

REVIEW

Policy options for Agriculture Green Development by farmers in China

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Abstract Farmers are the key agents who manage land and water. Agriculture Green Development (AGD) requires a transformation in farming from high resource consumption and environmental cost to sustainable intensification with high productivity, high resource use efficiency and low environmental risk. This paper analyzes the public policy challenge of AGD and makes the case for a location-sensitive policy mix made up of regulation, advice provision, voluntarism and targeted incentives. The public agricultural extension service in China is a key resource, but one that requires reorientation and reform with the aim of better balancing high farm productivity with environmental protection.

Keywords agriculture, environment, development, incentives, policy, regulation

1 Introduction: farmers as agents for Agriculture Green Development (AGD)

Responding to degradation of the natural environment, and in accord with the relevant UN Sustainable Development Goals, policy makers and researchers in China increasingly emphasize transformation of Chinese agriculture from high resource consumption and environmental cost to sustainable intensification with high productivity, high resource use efficiency and low environmental risk^[1]. This transformation has been termed AGD in China. This paper reviews policy options to achieve this in China. Although the focus is on the actions of farmers, it should be recognized that food and water consumers, and other actors in farm input and output supply chains, also have important influences and roles.

The nature and scale of the transformation needed can be illustrated by the following. Recent estimates of the total

economic cost of environmental damage in the sector range from 7% to 10% of national agricultural gross domestic product^[2]. Expansion of agricultural land has resulted in significant loss of wetlands and forests and their ecological services, while over-exploitation of ground water for intensified production is unsustainable in large areas, especially in northern China^[3]. Agriculture is a major source of nutrient pollution of water, accounting for approximately one third of the nitrogen released into surface and ground waters; over 40% of rivers are severely polluted and 80% of lakes suffer from eutrophication^[3]. Approximately 20% of agricultural land, 10% of forest land and 10% of grassland have been contaminated by inorganic and organic pollutants^[3].

Food and fiber production use more water and land than other human activities, and thus how farmers manage natural resources is of leading importance for the conservation of ecosystems and the sustainability of ecosystem services. Sustainable intensification of farming requires improvements in the quality and resilience of ecosystems and of the services they provide to people, including farm production. Farming practice particularly impacts the sustainability of soil fertility, and water quantity and quality for human and ecosystems use. For water, land use and farming practice moderate: infiltration of rainfall and soil moisture retention; demand for, and storage of, water for irrigation; water consumed by crops and livestock; and the quantity and pollution of surface and subsurface drainage flows^[4].

How a farmer can best achieve high productivity, high resource use efficiency and low environmental risk, and manage inevitable trade-offs between these, depends on local conditions and available technologies. Technologies and farming practices well adapted to biophysical, farming system and socioeconomic conditions are needed. These can be termed ‘best management practices’ (BMPs). The aim for public policy is to achieve the form and level of adoption of BMPs by farmers that will achieve society’s goals. Such goals in China include achieving local and national food security, securing rural livelihoods,

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conservation of landscape amenity and cultural heritage, and environmental quality and ecosystem service provision.

The policy challenge is complex given these multiple goals, the multifunctionality of land use, the form and distribution of relevant property rights, and the small farm sizes and diversified livelihoods of many farmers in China. High productivity, high resource use efficiency and low environmental risk cannot all be achieved everywhere. When trade-offs must be made, what should take priority and how should the interests of the farmer be balanced against those of wider society? For example, should the farmer, final consumer, supply chain intermediaries or government bear any costs of producing food in less environmentally damaging ways? It may also take years to reverse past degradation of soil and water^[5]. Thus, policy choices involve both the intra- and inter-generational distribution of costs and benefits and political choices are necessary. Coherent choice of policies and the means for their delivery are needed. This paper identifies key components for this and briefly assesses current relevant capacities in China.

2 Materials and methods

Preparation of this paper primarily employed review and analysis of literature and secondary data. This was supplemented by semi-structured interviews with key informants and direct observation during visits to farms, villages and on-farm trials in China. The author also participated in workshops and conferences with national level scientists and stakeholders.

