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Delivering improved nutrient stewardship in China: the knowledge, attitudes and practices of farmers and advisers

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Key Messages

- There is a need to assess and re-orient agricultural knowledge and innovation systems (AKIS) in China, aiming to rebalance the importance of productivity alongside the stewardship of farm inputs, natural resources and broader protection of the environment; a new ethos is needed.
- Farm advice should emphasize resource use efficiency, profit maximisation and environmental protection alongside the goal of high productivity. It should address farms as businesses, looking beyond yields to the objectives of the farming family and management of costs, labour 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, given the increasing diversity of farm scales, types and needs.
  - Similarly, a greater diversity of communication and education methods should be employed, matched to the needs and access of different farmer types, and also targeting wider public awareness of environmental quality and food safety.
- The public agricultural extension system is a key resource for delivery of such messages, training and wider education, but also for coordination and quality control with other AKIS actors.
  - Provision of agricultural advice needs to be coordinated and consistent with an agreed nutrient management strategy for a defined farm type, cropping system and area; even if that advice is delivered via multiple public and private sector pathways.
  - Closer inter-agency working, with improved communication and data sharing at all levels, are required to develop the new ethos and overcome barriers to coordination created by functional divisions and specialisations.
  - Farmer participation and feedback should increasingly inform research and extension agendas through a 2-way dialogue and process of information exchange.
  - Planning and regulation is needed for confined animal feed operations (CAFOs) to achieve integrated livestock and crop production systems, on farms or within localities, at a catchment or sub-catchment scale.
  - Support should be given to emerging farmer associations and cooperatives, whilst leading agro-enterprises should be assisted and utilised as demonstrations of best practice for sustainable production systems.
  - Soil testing should become more accessible to farmers, with improved frequency and spatial resolution, and results better used in informing nutrient management planning and advice.
- Success in all these activities should increase farmers' trust and respect for public extension as a leading and reliable source of agricultural and environmental management advice.

The importance and focus of this briefing paper

The evidence that nutrient management is inefficient in many farming systems in China is increasingly well established. Use of synthetic fertiliser is often excessive, use of organic manures may be less than the potential or poorly accounted for, and accumulating soil nutrient stocks are often an under-exploited resource[1]. Improving efficiency of nutrient use could reduce farm costs and will reduce risks of water pollution and greenhouse gas emissions.

There are various ways through which efficiency of nutrient use can be improved. These include nutrient content analysis and accounting for fertilisers, manures and animal feeds, use of soil testing to inform locally adapted fertiliser recommendations, optimal application rates and methods, improved irrigation management, and spatial planning for integrated crop and livestock systems at a scale that ensures recycling of crop residues and manures. Delivery of these improvements requires an enabling national framework of policies and local nutrient management strategies incorporating technologies and actions well 'tailored' to farming system and catchment conditions. Foremost, however, is the need for change in the knowledge (including awareness of environmental impacts), attitudes and practices of farmers. Hence a key role exists for agricultural knowledge and innovation systems (AKIS); defined as the entire set of organizations and institutions that through services to farmers will exchange information, enhance farmer skills and enable them to co-produce knowledge and solutions[2].

AKIS in China are currently in an uncertain transition towards the more diverse, liberalised and networked systems observable in most developed economies. China's public agricultural extension system is the largest in the world in terms of staffing and number of township 'stations'[3], and still demonstrates an interventionist approach to agricultural modernisation based on national integration of public research, education and extension bodies under the Ministry of Agriculture, and a linear model of technology transfer (from scientists to the users). This presents both an obstacle and an opportunity: an obstacle if people, procedures and institutions are single focus and resistant to change, but an opportunity in terms of the human and physical capacity that exists. Hence current attempts to improve nutrient stewardship in China must focus in large part on the attitudes, scope and capabilities of the public extension service.

This briefing is informed by research[4] conducted on farmers' experience of advisory services in four case study farming systems (Figure 1). A literature review, field visits, stakeholder and expert workshops, key informant interviews and a knowledge, attitudes and practices (KAP) survey of 280 farmers were used to gather and validate information. Key findings are summarised below.

The knowledge, attitudes and practices of farmers and advisers

In all four farming systems studied farmers hold strongly risk-averse attitudes to reductions in use of synthetic fertiliser and any possibility of consequent yield reduction. In some farming systems the same applies to use of manure, although in general farmers are ill informed regarding the nutrient value of manures and how best to use them in combination with fertiliser. Over more than 35 years national priorities and policy, low market risk and reliable farm profitability, incentives for local government and productivity focused extension and technology transfer have combined to create a strong ethos of

[1] See for example, Bellarby et al., 2015, Inefficiency and Environmental Risks associated with Nutrient Use in Agriculture within China and the UK, SAIN Policy Brief 12, September, 2015.

