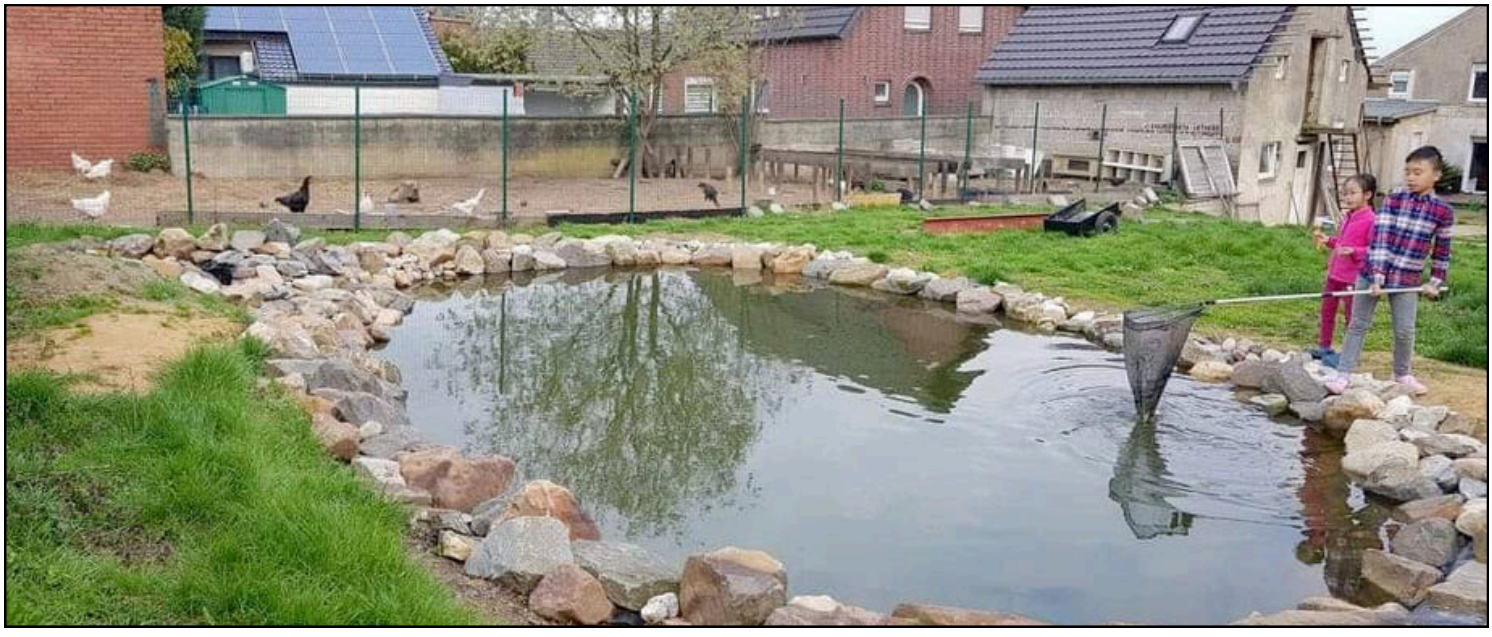

Figure 4: VAC Style "Lagoon Farming" in Vietnam
Photo Credit: https://vnexpress.net/

Notable Lagoon-Based Permaculture Style of Farming

Sundarbans, India and Bangladesh
Project Name:
Integrated Mangrove-Aquaculture Farming System
Overview: The Sundarbans, a vast mangrove forest area in India and Bangladesh, features innovative permaculture projects where rice fields are integrated with mangrove lagoons. These ecosystems harness the natural benefits of mangroves, such as water filtration and storm protection, alongside sustainable rice and tree cultivation.

Figure 5: Mangrove Aquaculture, India
Photo Credit: Tamil Nadhu, India © MSSRF.
(http://www.mangrovesforthefuture.org/news-and-media/news)

Key Features:

- Utilization of brackish water from mangrove forests in rice cultivation.
- Planting of mangrove trees and other salt-tolerant species around rice paddies and lagoons.
- Integration of aquaculture, including fish and shrimp farming, within lagoon systems.

Figure 6: Integrated Mangrove Aquaculture, India
Photo Credit: Aquaculture Journal Issue 209, p. 43-59

Benefits:

- Enhanced resilience to climate change and storm surges.
- Improved water quality and soil health through natural filtration.
- Sustainable livelihoods through diversified agriculture and aquaculture.

Notable African Permaculture Project

Abukassims Oasis, Egypt
Project Name: ***Sekem Project***
Overview: The Sekem Project in Egypt's desert region is a pioneering example of large-scale sustainable agriculture. It integrates water-efficient permaculture practices with rice and tree cultivation within man-made oasis systems.

