Global TraPs
Global Transdisciplinary Process For Sustainable Phosphorus Management (2010-2015)
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Orientations for the Second Half of the Global TraPs Project

An address by the practice leader, Amit Roy, and the science leader, Roland Scholz

Where we are

The Global TraPs project formally began on February 06, 2011, as a five-year transdisciplinary project targeting sustainable phosphorous management solutions. The First Global TraPs World Conference that took place in June 2013 and the comprehensive Springer book, *Sustainable Phosphorous Management, a Global Transdisciplinary Roadmap*, are the main products of the first phase. We will use this midpoint in the project to address what has and has not been achieved, and what aspects will be focuses going forward.

The Global TraPs project has high aspirations. It is the first global transdisciplinary process (with co-leadership between science and practice at all levels of the project) on resources management. The project was launched with the final objective being to develop consensus policy options reflective of all stakeholders' experiences and knowledge following a thorough system analysis and mutual learning process. This process was designed to enable all engaged stakeholders to contribute to the formulation of policy options that would result in efficient and sustainable phosphorus use.

The goals of the project are conveyed in the guiding question of the Global TraPs project.

Guiding Question
"What *new knowledge,* technologies and policy options are needed to ensure that future phosphorus use is sustainable, improves food security and environmental quality and provides benefits for the poor?"

In our opinion, this question captures all key domains that must be addressed to ensure an equitable and sustainable transitioning of phosphorus management.

From some perspectives, knowledge is still missing

The idea of transdisciplinary processes to sustainable transitioning is based on mutual learning among scientists and practitioners of the specific system to be transformed. In Global TraPs, the system under review is the global phosphorus cycle. In order to better understand the cycle, the project includes representatives of all key stakeholders involved along the supply-demand chain (see Figure 2).

This approach has functioned well in the first phase of the project. For instance, in the Exploration and Mining nodes of the supply-demand chain, various national geological surveys are contributing, as well as mining companies and fertilizer producers. However, some important countries of the world are underrepresented or not yet sufficiently involved in the process.

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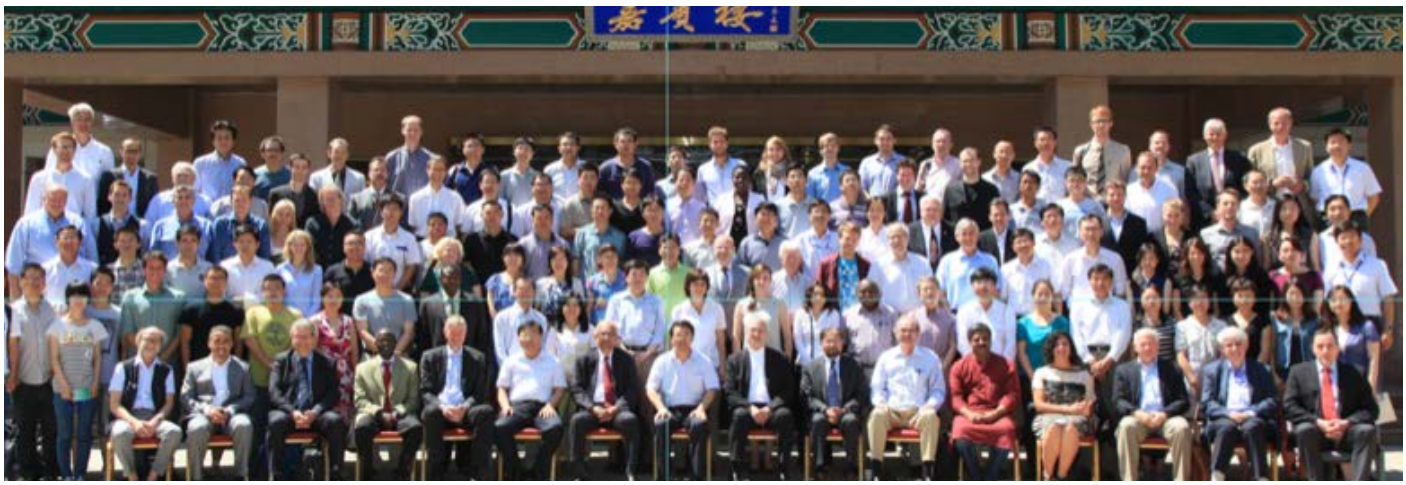

Fig. 1: The 1st Global TraPs World conference was held from June 18-21, 2013, in Beijing at the China Agricultural University. This conference was a collaborative effort of the UNEP Global Partnership on Nutrient Management (GPNM) and run under the heading "Learning from Cases – Exploring Policy Options to Ensure Food Security and Environment Sustainability."