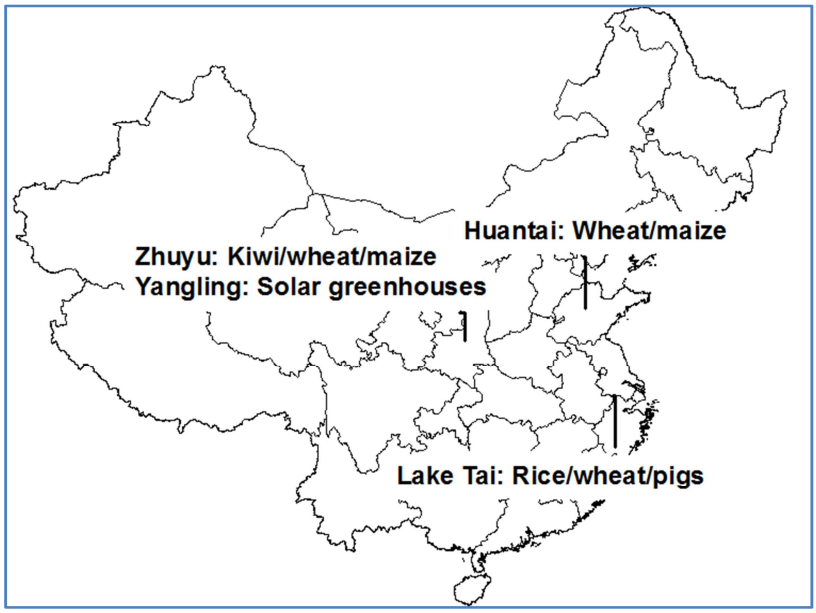
[2] EU SCAR, 2012, Agricultural knowledge and innovation systems in transition – a reflection paper, Brussels.

[3] Ruifa, H., 2012, China's agricultural innovation system: Issues and reform, in OECD, Improving Agricultural Knowledge and Innovation Systems: OECD Conference Proceedings, OECD Publishing.

[4] The China-UK Project "Knowledge, policy and practice for sustainable nutrient management and water resources protection in UK and Chinese agro-ecosystems", funded by the UK's Department for Environment, Food and Rural Affairs and by China's Ministry of Agriculture, and part of the China-UK Sustainable Agriculture Network – SAIN (see www.sainoline.org).

maximising yield amongst farmers and farm advisers[5]. In the survey a majority of farmers reported applying more fertiliser than recommended to ensure sufficiency, particularly when short of labour and/or applying less than the recommended number of individual fertiliser applications. During workshops some extension technicians admitted to being as risk averse as farmers with regard to their fertiliser recommendations.

Figure 1: Location of the case study systems in China and dominant production system in each case study.



Farmers across the areas studied are heterogeneous with respect to their potential for change in behaviour. Key determinants of this include age, level of education, labour availability relative to holding size, sensitivity to fertiliser cost, openness to new sources of information and the progress of land transfer in the area. However, perceptions and understanding of the environmental impacts of nutrient losses were almost universally weak with the exception of some farmers in areas bordering Lake Tai.

Other influences on fertiliser use

Farmers in the arable systems surveyed (Lake Tai and Huantai; Figure 1) considered the cost of fertiliser to be a more significant influence in their decision making than those in the higher value horticultural systems (Zhuyu and Yangling) who are particular responsive to output prices and yields. Arable farmers were also more likely to indicate that labour availability is a constraint to following recommendations for multiple fertiliser applications and use of manure. Horticultural producers were more likely to be influenced by the recommendations of fertiliser companies and information printed on fertiliser packaging; whereas arable farmers indicated greater responsiveness to leaflets produced by local extension technicians and guidance from TV programmes. There is no single means of communication that is obviously superior to others, but there is evidence that farmers respond well to demonstration sites and adoption practices of neighbours[6].