3 Policy options for AGD in China

A priority is to remove, or at least reduce, perverse effects of producer price support or input subsidies that encourage inefficient or damaging farming methods. Such economy-wide policies neglect spatial variation in biophysical conditions and can incentivize production poorly matched to natural resource availability and ecosystem capacity to absorb pollution in a given location^[6].

Policies to influence farmer practice then include regulation, economic incentives and promotion of voluntarism^[7,8], but it is a combination of these that will be required. For example, biophysical uncertainties and the temporal, spatial and scale characteristics of farming in China make a solely regulatory approach very costly, if not impractical. Use of economic incentives alone may similarly be difficult and costly to administer. For example, polluting emissions can be taxed but measurement and enforcement costs for this are likely to be prohibitive. Alternatively, the farm input causing emissions can be taxed but demand for its use is likely to be inelastic, thus

limiting effectiveness. Making such a tax higher will tend to be limited in China by concerns for food prices, trade competitiveness, potential for substitution of polluting practices (pollutant swapping), farm incomes and equity for farmers already compliant with input use advice. Lastly, change through voluntarism alone will also be limited by small farmer income needs once trade-offs between productivity and environmental protection apply.

Thus, combined and layered policies are likely to be superior to any single policy, and this can be depicted in an idealized form as in Fig. 1.

Cost-effective regulation and technology transfer to farmers is needed to establish a baseline of 'good' farming practice that achieves high productivity, high resource use efficiency and low environmental risk. In Fig. 1 this is termed the reference level^[10] and defines standards to be achieved by farmers at their own cost. This level can be raised by technological innovation and effective BMPs that sustain or increase productivity while reducing environmental risk. Investment in agricultural research and the knowledge base that supports the policy framework in Fig. 1 is thus essential. Development of BMPs can extend the range of geographical areas, farming systems and farm scales for which trade-offs between productivity and environmental protection can be minimized. This is important given the diversity of crop and livestock production systems in China and of regional agro-ecological conditions. Research also provides policy makers, farm advisers and farmers with information on expected BMP outcomes, costs and adoption rates.

Above the reference level, trade-offs must be managed, and for further environmental protection this requires more regulation, voluntarism by farmers and usually payment to farmers (at least as compensation for income foregone). When such compensation is to be paid, the reference level becomes a compliance condition that farmers should meet to receive payment^[7]. Given budget constraints, the triangular shape of Fig. 1 represents how use of payments to farmers will have to be spatially targeted. Political choices must be made to target those locations for which AGD requires achievement of greater environmental protection at the expense of constrained productivity.

Payments to farmers in targeted areas can be termed payments for ecosystem services (PES). In effect, an environmental service (most often a land use providing the service) is paid for by the state, or other buyers. Narrowly defined, PES requires payments for the opportunity cost to the farmer of the service provided, conditional on its delivery^[11]. In practice causal relationships are difficult and costly to quantify, and payments are rarely conditional on ecosystem service output. More commonly, payments contribute to estimated income foregone, farm infrastructure improvements and/or costs of BMPs, based on assumptions that this will deliver the buyer's objective^[12].

Other incentive policies to change farmer behavior can involve other market-style mechanisms. For example,

