Original Research Article

Interdisciplinary governance of soil erosion on the Loess Plateau

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Abstract: The Loess Plateau is one of the most severely eroded regions in the world. Over the past decades, China's ecological restoration programs, such as the Grain for Green Project, have significantly reduced soil erosion but also created new challenges including the reduction of arable land and livelihood difficulties for farmers. This paper adopts an interdisciplinary governance perspective—Integrating ecology, agricultural economics, law, sociology, and ethics—To analyze the limitations of current policies and explore pathways toward sustainable soil and water management. The findings indicate that single-disciplinary policies often overlook the socio-economic complexity of environmental governance, whereas interdisciplinary approaches can better coordinate ecological restoration, economic incentives, legal safeguards, and social justice. Policy recommendations include promoting eco-agricultural coexistence models, establishing long-term market-based incentive mechanisms, clarifying land tenure rights with legal guarantees, and building urban–rural ecological compensation systems to ensure a win–win outcome between environmental sustainability and rural livelihoods.
Keywords: Loess Plateau; soil erosion; interdisciplinary governance; ecological compensation; agricultural sustainability; social equity

1. Rationale

The Loess Plateau is one of the most seriously soil eroded regions in the world(Chen et al., 2007). Over the past few decades, the Chinese government has implemented a series of governance policies to reduce soil erosion and improve the ecological environment. However, these measures have also brought new challenges such as a reduction in arable land and damage to the livelihoods of farmers(Wen and Zhen, 2020).

The main task of this briefing paper is to assess whether an interdisciplinary approach can optimize soil and water erosion control while promoting sustainable agricultural development and improving people's well-being. Briefing paper will analyze the pros and cons of existing policies and provide more feasible policy recommendations from the perspectives of ecology, economics, law, philosophy and other disciplines. Particularly, how to find a balance between ecological protection and agricultural production to ensure environmental sustainability while ensuring rural economic development and social fairness.

This briefing paper is mainly aimed at environmental managers, policymakers and rural development researchers, providing them with policy recommendations based on multidisciplinary analysis. It does not involve specific engineering technology, but focuses on optimizing policy measures to improve the sustainability of soil and water governance.

2. Background

The Loess Plateau region is located in central China. It is one of the most seriously eroded and ecologically fragile regions, with serious soil erosion and desertification. However, it is also one of China's important grain production bases(Zheng and Wang, 2014). Each year, the Loess Plateau loses nearly 1.6 billion tons of sediment,

which not only leads to a decline in agricultural productivity, but also contributes to the sedimentation problem of the Yellow River, affecting water resource management and ecological security in the lower reaches(Huang et al., 2003).

To address this challenge, the Chinese government launched return farmland to forest in 1999 to encourage farmers to convert farmland to forest or grassland in order to reduce soil erosion. The policy has achieved some results in ecological restoration, increasing the vegetation coverage rate in some areas from 20% to more than 50%(Zhou et al., 2009). However, after the farmland was returned, the farmers' farmland decreased, agricultural production was restricted, and many farmers lacked alternative sources of livelihood, facing declining incomes and economic instability(Liang et al., 2012). Additionally, unclear land ownership and an imperfect ecological compensation mechanism affect the effectiveness of policies(You et al., 2022). Therefore, how to optimize policies to reduce soil erosion while improving the sustainability of agriculture is a key issue currently facing China.

3. Current status

The problem of soil erosion on the Loess Plateau has global and regional implications, and its severity is reflected in multiple aspects such as ecology, agriculture, economy and society. In terms of ecology, soil erosion leads to a decline in soil fertility, making it difficult to restore vegetation, and affects the water quality of the lower reaches of the Yellow River. In some areas, long-term erosion has created a fragmented landform with thousands of ravines and valleys, making natural recovery extremely difficult(Huang et al., 2003). In agriculture, soil erosion degrades farmland, thins the cultivated layer, reduces crop yields, and forces farmers to abandon or migrate(Dang et al., 2020). In terms of the economy, the policy of returning farmland to forest has led to a decline in income for some farmers due to a reduction in arable land, while ecological compensation funds have difficulty covering all affected farmers in the long term, increasing the risk of returning to poverty. Socially, land use policies have led to an exodus from some villages and a decline in the vitality of the rural economy(You et al., 2022).