Farmer training in fertiliser use

Over 90% of the farmers surveyed were 40 years old and above; and hence standards of education were generally low. Less than 40% had participated in training provided by the public extension service, and of those trained the majority had received less than 5 hours of training. Participation in training was least

[5] Smith, L. and Siciliano, G., 2015, A comprehensive review of constraints to improved management of fertilizers in China and mitigation of diffuse water pollution from agriculture, Agric. Ecosyst. Environ, 209, p15-25.
[6] From workshops, and see for example Huang, J. et al., 2015, Long-term reduction of nitrogen fertilizer use through knowledge training in rice production in China, Agricultural Systems 135, p.105–111.

common for the sample of solar greenhouse producers; the most intensive of the four systems. Direct training of small-scale farmers remains the predominant practice for Zhuyu and Yangling. In the Lake Tai and Huantai areas land transfer and consolidation has progressed further, and training is usually provided to the managers of leading agro-enterprises and larger farms rather than small-scale independent farmers. Training is normally provided pre-season and tends to focus on input use for yield maximisation, rather than whole system optimisation and mitigation of environmental risks.

Use of soil testing

Less than 30% of farmers surveyed reported having had tests for their soil. Soil testing was more common amongst larger scale arable farmers and solar greenhouse producers. Such testing was infrequent. The majority of farmers reported that they were unaware of how to get information on soil testing. The public extension service in each area does make crop specific fertilizer use recommendations based on regional average soil test results, and appropriate compound fertilizer formulations are then produced by participating fertilizer manufacturers. It is typical that only one or two such formulations are made at the scale of a county, and only for the predominant crops. This may be a factor influencing the degree to which farmers have trust in such recommendations and formulations.

Farmer knowledge about soil testing and its potential benefits is relatively strong and clearly there is scope to improve soil testing in terms of frequency, spatial resolution and accessibility to farmers. Test results are only valuable, however, if used to improve advice given, nutrient stewardship by farmers and fertiliser compounds available. Soil testing by the public extension service remains infeasible for all individual plots or even farms given the number of farms in China, but assessment must be made of the implications of the process of land transfer which is creating larger scale farm businesses, and of the services that could be provided by private sector and supply chain, or farmer and community-based organisations. There is a need for targeting of soil testing resources where they can be most effective for both resource use efficiency and environmental protection.

Public agricultural extension: orientation, structures and performance

Our survey showed that for the majority of farmers in all four areas, neighbours and relatives are preferred as a source of guidance for fertiliser use. Thus most farmers have more trust in, and certainly better communication with, neighbours and relatives than township and village level extension technicians.

For the study sites the public agricultural extension system is relatively well resourced but its priorities, ethos, organisation and activities need assessment and evolution. Training and recommendations typically focus on technology adoption and agronomy, as resource use efficiency and environmental protection tend to remain low on the political agenda at local level, even if prioritised more recently at higher levels of government[7]. There also remains a strongly hierarchical structure, with authority and prioritisation of actions linked to the continued production and growth ethos in both the extension service and local government.

Technology stations' exist at township, county and city/district levels and trained technicians are employed at township and village level. Township stations are usually integrated and holistic in their coverage of local production systems, but above this functional specialisation and sub-sector divisions remain the norm. The system is capable of disseminating information, but there is little indication that feedback from lower levels can influence research and advice agendas. Farmers are thus passive recipients of technology recommendations, with little formalized opportunity to feedback their priorities and needs. Inevitably gaps

[7] Smith and Siciliano, *op. cit.*

in communication arise. Farmers want answers to their specific problems but find that advice provision that must cater for large numbers and areas can be lacking in detail and relevance. Within the extension service knowledge and skills for modern communication techniques may also often be lacking.

Universities and other research institutes also engage in technology development and transfer in agriculture. Clearly this is not universal in coverage but does apply in many farming areas. In our four case study sites university researchers and advisors were trusted and well received by farmers, but success in changing farm practices varies and remains challenging given the risk averse attitudes and labour constraints of small farmers. Many farmers also receive advice from private fertiliser companies, farmer associations, larger agro-enterprises and other produce buyers. This diversity will only continue to expand and needs to be utilised to good effect. Yet, currently it leads to the concern that messages received by farmers are diverse and lacking in coordination and scientific validity. At a local level coordinated efforts to develop a coherent nutrient management strategy and policies to improve nutrient use efficiency by farmers are generally lacking, and the public extension service must take a lead in this in partnership with universities and research institutes.

The challenges and opportunities of land transfer.