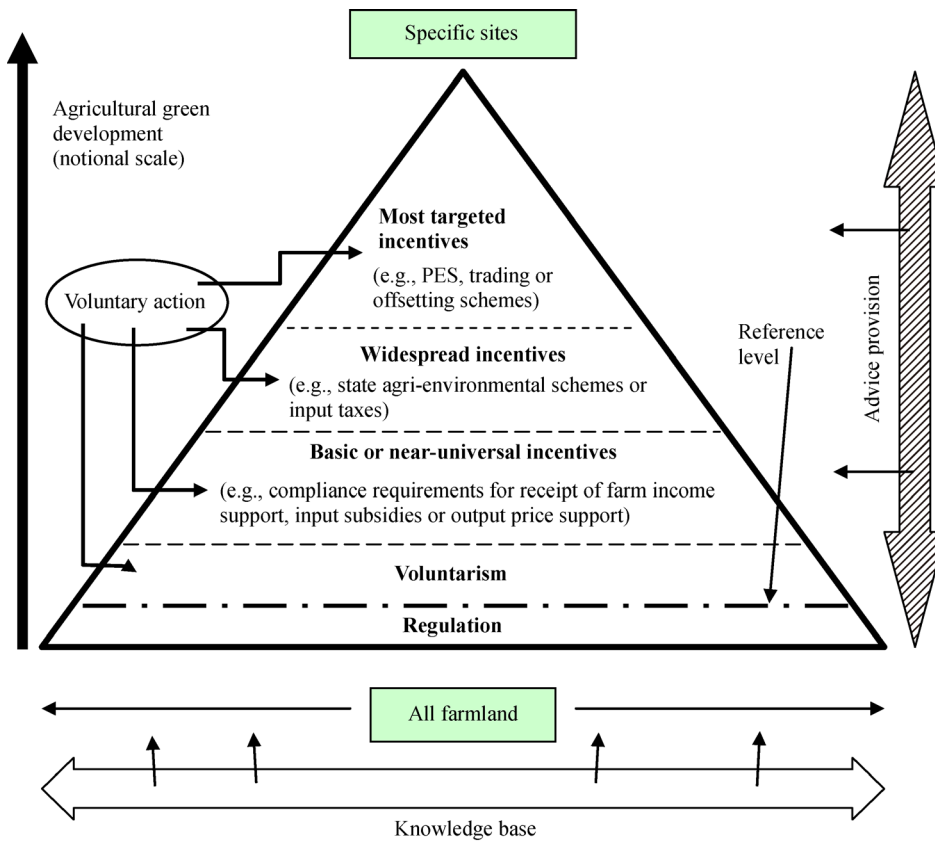


Fig. 1 A policy framework for agricultural green development (AGD). Adapted from Smith et al.^[9], with permission from Elsevier.

trading of irrigation water allocations, or of emission quotas given a cap-and-trade regime for a water pollutant such as nitrate^[6]. Examples exist but achieving change at scale requires that conditions vary sufficiently across farms within an area to allow gains from trading net of transactions costs. In addition, even proxy measurement of water volumes, emissions or environmental change remains costly and institutionally demanding^[6]. However, offsetting schemes offer potential, at least for environmental improvements. For example, wetlands banking can create wetlands (or other conservation areas) in multiple locations and sell credits to expanding or intensifying commercial farms to offset any wetland or other environmental loss.

Figure 1 also suggests that advice provision and voluntary action are crosscutting corequisites for regulation and for incentive schemes. There are too many farm management choices and varied local conditions to monitor for regulation alone to be either affordable or effective. Similarly, for monitoring of conditionalities attached to incentives. Making regulation or incentives work at farm scale, particularly for thousands of small farms, is dependent on and enhanced by voluntary compliance. Consequently, if protection of the environment is to go beyond prosecution of only the most egregious and visible cases of harm, there must be local

and voluntary acceptance of the responsibilities which regulation or an incentive scheme requires.

Farm advice can also encourage and assist a farmer in complying with regulation or incentive scheme conditionality at the least cost. It can also promote adoption of those BMPs that can achieve high productivity, high resource use efficiency and low environmental risk. Farmers themselves sometimes innovate or improve such technologies and farm advice services can aid dissemination of resulting best practice.

Professional technical providers, able to work well with farmers, developers and local government are a valuable resource. Generic technical capacities needed include understanding of relevant planning, environmental and land use regulation, and of environmental conservation, land management, farming systems, surface (including highway and storm water drainage) and riparian corridor management. To be most effective for AGD, farm advice needs to holistically appraise alternatives for the farm business and a farm family's objectives, and not just focus narrowly on either productivity or environmental protection. The best farm advisers come from the same region and social background as farmers, speak with the same accent or dialect and share the same concerns about the local economy and environment^[13].