Orientations for the Second Half of the Global TraPs Project *(continued from page 1)*

Thus, for example, mining companies from Russia and China are missing, as are some farmer organizations, such as from Latin America. We also see some gaps regarding university participation. This is due to the fact that certain subjects such as the innovation of fertilizers is missing in public research institutes if we go beyond the level of agricultural departments.

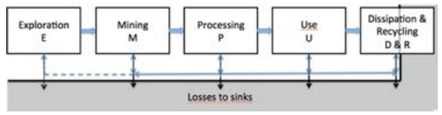

Fig. 2: Global TraPs analyses the anthropogenic phosphorus flows along the supply-demand chain. Five nodes (E, M, P, U, D&R) and the overarching Trade and Finance Node build the conceptual and organizational grid. For environmental evaluation, the anthropogenic flows must be related to the natural flow.

Review of project progress and achievements

The discussion, learning and work process of Global TraPs was well organized around the themes of the first four workshops. The 1st Workshop convened under the theme, *Building Partnership and Co-leadership*. Several scientists from various universities and representatives of IFDC and IFA comprised the startup team.

The 2nd Workshop focused on *Consenting the Guiding Question*. The guiding question for the Global TraPs project was the product of this workshop after broad consultation among the workshop participants.

Workshop 3 was dedicated to Identifying *Critical Questions* and knowledge gaps within each node on what may be wrong with current phosphorus use. The discussion of these critical questions resulted in identification of priority case studies, which will allow for better understanding of the complexity and the different context in which certain problems are embedded. Examples of case studies include water management at phosphorus mines, improving efficiencies in mining phosphate rock and environmental issues associated with the over or underuse of phosphorus fertilizers by smallholder farmers.

The 4th workshop in El Jadida, Morocco, was dedicated to the topic, *Defining Case Studies - Setting Priorities*. Here, participants' discussions of the first drafts of chapters 2-7 of the Springer book were viewed as a first highlight of the Global TraPs project. After this workshop, the steering board identified and launched a set of case studies in preparation for the 1st Global TraPs World Conference in Beijing, June 18-20, 2013. This conference was centered on the theme, *Learning From Case Studies - Exploring Policy Options*.

Developing policy options for all key stakeholders is the challenge

Looking back at the 1st World Conference, we acknowledge that the policy options-related goal could not be fully achieved. However, the conference provided a comprehensive view of the global phosphorus cycle. Various speakers from academia and practice identified current concerns and suggested policy options to overcome these flaws (Fig. 3). Another important outcome of the 1st World Conference was the joint meeting with the UNEP Global Partnership for Nutrient Management (GPNM) on the second and third days. These days of the conference were devoted to issues related to the production and use of nitrogen and phosphorus fertilizers, along with the need for balanced fertilization in sustainable agriculture. As one can see from the extensive report on the Beijing conference by Christopher Thornton (member of the Global TraPs steering board), in the Scope Newsletter 97 (http://www.ceep-phosphates.org/Files/ Newsletter/ScopeNewsletter97.pdf), conference participants identified a long list of critical points and deficits of phosphous and nitrogen management.

Fig. 3: Xuefeng Ziu, executive vice president of the China Phosphate Industry Association, provides information about China's phosphorus situation.

A challenge for the coming years will be to identify policy options not only for governmental actors but also for mining and fertilizer companies, traders, farmers and farming organizations and the food industry, which may contribute to sustainable phosphorus use.

Last but not least, we should report on the first day of the 1st Global TraPs World Conference. On this day, nine Mutual Learning Sessions (MLS) and five Dialogue Sessions (DS) took place. Some of the Mutual Learning Sessions were held at plants, farms or factories in the vicinity of Beijing and included local key stakeholders.

Based on the MLS and DS and two days of presentations, panel dialogues and intense discussions on a broad and in-depth view could be developed on critical questions linked to sustainable nutrient management, and phosphorus management in particular. You may find the slides of the contributions on the Global TraPs website (http://www.globaltraps.ch/ beijing-conference-presentations.html).

Based on this and follow-up discussions with the steering board, seven focus areas were identified for in-depth study during the second half of Global TraPs. As the project considers these focus areas, stakeholders will continue to reflect on whether all of the important issues have been identified and which issues require more attention.