Small and fragmented farm holdings remain an underlying cause of many nutrient management problems by impeding scale production and technology adoption including mechanisation. Land consolidation into larger enterprises, encouraged by national policy, is proceeding rapidly through a range of rental and management transfer arrangements and through vertical coordination of supply chains by agro-enterprises[8]. Among our survey sites, in the Lake Tai area farmers most strongly expressed the ambition to leave farming and rent out their land to a larger producer. This area is characteristic of rice farming in the most developed regions of China, and among our sites is where farm consolidation has progressed furthest to date. Next for progress of both farm consolidation and strength of ambition to leave farming is the Huantai area, which is characteristic of the north China plain. Farm consolidation and the ambition to leave farming are present, but least evident in comparison, for the high value field and protected horticulture producers of Zhuyu and Yangling respectively; here financial incentives to remain in farming are stronger.

Concentrating nutrient management in larger-scale farms will facilitate adoption of best management practices, investment in manure management systems, and provision of extension advice, training and monitoring of adherence to guidelines and regulations. Mechanisation can address scarcities of agricultural labour that contribute to deficiencies in management of farm inputs. Although less developed in most areas there is also potential for farmer cooperatives to engage in horizontal coordination for scaling up input use, production and marketing, training and information dissemination.

Key responses and extension messages

A concerted effort is needed to counter the entrenched risk averse attitude of farmers and advisers with regard to use of synthetic fertilisers. The cost of fertiliser to farmers in China is relatively cheap by international standards but not an insignificant proportion of farm costs. Extension messages must holistically address farms as businesses, and address resource use efficiency, profit maximisation and environmental protection alongside the goal of high productivity. An important aspect of this is information provision on the nutrient value of manure and how best to integrate its use alongside synthetic fertiliser as part of nutrient management plans. Farmers respond to the demonstration effect of peers and neighbours, and more use should be made of farm-scale demonstration sites.

[8] Smith and Siciliano, *op. cit.*

In addition to the bio-physical characteristics of areas and production systems, advice, training and demonstrations should be differentiated for the objectives and characteristics of farming families and companies. Farming in China now spans from residual household 'backyard' plots to large modernised enterprises. Apart from the latter, farms remain too numerous in China to be targeted individually but categorisation and typologies should increasingly be informing local nutrient management strategies developed by the extension service. A diversity of communication and training methods are needed and the extension service should seek to work in partnership with emerging intermediary organisations that engage successfully with farmers. These include fertiliser companies, farmer associations, agro-enterprises and other actors in consumer supply chains. Through such partnerships a strategy also needs to be developed to expand and improve farmer access to, and use of, soil testing.

In conclusion

Perhaps of necessity in such a large, populous and diverse country the administrative structure relating to public agricultural extension is complex and hierarchical, slow to change and possessed of authority and prioritisation focused on a historic national ethos for production and growth. As a consequence an apparent 'conflict' has arisen to date between incentives for local officials and farmers to maintain and increase food output and the environmental damage that intensive agriculture has caused. To resolve this new approaches are needed that rebalance the importance of productivity with sustainable stewardship of farm inputs and natural resources. With regard to synthetic fertiliser use, this ought to be relatively easy, at least at first, as much scientific research shows that fertiliser use can be reduced without yield loss in the most intensive farming systems. Obstacles to achieving this are the current knowledge, attitudes and labour constraints of small farmers, and the knowledge, attitudes and incentives of managers of larger and modernising farms. The public agricultural extension service must target these obstacles by guiding research agendas and leading technology transfer and communication that seek to achieve resource use efficiency and environmental protection by farmers without reduction in yield and production.

Change in extension approach must take account of the rapid progress of land transfer and the growing diversity of farm types and scale. Also the similarly growing diversity of technology and advice provision by agro-enterprises, input suppliers, supply chains and producer organisations; noting that these are first driven by profit motives that may override concern for resource use efficiency and sustainability.

It is thus time to see the planning and implementation of local nutrient management strategies well matched to local farming systems, farm characteristics and catchment conditions as 'public goods' to be produced by the public extension system in partnership with universities and research institutes and local government. Such strategies will incorporate generation and dissemination of farm technologies and best management practices, and action plans for training and communication designed to meet the needs of differing farm scales and farmer types; and to raise wider public awareness.

Currently the functional divisions at higher administrative levels may indicate that organisational structures for extension are poorly equipped to meet the needs for integrated and holistic assessment of needs at farming system and catchment or landscape scale, comprehensive design of measures and coordinated implementation. This must be addressed by higher level leadership and where necessary re-structuring. At township and village level, functions and approaches are more integrated and despite limitations in terms of human and technical capacity, there is scope for the emergence of approaches capable of balancing agricultural production and environmental quality.