Thus, a coherent choice of policies depends on the

complementarities between research, regulation, incentives, voluntarism and advice provision. Given the inherent variability of farming practice, farm sizes in China and the costs of monitoring and enforcement, the reference level of regulation can only be used to manage severe environmental risks even at regional or farming system scale. Its existence, however, sets the baseline for consistency and additionality of voluntary and incentivized further improvement. Helping, for example, to avoid giving incentives to worst-case farmers. Advice provision then facilitates and improves choices made by farmers. Ultimately most of their compliance and adoption decisions are voluntary and will be improved by access to high quality information and advice.

4 Capacities to implement policies for AGD in China

4.1 Economy-wide policies

There appears to be limited scope for reducing negative environmental impacts of agricultural support policies in China, although this may increase if current policy trends continue to stimulate domestic production^[14]. Relevant policies introduced since 2004 include direct payments for grain production, a general subsidy for agricultural inputs, a subsidy for adoption of improved crop varieties, a farm machinery purchase subsidy, minimum grain purchasing prices, support for temporary storage, and subsidies for agricultural insurance, credit, land consolidation, and soil conservation and improvement^[14,15]. Despite this diversity, the value of support by farm remains relatively low and can be considered decoupled from production decisions^[9,14]. However, larger farms offer more potential for AGD through more cost-effective regulation and advice, and capability to undertake environmental protection measures^[3], and thus existing farm support at least partly inhibits land transfer, farm restructuring and pooling of farmland into farming cooperatives^[16,17]. China is also largely missing the policy tiers in Fig. 1 labeled as basic or near-universal incentives and wide-spread incentives. Where it is necessary to prioritize environmental protection there is a need to move from the existing subsidies that aim to ensure yields and farm incomes “to a green subsidy which focuses on agro-ecological compensation”^[18].

The fertilizer sector in China also merits further reform. A policy of price caps was removed in 2009 but import tariff reductions are still used to mitigate domestic shortages, and the industry’s energy, transport, storage and credit costs are subsidized^[19]. The general farm input subsidy and these industry subsidies contribute to inefficient manufacturing, variable quality, relatively low domestic compared to world prices and excessive and poorly managed use by farmers^[9,16].

4.2 Regulation

For AGD, relevant farm-level regulation and its effective enforcement have been inadequate in China. This has been inevitable given the number and size of farms, their historic role in economic development and the long-standing growth-first mentality of officials and scientists^[16]. More recently, direct command and control policies including standards and rules regulating agricultural pollution have been introduced to reduce water pollution from livestock and agrochemicals and air pollution from biomass combustion. For example, in 2015 the Ministry of Agriculture set caps to growth in agricultural chemical use to be achieved by 2020^[3]. Recycling of biomass *in situ*, as livestock feed or through bio-energy generation, is also encouraged and often subsidized.

Authorities in most countries are sparing in enforcement of regulation of agriculture given the costs of legal prosecution and often a lack of political support for a rigorous approach^[9]. China is no exception^[20], but its agricultural sector lacks the politicization and lobbying by farming organizations that has been influential in limiting farm regulation in, for example, Europe and North America. Despite this, farm scales and low incomes may still limit the compliance-related costs that can be imposed before many small farms become non-viable^[21,22].

Even when there is a strong intent at high level to regulate for environmental protection in China, it has been observed that this is often decoupled from ability for implementation and enforcement at a regional or local level^[20,23,24]. The environment ministry provides guidance to the environmental protection bureaus that exercise environmental governance locally but lacks authority over them, while local governments control their staffing, financing and hence decision making, and may prioritize economic growth over environmental protection^[25]. Bureaucratic fragmentation and overlapping of responsibilities can also result in a lack of coordination and ineffective regulation^[23,26]. The transaction costs of coordination across sectors and agencies can also be burdensome^[3]. Other historic barriers to strengthening farm regulation are the great diversity of China’s physical geography and farming systems, and again weak interagency communication, data sharing and coordination.

