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SAIN's Contribution to Evidence Based Policy Development[1]

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The assessment of SAIN's contribution as with any other initiative to support national or international research is not straight forward because of the multiple forces affecting agricultural policy development and implementation. These forces go beyond the impact of the research and the knowledge sharing and mutual learning promoted by SAIN. In particular they include the economic policies which strongly influence the design of technological and management innovations for sustainable agriculture and their appropriateness to the physical and economic situation of farms of all sizes.

The contribution to policy development can be examined from several perspectives, and with varying levels of uncertainty because of the numerous other research initiatives with related objectives. SAIN's research budget of less than £4 million for 2008-2016 is very small compared with China's total public agricultural R&D budget of more than £10 billion for the same period. Moreover, any evaluation of SAIN's 11 projects has to be in the context of the hundreds of research projects funded by MOA, MOST, and the NSFC each year and implemented by CAS, CAAS, CAAE and numerous universities. Nonetheless, SAIN and its projects have had an above average impact in terms of the number and profile of its publications, its support to the up-grading of research techniques in China, and in the sharing of policy experience.

This policy brief focuses on four particular perspectives: impact of the research programme in terms of the original objectives of SAIN when it was set up in 2008; development of sustainable agriculture policies in China; evolution of Defra collaboration with China since 2008; the future role of SAIN.

Impact of the SAIN's support to evidence based policy development

The original objectives of SAIN are given in the Defra/MOA agreement of November 2008. They were to foster collaboration and innovation in three areas:

(i) Creation of improved institutional mechanisms for collaborative research to:
- Facilitate joint research and the exchange of policy expertise and research findings between leading UK and Chinese individuals and institutions active in the field of agricultural and environmental sustainability.
- Increase S&T research in support of new areas of policy formulation such as renewable energy, biotechnology and the circular economy.

(ii) Development and adoption of new policy approaches by :
- Expanding capacity building for better policy making, interdisciplinary research, communication and application of appropriate technologies
- Providing advice to policy makers on the risks of current development paths and the benefits of alternative paths

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(iii) Translating policy and science in to practice on the ground by:

- Fostering a better understanding of how to translate research into practice by farmers
- Supporting farmers, farmers associations and agro-industrial enterprises in the adoption of sound agricultural practices

Over the past 8 years SAIN has made a positive contribution to each of these areas.

Creation of improved institutional mechanisms for collaborative research

Four actions have been of particular importance to this objective. First, priority setting by SAIN's Governing Board ensured that the research programme was focused on areas of common interest to both countries. Their decisions were strengthened by the requirement that all of the Working Groups established to address the agreed priority areas should first conduct gap analysis to identify the key research tasks for policy development. Consequently all of SAIN's projects (Box 1) were designed and selected on the basis of gap analysis that took account of the priorities of China's 11th (2006-2010) and 12th Five Year Plan (2011-2015) and have proved to be equally relevant to the 13th Five Year Plan.

Second, members of the working groups and research project teams were selected to promote inter-disciplinary collaboration, and especially the involvement of socio-economists as discussed in the next section.

Third, finalization of the research programmes and subsequent discussions of results and their policy implications were achieved through international, national and local workshops involving farmers and farmers associations. Such activities enabled SAIN to develop links at all levels of the Chinese Government and the research community (Box 2).

Fourth, links were maintained between projects through cross-representation of team members and regular communications about project progress and planned activities.

Box 1 SAIN's Joint Research Projects

- Improved Nutrient Management in Agriculture - a Key to the Low Carbon Economy April 2009 – March 2012
- A review of Manure Use in China (MUC) March 2010- September 2011
- ADMIT: Harmonising Adaptation and MITigation for agriculture and water in China April 2010 – March 2012
- Estimates of future agricultural greenhouse gas (GHG) emissions and mitigation in China April 2010 – March 2013
- Conservation for enhanced utilization of crop wild relative diversity for sustainable development and climate change mitigation April 2010 – March 2013
- Addressing vulnerabilities and building capacity for adaptation of agriculture to climate change in China April 2010 – March 2013
- Developing a catchment management template to mitigate nonpoint source pollution in China January 2011 – March 2011
- The future of food and farming - Foresight Report's implications for China
- September 2011 – December 2011
- Suitability of bio-char in China and sub-Saharan Africa: biophysical and socio-economic "fit" April 2012 – September 2014
- Collaborative research on the role of trade between the UK and China in supporting innovation for the sustainable intensification of agriculture and the food chain in both countries May 2014 – August 2015
- Knowledge, policy and practice for sustainable nutrient management and water resources protection in UK and Chinese agro-ecosystems April 2013 – March 2016