Figure 7: Mixed Trees of Ecovillage Sekem Gardens
Photo Credit: Brochure, SEKEM (www.sekem.com)

Key Features:
• Creation of water lagoons and channels for effective irrigation in arid regions.
• Cultivation of rice alongside date palms, citrus trees, and other fruit trees.
• Use of biodynamic farming practices to enhance soil fertility and productivity.

Benefits:
• Efficient use of scarce water resources in arid environments.
• Increased biodiversity and ecological balance.
• Promotion of sustainable agriculture and rural development.

Quote from SEKEM:

Sekem. (2024 May) "The climate above the surface of the soil is one factor that determines how fast soil degrades and water evaporates. By planting trees around the fields, we achieve several effects, on top of a pleasant scent: The trees break the wind so that it cannot blow away the top soil; the shade brings cooler and more humid air, which creates a micro climate among the surrounding tree lines of a field; the photosynthesis of the trees uses carbon dioxide and emits the needed oxygen instead; and in the long term, the groundwater level slowly rises because of the cooler surface and brings additional micro-climatic change."

Webpage: AIR & WATER. Sekem. Retrieved from https://sekem.com/en/ecology/air-water/

SPEEDRICE Permaculture Project in Madagascar

Project Overview: The SPEEDRICE project, initiated by the Aga Khan Foundation in collaboration with the Innocent Foundation, focuses on improving rice yields and enhancing food security among vulnerable households in Madagascar. The project introduces the Zanatany Rice Permaculture System (ZRPS), which integrates various sustainable agriculture techniques aimed at boosting productivity while preserving the environment.

Key Components of ZRPS:

- Self-Made Inputs: Farmers are trained to produce their own high-quality seeds, natural pesticides, and organic fertilizers, significantly reducing costs and dependency on external inputs (AKF | The Learning Hub) (Serve Boldly With the Peace Corps).
- Direct Seeding: This technique reduces labor by up to 50% and produces larger, healthier, and more drought-tolerant plants. It also leads to earlier ripening crops (AKF | The Learning Hub).
- Crop Rotation and Mixed Cropping: Integrating legumes such as beans or cowpeas into rice fields improves soil fertility and moisture retention, supporting year-round crop production (AKF | The Learning Hub).
- Agroforestry Integration: Trees and shrubs are integrated into rice fields to enhance biodiversity, provide additional sources of income, and mitigate climate change impacts (AKF | The Learning Hub) (Aga Khan Development Network).

Minimal Tillage: Reduced tillage practices enhance soil structure, increase organic matter content, and improve the soil's water retention capacity (AKF | The Learning Hub).

Benefits:

• Enhanced soil fertility through natural mulching and organic matter from bamboo.
• Improved water retention and prevention of soil erosion.
• Diversified income streams for local communities from bamboo, rice, and fruits.
• Increased resilience of farming systems to climatic variations.

Challenges

Despite its promising approach, the SPEEDRICE project faces challenges such as limited access to agricultural tools and irregular rainfall patterns. Continued support and adaptation to local conditions are essential for the long-term success of the project. Expanding training programs and integrating more advanced water management systems could further enhance the resilience and productivity of rice farming in Madagascar (Aga Khan Development Network) (AKF | The Learning Hub).

Future Directions

The SPEEDRICE project in Madagascar demonstrates a comprehensive approach to tackling food security and environmental challenges through sustainable agriculture. By empowering local farmers with knowledge and resources to implement the Zanatany Rice Permaculture System, the project not only aims to increase rice yields but also promotes environmental sustainability and resilience against climate change. Continued investment and support for such initiatives are crucial for the long-term prosperity and food security of communities in Madagascar.

Linking Wetlands Agroforestry to Madagascar's Deforestation Issues

Madagascar has experienced extensive deforestation due to agricultural expansion, illegal logging, and the use of slash-and-burn farming methods. This deforestation has led to soil degradation, loss of biodiversity, and disrupted water cycles. Integrating permaculture principles, including water storage, groundwater management, and tree planting, can address these issues effectively.

Combatting Soil Erosion and Degradation

Tree Planting: Reforestation and agroforestry practices can restore degraded lands. Trees stabilize the soil, preventing erosion and improving fertility, which is essential for sustainable agriculture.

Permaculture Design: Implementing permaculture designs that include swales and contour planting can reduce soil erosion and enhance water infiltration, benefiting both the environment and agricultural productivity.
Restoring Biodiversity

Habitat Creation: Planting native trees and creating diverse agroforestry systems can restore habitats for Madagascar's unique wildlife, promoting biodiversity and ecological balance.

Integrated Systems: Permaculture systems that integrate trees, crops, and livestock create multifunctional landscapes that support a variety of species and ecological functions.
Improving Water Management.

Water Storage Solutions: Building ponds, reservoirs, and implementing rainwater harvesting systems can enhance water availability for agriculture, reducing pressure on natural water sources and improving resilience to drought.