The Ministry of Ecology and Environment was created in 2018 to integrate environmental protection responsibilities and unify supervision and enforcement responsibilities, including assimilation of the responsibilities of the Ministry of Agriculture for agricultural non-point source pollution^[26]. This creates a powerful and dedicated body for environmental regulation and progress has been made. Further improvement in baseline regulation of the farming sector can be foreseen, but coordination between agencies and levels of government will remain necessary^[26].

4.3 Incentive schemes

PES schemes in China are generally described as eco-compensation programs. Most have concerned provision of watershed ecosystem services in upper catchment areas^[27] and have made compensation payments in cash and/or grain to farmers who reduce deforestation, soil erosion and/or water consumption. Leading examples include the Sloping Land Conversion Program^[28], the Grain for Green Project^[29] and the Paddy Land-to-Dry Land Program^[30,31]. Such programs have shown some success^[31], but observers suggest that targeting, design, environmental outcomes, sustainability, setting of farmer compensation, institutional gaps, scheme overlaps, effective tools for monitoring ecological outcomes and overall program cost effectiveness could all have been improved^[29,31–37]. A lack of farmer and community participation in scheme design and implementation and effective engagement of local government and civil society intermediaries has also contributed to weak outcomes^[27,38]. Further improvement would come from strengthening policy design and implementation capacity through improved inter-agency collaboration and networking^[39].

Growing demand for improved environmental quality, water, leisure activity and tourism may increasingly provide drivers and finance for further eco-compensation schemes, although to date most schemes in China involve transactions between local governments in upstream and downstream watersheds rather than other private entities^[40]. Key tenets of Fig. 1 including a reference level for farming practice, spatial targeting and conditionality of payments need to be understood by stakeholders and inform scheme design. Schemes need to be well adapted to Chinese conditions, locally varied^[30] and innovative in institutional arrangements to overcome resource constraints and resolve jurisdictional issues over cross-boundary ecosystem service provision^[34].

4.4 Voluntarism

A culture of environmental stewardship by farmers and communities has many historical antecedents in traditional farming practice in China but often lacks contemporary practical expression. There is great potential to improve the efficiency of farming practice while maintaining productivity and reducing risk to the environment. For example, management of soils, manures, chemical fertilizer and irrigation could all be improved to more closely match crop requirements, reduce risk of losses to air and water and save on-farm input costs (e.g., Powers et al.^[5] and Chen et al.^[41]). However, scope for change through voluntary action by farmers often remains limited by field and farm size, plot fragmentation, income levels, prevailing knowledge, attitudes and practices (in part age and gender related^[17]), and increasingly by labor constraints^[16,42].

The potential for more larger and more commercial farms^[3] brings greater scope for change, but an ethos to maximize production may still drive the decision-making in such farms^[16].

4.5 Agricultural advice

All the above considerations emphasize the need for an effective agricultural knowledge and innovation system and the ability to change farmer behavior through advice, training and access to technologies. Relatively well-resourced, including staffing and number of township stations, and with a clear and hierarchical institutional structure, the public agricultural extension service (PAES) is the leading resource available in China to achieve AGD. Indeed, it is the largest public agricultural extension system in the world with approximately 700000 staff^[43].

However, many observers are critical of its performance, emphasizing: low responsiveness to community and farmer needs; low trust in the service among farmers; insufficient information provision and use of information technology in remote areas; functional specialization and ‘silo-working’ at ministerial, provincial, municipal and county levels (though at township level a single station usually implements all extension activities); and lack of coordination and scientific consensus with universities and research institutes^[9,44,45].

Farmers are too often passive recipients of recommendations with little formalized opportunity to feedback priorities and needs. At local level the education level of extension agents is relatively low, efficiency in input use and environmental protection have been low priorities for advice given in rural areas, and the PAES remains focused on productivity increase and lacking in strategies to balance this with environmental protection even when appropriate BMPs are known and available^[16]. In comparison to other countries, for example the UK, it is also notable that China lacks non-governmental organizations focused on environmental conservation that could help mediate between state and farmers and to further tailor advice and technologies to local conditions.