Box 2 SAIN's links at all levels of the Chinese Government and research community

Central government: MOA, National Development and Reform Commission (NDRC) and Ministry of Environmental Protection (MEP)

Central government institutions: Development Research Centre of the State Council

Ministry departments and institutions: MOA's Agro-Environmental Institute, Tianjin

Provincial and Municipal governments: Anhui, Beijing, Hunan, Inner Mongolia, Jiangsu, Jilin, Shaanxi & Shangdong

Chinese Academies of Agricultural Sciences, of Sciences, Agricultural Engineering and Social Science and their institutions and research stations

Provincial Academies of Agricultural Science: Guangdong, Hebei, Heilongjiang & Jiangsu

China Agricultural University, Peking University, Northwest Agriculture and Forestry University, Nanjing Agriculture University, Nanjing Forestry University, Nanjing Normal University & Universities of Fudan, Hebei, Jilin, and Zheijiang

Development and adoption of new policy approaches

The actions on this objective have been centred on four activities.

First, on capacity building, the introduction or strengthening of new analytical techniques such as life cycle analysis (LCA) and marginal cost benefit analysis. The former, for example, highlighted the importance of GHG emissions from nitrogen fertilizer production (and the policy distortions arising from energy subsidies) and manure mismanagement. The early SAIN research in these areas summarized in Policy Brief 1 appears to have stimulated the Government of China (GOC) to give greater priority to the estimation and reduction of agriculture's direct and indirect GHG emissions. The 2005 submission to the FCCC paid little attention to the emissions from N fertilizer production and had gave relatively low estimates for livestock related emissions. More recent official estimates of these emissions are much higher.

Second, the promotion of greater inter- disciplinary collaboration, and particularly the involvement of socio-economists in SAIN projects, which previously had been the exception rather than the norm in earlier projects.

Third, the selection and design of projects that had clear policy development as well as technological objectives. All of the SAIN projects have a policy development component (Box 1).

Fourth, the findings of SAIN projects have been communicated to senior decision makers and policy developers through a series of short policy briefs that examine the relevant issues, identify technology and policy options and in some cases suggest policy priorities (Box 3). These have all been posted on the SAIN website, distributed directly to relevant parties by the Secretariats and well received. It is difficult to assess the impact of these policy briefs but it is clear that they have at least reached GOC officials at the highest level. For example, in the case of Policy Brief 1 *Improved Nutrient Management in Agriculture – A Neglected Opportunity for China's Low Carbon Growth Path* our Chinese colleagues prepared a version in Mandarin that went to the General Office of the State Council and the CPC Central Committee, was noted by national leaders and passed to some ministries for policy consideration. Moreover, it is clear that the project outputs as laid out in the policy briefs relate very closely the GOC decisions laid out in the 13th Five Year Plan and related documents, for example, the zero increase policy for nitrogen fertilizers and pesticides. Some of these relationships are shown in Table 1 for the National Sustainable Agriculture Development Plan for 2015-2030.

Translating policy and science in to practice

It is worth stressing three particular contributions to this objective. First, the emphasis that SAIN has placed on improving basic information on key factors affecting the choice of interventions. For example, on the source of different nitrogen (N) inputs to crop growth (notably crop residues, irrigation water and atmospheric deposition) and the N content of manures. Knowledge on these inputs is vital to the correct estimation of how much synthetic N farmers need to apply. Second, by fostering the involvement of socio-economists in SAIN projects as discussed above. Their

involvement is critically important to determine the variation in profitability of different technological inputs and management practices according to farm size, and for the correct identification of farmer's needs and response options. Thirdly, the communication of research results in a form appropriate for senior officials. The main vehicle for this is the policy briefs described in the previous section and listed in Box 3.