Groundwater Recharge: Trees and other permaculture practices that enhance soil structure and water infiltration help recharge groundwater, ensuring a sustainable water supply for both agricultural and domestic use.
Promoting Sustainable Livelihoods

Economic Benefits: Diversified agroforestry systems provide multiple income sources, improving the economic resilience of communities. This reduces the need for destructive practices like slash-and-burn agriculture.

Community Engagement: Engaging local communities in permaculture projects can build awareness and skills for sustainable land management, fostering long-term environmental stewardship.

Figure 8: Madagascar Rice Production. Where are the Trees?
Photo Credit: Aga Khan Foundation (https://www.akf.org.uk/speedrice/)

Techniques for Enhancing Water Storage, Groundwater Health, and Tree Integration
Swales and Contour Planting

Swales: Swales are shallow, broad channels designed to capture and slowly release water into the soil. They are typically constructed along contour lines to maximize water infiltration and reduce runoff.

Contour Planting: Planting along contours helps slow water flow, enhancing infiltration and reducing erosion. This technique is particularly effective in hilly or sloped areas.
Ponds and Reservoirs

Water Storage: Constructing ponds and reservoirs within or adjacent to rice fields provides significant water storage capacity. These structures capture rainwater and runoff, making it available for irrigation during dry periods.

Microclimate Regulation: Ponds also help regulate microclimates by increasing humidity and providing habitat for beneficial wildlife.
Mulching and Ground Cover

Mulch: Applying organic mulch around rice plants helps retain soil moisture, reduce evaporation, and improve soil health. Mulch also contributes to the organic matter in the soil, enhancing its water-holding capacity.

Ground Cover Crops: Planting cover crops during off-seasons prevents soil erosion, improves soil structure, and enhances groundwater recharge.

Rainwater Harvesting Systems.

Collection Systems: Installing rainwater harvesting systems on rooftops or other structures captures and directs rainwater into storage tanks or directly into the fields. This water can be used for irrigation, reducing reliance on external sources.

Supplementary Irrigation: Harvested rainwater can supplement irrigation during critical growth stages of rice, ensuring that water needs are met without stressing groundwater resources.

Figure 9: Recirculating Wetlands Agroforestry.
Photo Credit: Coman, with assistance from Openart.ai

Conclusion

Effective water storage, groundwater health, and the integration of trees are vital components of a successful permaculture rice field. These practices can also play a significant role in addressing the deforestation issues in Madagascar. By implementing sustainable water management practices and integrating trees into farming systems, permaculture can contribute to reforestation efforts, soil restoration, biodiversity conservation, and community resilience. Embracing these strategies not only ensures the long-term sustainability of agricultural production but also supports the restoration and protection of Madagascar's valuable ecosystems. Through collaborative efforts and a commitment to sustainable land management, permaculture offers a promising pathway towards mitigating deforestation and promoting environmental stewardship in Madagascar and beyond.

Figure 10: Recirculating Wetlands Agroforestry.
Photo Credit: Coman, with assistance from Openart.ai

References

1. Altieri, M. A. (1995). Agroecology: The Science of Sustainable Agriculture. Westview Press.
2. Uphoff, N. (2003). Higher yields with fewer external inputs? The System of Rice Intensification and potential contributions to agricultural sustainability. International Journal of Agricultural Sustainability, 1(1), 38-50.
3. Mollison, B., & Holmgren, D. (1978). Permaculture One: A Perennial Agriculture for Human Settlements. Tagari Publications.
4. FAO. (2015). Agroforestry for Sustainable Agriculture. Retrieved from FAO website.
5. Jacke, D., & Toensmeier, E. (2005). Edible Forest Gardens: Ecological Vision and Theory for Temperate Climate Permaculture. Chelsea Green Publishing.
6. Milder, J. C., Majanen, T., & Scherr, S. J. (2011). Performance and Potential of Conservation Agriculture for Climate Change Adaptation and Mitigation in Sub-Saharan Africa. EcoAgriculture Partners.
7. Lin, B. B. (2011). Resilience in Agriculture through Crop Diversification: Adaptive Management for Environmental Change. Bioscience, 61(3), 183-193.
8. Smith, J., Pearce, B. D., & Wolfe, M. S. (2013). Reconciling productivity with protection of the environment: Is temperate agroforestry the answer? Renewable Agriculture and Food Systems, 28(1), 80-92.
9. Aga Khan Development Network. (2022). SPEEDRICE: Effortless rice permaculture in Madagascar. Retrieved from AKDN.
10. Aga Khan Foundation Learning Hub. (2024). Zanatany Rice Permaculture System. Retrieved from AKF Learning Hub.
11. Peace Corps. (2015). Improving rice farming in Madagascar. Retrieved from Peace Corps.