The difficulty in solving this problem lies in its complexity, which makes it difficult for a single policy to be completely effective. Firstly, the uncontrollability of natural factors makes governance more difficult. Precipitation on the Loess Plateau is seasonal, with heavy summer storms causing a lot of scouring in a short period of time. Traditional soil and water conservation measures are difficult to withstand the impact of extreme rainfall(Wang et al., 2024). Moreover, the loess itself has fine particles and is easily washed away by water. Even if vegetation recovers, if it is not properly maintained, it may still face secondary erosion(Zhuang et al., 2021).

Secondly, economic and social difficulties also pose a challenge to governance. After returning farmland to forest, farmers' main source of income has decreased, and the existing compensation mechanism lacks long-term guarantees, leading some farmers to resume farming in violation of regulations. Additionally, urbanization has led to an outflow of young rural labor, weakening the ability to promote ecological technology(You et al., 2022).

Thirdly, limitations in policy implementation also make it difficult for governance to achieve long-term results. When the government implemented the policy of returning farmland to forest, it initially provided farmers with subsidies for 5 to 8 years. However, after the expiration of the subsidies, the financial support for farmers decreased, resulting in the resumption of farming(You et al., 2022). Additionally, land ownership is unclear, and many farmers are worried that the land will be reclaimed by the government after they have returned the land to the fields, so they are reluctant to actively participate in the policy(Dang et al., 2021).

In summary, soil and water management on the Loess Plateau involves multiple fields such as climate change, agricultural economics, land policy, and ecosystem dynamics. The complexity of management far exceeds the scope of solutions from a single discipline. Future policies require multidisciplinary collaboration

that takes into account ecological, economic, social, and legal factors to ensure the long-term sustainability of governance measures.

4. Key arguments

4.1. Definition and applicability of interdisciplinary methods

Interdisciplinary approaches do not simply add together multiple disciplines, but emphasize the interaction, cross-fertilization and integration of methods between disciplines. For example, ecology can provide effective soil and water conservation measures, but ignoring agricultural production has led to a policy backlash. Agricultural science focuses on increasing yields, but this increases soil erosion. Economics focuses only on the short-term benefits of policies on rural livelihoods, and may lead to the failure of compensation mechanisms due to neglect of the law.

Single-disciplinary legal studies emphasize the institutional design of land ownership but increase contradictions in policy implementation by underestimating the social resistance to community cooperation, and sociology can analyze the acceptability of farmers and the feasibility of community cooperation. Only on the basis of the combination of these disciplines can design viable and sustainable policies.

4.2. An interdisciplinary approach can effectively find win-win solutions.

4.2.1. Integrate ecology and agriculture, and coordinate ecological protection and food security

Traditional soil and water conservation measures often emphasize vegetation restoration but ignore the sustainability of agricultural production, which affects food security. It can even lead to a decline in the groundwater level due to excessive transpiration by trees, worsening ecological imbalances. Agricultural science focuses on improving soil productivity and agricultural adaptability, but policies oriented towards a single agricultural approach may ignore the need for ecological restoration. If operating in isolation, it may lead to policy imbalances, but if combined with an interdisciplinary perspective, it can develop a win-win measure that can achieve the effect of conserving soil and water while also increasing farmers' income(Gong et al., 2020).

4.2.2. Integrate economic incentives and policy tools to ensure the sustainability of ecological governance

Economics provides analytical tools for market mechanisms such as carbon trading and the branding of ecological agricultural products, while policy research can assess the difficulty of implementing these measures and their long-term feasibility. An interdisciplinary approach can help decision-makers establish scientifically sound ecological compensation mechanisms.

4.2.3. Legal and policy dual guarantees ensure fairness and long-term enforceability

Unclear land ownership and uneven implementation of policies are important legal and institutional obstacles facing current soil and water governance policies(Li et al., 2022). An interdisciplinary approach can integrate the perspectives of law, political science, and social science to optimize policy implementation methods.