Table 1 Five key tasks set by the National Sustainable Development Plan for 2015 to 2030 for promoting sustainable agricultural development.

Key Task	**Examples of supporting evidence or response options given in SAIN Policy Briefs**
Optimize development and enhance agricultural productivity	Policy Brief 5 demonstrated the breadth of the technogical and policy responses needed to fulfill this task, involving new extension messages and how to communicate them; small scale mechanization; new technologies; changes in subsidies etc.
Protect arable land resources and promote the sustainable utilization of farmland.	Critical actions for this task concern climate change mitigation and adaptation. This is a cross-cutting feature for almost all of the SAIN policy briefs, and addressed comprehensively in briefs 8, 9 & 10. The need to address the problem of soil acidification has been highlighted as a likely cause of "hidden yield loss".
Use water efficiently and ensure the safety of agricultural water.	Policy Brief 3 highlighted for the first time that energy use for irrigation water was a significant proportion of GHG emissions. It pointed the need for integrated water, energy and environmental policies.
Curb environmental pollution and improve the agricultural and rural environment	Policy Brief 6 shows that in the light of UK and EU experience it is important that China adopts a more holistic approach to improved manure nutrient management and to include the following: • Retaining nutrients through the manure management continuum • Using an integrated nutrient recommendation system • Generating knowledge of the nutrient content and nutrient availability of manure, compost and digestate • Ensuring CAFOs have manure nutrient management plans for utilisation in the local area (planning regulations) • Encouraging and incentivising improvements in other infrastructure, e.g. to facilitate mechanised transportation and spreading of manure. Another very important action is on non-point source pollution and Policy briefs 12, 13 & 14 make a number of recommendations based on the UK's extensive experience on this problem.
Restore the agricultural ecology, enhance ecological functions, protect the grassland ecosystem and biological diversity and restore the aquatic ecosystem	Policy Brief 4 from the CWR China project provided some of the baseline data needed to inform future CWR conservation and use policy in China. It supplied information on which species of economic importance currently exist in China and which of these should receive highest priority It proposed the establishment of new genetic reserves for CWR conservation.

Box 3 SAIN's Policy Briefs

No. 1 (2010, updated 2011). Improved Nutrient Management in Agriculture – A Neglected Opportunity for China's Low Carbon Growth Path

No. 2 (2010). Greater food security and a better environment through improved nitrogen fertilizer management

No. 3 (2011). Greenhouse-gas emissions from energy use in the water sector

No. 4 (2011). The importance of China's crop wild relatives for the future of food and farming

No. 5 (2012). Policies and technologies to overcome excessive and inefficient use of nitrogen fertilizer: delivering multiple benefits

No. 6 (2012). Improving manure nutrient management towards sustainable intensification in China

No. 7 (2013). How do farmers respond to climate change risk?

No. 8 (2013). Economic Potential of Greenhouse Gas Mitigation Measures in Chinese Agriculture

No. 9 (2013). Technical options to reduce greenhouse gas emissions from croplands and grasslands in China

No. 10 (2013). Technical options for reducing enteric methane emissions from livestock production

No. 11 (2014). The status and suggestion of fertilization

No. 12 (2015). Inefficiency and environmental risks associated with nutrient use in agriculture within China and the UK

No. 13 (2015). Delivering improved nutrient stewardship in China: the knowledge, attitudes and practices of farmers and advisers

No. 14 (2016). Mitigation of diffuse water pollution from agriculture in England and China, and the scope for policy transfer

No. 15 (2017). Enhancing UK China Knowledge Sharing and Mutual Learning in Agriculture, Food and Environment

Development of sustainable agriculture policies in China

Many of the research challenges addressed by SAIN require policy actions that the UK faced in the past or continues to face and so provide opportunities for knowledge sharing and mutual learning (KSML). They have been the focus of much of the collaborative research, for example, that on non-point source pollution, catchment management and manure management, and the reason for many of the staff exchanges, and training programmes.

The most tangible contributions to policy development by SAIN are the 90 or so papers in leading international and Chinese journals, two book chapters and 15 policy briefs. They all provide new evidence for improved policy approaches and/or the technical and institutional means for implementing them.