5 Conclusions

A focus on three policy approaches can be recommended. First is the need for baseline regulation of good farming practice. Laws are already in place at national level but transposition of these into binding regulations at a provincial and local level is needed. Robust and cost-effective means for monitoring and enforcement then need to be developed, and this could be enhanced by engagement with and participation by the farming community in any given location or region. As a minimum, as land transfer continues at a pace appropriate to local conditions, a reference level of enforceable regulation for

all large commercial farms is needed.

Second, targeted incentive payment schemes (eco-compensation subsidies) can be used strategically to protect areas of high ecological quality and value, managing the inevitable trade-offs between productivity and environmental risk that exist in the most sensitive environmental areas. Payments would facilitate conversion of land out of intensive agricultural production to lower intensity farming or other land use with lower risk of pollutant emissions. Payment regimes are needed that ensure long-term land use change and prevent reversion. For this, payments need to be sustained over long enough for farmers to be able to develop alternative income streams or migrate. Objective and transparent approaches are needed, and again these can be enhanced through engagement with all stakeholders at a local level. The literature evaluating eco-compensation schemes in China is now extensive, and it is time to draw lessons of experience from this to improve policy design and implementation well-matched to local conditions.

Third, a relatively well-resourced PAES exists to help farmers maintain and increase agricultural productivity and this can be reoriented and reskilled for AGD. There is potential to reform the priorities, ethos and modes of working of the PAES. The service also has the potential to coordinate and quality assure the actions of other actors within an increasingly diverse national agricultural knowledge and innovation system. Reorientation and retraining for staff and managers at all levels will be required. The need is to rebalance the importance of productivity alongside the stewardship of farm inputs, natural resources and wider environmental protection. Farm advice should emphasize resource use efficiency, profit maximization and environmental protection alongside the goal of high productivity. It should increasingly address farms as businesses, looking beyond yields to the objectives of the farm family or business, and to management of costs, labor use, crop residues and animal wastes, marketing and supply chains and environmental impacts. Advice and training modes should become more differentiated by farm size, management type and cropping system. Similarly, a greater diversity of communication and education methods should be employed, matched to the needs and access of different farmer types, and additionally targeting wider public awareness of environmental quality and food safety^[46].

Both farm advice provision and continuing agricultural research needs to be tailored to farmer needs as informed by their participation in a two-way dialog. Closer interagency working, with improved communication and data sharing at all levels, are also required to develop the new ethos and overcome barriers to coordination created by functional divisions and specializations. Support should be given to emerging farmer associations and cooperatives, while large agro-enterprises should be well-regulated but also assisted and utilized as demonstrations of best

practice. Small farmers in China are experienced but often aging and poorly educated^[17]. However, a cadre of skilled managers of larger enterprises is growing and provides a resource for innovation, practice and demonstration in pursuit of environmental protection. Amalgamation of farms through land transfer also offers growing efficiencies of scope and scale for provision of advice and technology transfer (and for implementation of eco-compensation schemes)^[22]. To support and facilitate each of the three approaches identified here, investment is needed in applied research to build an accessible knowledge base. This knowledge base must encompass methods for public participation through to design and costing of farm BMPs and design of institutional mechanisms for eco-compensation.

Through cross-scale, cross-level and cross-sector collaboration and coordination between agencies and farming communities, adaptive formulation and implementation of complementary policies well-tailored to local conditions can be achieved. This can be expected to consist of regulation, incentives, advice provision and voluntarism. Research and knowledge management are also fundamental in support. Information should flow between levels, organizations, stakeholders and the wider public to facilitate shared understanding, improve interventions, minimize conflicts, garner support and coordinate action. Effective intermediaries that can facilitate collaboration and coordinated action across locations, scales and activities are key. Hence, it may be necessary to strengthen human and organizational capacity and accountability at local level, and programs for AGD need to be built from existing organizations and partnerships, strengthening and expanding these as necessary.

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