4.2.4. Combining social justice and ethical considerations to reduce social inequality in ecological governance

Ecological policies often emphasize environmental priorities, but rural residents often have to bear short-term economic losses, while the ultimate beneficiaries are mainly urban residents or future generations. This imbalance may lead to resistance from rural groups and even affect the sustainability of policies(Ma, 2024). An interdisciplinary approach can ensure the fairness of ecological policies through the combination of social sciences and ethics.

4.3. Limitations and challenges of interdisciplinary approaches

Despite an interdisciplinary approach has theoretical advantages, it still faces many challenges in practice:

Coordination is difficult, involving multiple disciplines and government departments, with high communication costs and difficulties in implementing policies. Market mechanisms are immature, and mechanisms such as carbon trading are still in the development stage, making it difficult for farmers to enter the market. Local governments have uneven enforcement capabilities, and some may weaken the implementation of ecological policies due to short-term economic goals. Ecological fairness is difficult to quantify, and how to define the proportion of responsibility between rural and urban areas in ecological protection is still a difficult problem in policy formulation.

4.4. Learning from other successful cases

Interdisciplinary methods have been successfully applied in ecological governance in other countries and can provide a reference for the treatment of soil erosion on the Loess Plateau. For example:

Agricultural pollution in the Mississippi River basin in America has led to the ‘dead zone' phenomenon in the Gulf of Mexico. The interdisciplinary approach combines ecology and economic incentives, using precision agriculture techniques, wetland restoration and nutrient management, while also introducing market incentives has reduced nitrogen and phosphorus pollution and improved the sustainability of agriculture(Rabalais et al., 2002).

Water resources management in the Mekong River Basin faces challenges such as the construction of cross-border dams, ecological destruction and the undermining of the livelihoods of coastal communities. An interdisciplinary approach combines hydrological modelling with ecological protection to assess the impact of dams on flow rates and fisheries. At the same time, transnational consultation mechanisms such as the Mekong Agreement are introduced to promote the sharing of water resources, reduce ecological shocks and support the development of sustainable fisheries and agriculture.(Morovati et al., 2024, Sabo et al., 2017)

5. Recommendations

An interdisciplinary approach provides a more comprehensive perspective on soil and water conservation on the Loess Plateau, enabling ecological restoration, agricultural sustainability, economic incentives, legal safeguards and social fairness to work together. However, the effectiveness of interdisciplinary approaches depends on a variety of factors such as policy implementation and market maturity.

Firstly, ecological management methods should be optimised, shifting from simple vegetation restoration to a model of ecological and agricultural coexistence. For example, on the basis of returning farmland to forest, promote agroforestry systems that take into account soil and water conservation and agricultural production, and reduce the risk of damage to farmers' livelihoods.

Secondly, the reliance on financial subsidies should be reduced and establish long-term economic incentives. The government can promote the reform of the carbon trading market, lower the entry threshold for farmers, and at the same time support the branding of ecological agricultural products to increase market acceptance, so that farmers can obtain economic benefits while participating in ecological governance.

Additionally, legal guarantees are key to the sustainability of policies. Land ownership rights need to be clarified to ensure that farmers have a long-term interest in ecological governance. At the same time, an independent ecological compensation monitoring agency should be established to ensure that local governments implement policies fairly and avoid short-term economic goals from affecting long-term environmental governance.

Finally, social equity issues need more attention. Ecological governance policies should take into account the economic affordability of rural groups, establish an urban-rural ecological compensation mechanism, and allow beneficiaries of ecological protection to support rural ecological contributions through taxation or market

mechanisms. At the same time, vocational training and livelihood transformation are provided to help farmers transition to ecological agriculture or other sustainable industries, so as to reduce the negative impact of policies on farmers' livelihoods.

Although an interdisciplinary approach is not a panacea, it offers a more flexible and comprehensive path that combines the strengths of different disciplines to address the complex environmental issue of soil erosion. Future policy making should be promoted simultaneously at the scientific, economic, legal and social policy levels to ensure a win-win situation for ecological governance and agricultural development.

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