Less tangible but equally important are SAIN's contribution to capacity building, research techniques, policy development, productivity improvements and socio-economic and welfare benefits. Assessment of SAIN's contribution to the above as in most cases of impact analysis is confounded by the multiplicity of stakeholders involved in any technology or policy shift. As regards capacity building the contribution can partially be measured in terms of the number of study tours and staff exchanges, although the impacts are wider than these activities, and commonly relate to the following contribution. In some cases SAIN's impact on research has been institutional, and in particular the growing acceptance by Chinese agronomists and other bio-physical specialists that their research commonly needs to be conducted in association with socio-economists if their output is to be appropriate to farmers objectives and requirements. At a more concrete level there is the stimulus that SAIN projects have made to the use of important analytical tools such as Life Cycle Analysis and Marginal Abatement Cost Assessment as well as other specific research techniques. Moving on to SAIN's contribution to the sharing of policy experience and the development of policy options

regarding sustainable agricultural intensification it is appropriate to stress two aspects. First, many of the joint SAIN workshops in China attended by senior officials from MOA, MOST, Ministry of Water (MOW) and NDRC have included presentations by UK delegates that related the UK policy experience to the agricultural and environmental challenges facing China. Second, nearly all of the SAIN projects (Box 1) have had a policy development component.

Evolution of Defra/UK research collaboration with China since 2008

In the space of 8 years SAIN has forged strong links at all levels of government and across the whole agricultural research community (Box 1).

SAIN has progressively built up a wide network of research collaborators. In 2008 UK-China agricultural research collaboration was centred largely on Rothamsted Research, the Centre for Ecology and Hydrology (CEH), and the universities of Aberdeen, East Anglia, Edinburgh, Lancaster and London (UCL). It is now much wider. A similar change has occurred in China. In 2008 much of the research collaboration was with universities and institutions in Beijing and Nanjing, whereas now the UK's research partners are now located in over 20 more cities and counties. Furthermore, it can be argued that without this wider network it would have been much more difficult to launch the recent substantial expansion of RCUK collaboration with China supported by the Newton Fund, e.g. the two Virtual Joint Centres on Nitrogen. And SAIN has taken research collaboration beyond the academic sector to involve the commercial sector in knowledge sharing regarding the setting of research priorities, the tools to be used and the communication of results to farmers. Companies that have been involved include ABAgri (particularly British Sugar), Unilever, the Cereals, Oils and Foodstuffs Corporation (COFCO) which is the largest agricultural trading company in China, and SinoChem which is China's largest fertilizer manufacturer.

Looking Forward

SAIN remains a unique mechanism for China's international collaboration on sustainable agricultural innovation. Australia and Israel have had a strong input relating to irrigation and dryland agriculture. Germany has a long history of joint research with Chinese universities and research institutions on nitrogen management. The EU has supported collaboration since the early 1990s (largely with the Chinese Academy of Sciences and through the Framework Programme) and with notable successes regarding avian diseases, but this has declined in recent years. The USDA produces some excellent desk studies on various aspects of China's agriculture, but these are produced largely in house rather than through joint research. None of the foregoing equal the breadth of SAIN's collaboration nor probably its impact on China's agricultural policy.

However the current situation for UK-China collaboration of sustainable innovation is dramatically different from 2008 when SAIN was established. The level of funding, range of research topics and partners has increased considerably and so SAIN's past role as catalyst and funder of R&D is no longer as important. What should be its future role? The primary mechanism for fulfilling the objectives of the 2015 Defra-MoA MOU on collaboration? A facilitator for knowledge sharing and mutual learning? A policy support mechanism for programmes and projects led primarily by technologists rather socio-economists skilled in policy formulation? A resource centre to support and add value to the Newton Fund programme? A programme management centre for UK-China collaboration on sustainable intensification? Any one of these roles would be of value in facilitating and assisting collaborative efforts between UK and China on sustainable agriculture and the necessary policy frameworks. But the maximum benefit would be derived from combining several of these roles. The options are numerous but the next step must be chosen with care if UK-China objectives are to be achieved.