Conference reports:
Summary reports on the conference have been provided in the IFDC report volume 38 no. 3, page 32-36 (http://www.ifdc.org/getattachment/ Publications/IFDC_Reports/2013IFDCreport_Vol38No3FINAL_webRev.pdf/). Further, you may find a report on the key messages of all lectures in Scope 97 (http://www.ceep-phosphates.org/Files/Newsletter/ScopeNewsletter97.pdf), written by Chris Thornton. The reader is requested to review these documents or the slides of all presentations, which are available on the Global TraPs website

The Mutual Learning Sessions (MLS) and Dialogue Session (DS) of the 1st Global TraPs World Conference, Beijing, 2013, from the Perspective of Master and PhD Students Moritz Engbers, Rina Marie Maas-Deipenbrock and Philip Luthardt

For students in environmental and sustainability science, there is much interest in how research can be properly conducted when addressing pressing environmental or sustainability problems. Sustainable phosphorus management is an ideal but complex case that deals with resource management of an essential, limited resource, i.e., phosphate rock. A group of 15 MSc and PhD students from the Universities of Luneburg, Oldenburg, Augsburg (Germany) and Birmingham (UK) had the opportunity to be part of the Knowledge Integration Unit (KIU) of the Global TraPs project. They supported the organization, preparation and implementation of the MLS and DS for the Beijing Conference. To experience transdisciplinary processes at an international level proved to be a highly interesting and challenging endeavor for all participating students.

Fig. 1: Twelve MSc and PhD students from the Universities of Leuphana (Lüneburg), Oldenburg and Augburg (all in Germany) and the University of Bimingham (UK), together with Anh Pallas (Science Manager, Global TraPs), prepared nine Mutual Leaning Sessions and five Dialogues sessions.

On the first day of the conference the MLS and DS were held, followed by two days of plenary presentations for the International Nutrient Management World Conference that was jointly organized by GPNM and Global TraPs. The MLS and DS were implemented through small groups, which facilitated intense and interactive discussions that provided further insight to day two and day three presentations and plenary discussions on nutrient management.

Particularly interesting, from the students' perspective, was the coordination of international teams responsible for the various MLS and DS during the preparation phase and in the course of the workshops. Some students had the chance to moderate, co-moderate or even act as a case scientist of the session in which they were involved.

It was particularly exciting for the students to see how practitioners and scientists brought their perspectives into the process, and how these influenced the outcome of the different sessions.

As a member of the KIU Support Team, Moritz Engbers was responsible for the preparation and organization of the MLS 1.1 that dealt with the issue of phosphate use and recycling in concentrated animal production operations. He supported the preparation process of the MLS and shared his view of the process:

"A group of participants, among them Dr. Arno Roelcke and Lisa Heimann from the University of Braunschweig, Prof. Xuejun Lin, Dr. Quing Chen and Wang Guangzhou from CAU Beijing, Roxana Medozy Huaitalla, University of Hohenheim and Professor Schuchardt from von Thünen Institute Braunschweig and Professor Scholz of Fraunhofer IWKS, characterized the case in a booklet that was fundamental for the discussions.

"The discursive process for producing the booklet was very intense. Several views from international experts as well as the knowledge of case experts who were literate on the specific local conditions of the case had to be integrated.

"In Beijing, one of the MLS was held on a pilot pig farm in the Shunyi District. It was interesting to 'case encounter,' where we

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The Mutual Learning Sessions (MLS) and Dialogue Session (DS) of the 1st Global TraPs World Conference, Beijing, 2013 *(continued from page 3)*

got an overview on the operation of the livestock farms and an opportunity to discuss, directly with the farmers, issues related to the use of the significant amounts of manure produced. Even though the time was too short to discuss some aspects in more detail, we developed ideas on how to use manure in a more sustainable way.

"Many participants noted that it was particularly interesting to see the case first hand before discussing its facets and outlook in more detail. The preparation of the MLS booklet was crucial for the session since it brought together the different perspectives of participants. But to find a common understanding and to develop solutions is still a great challenge. Nonetheless, the MLS contributed, among other insights to understanding that spatial planning has a huge effect on the recycling of phosphorus and its use efficiency. Thus, we were able to learn from the 'actual' case and to better understand the role of phosphorus on a global level."

Fig. 2: Franz Ecker, MSc student of Environmental Management, University of Lüneburg, introduces the principles of communication in MLS and DS.

The MLS 2.1 Vietnam and MLS 2.2 Kenya, regarding the overuse and underuse of fertilizer by smallholder farmers, were merged. The thematic relation of the two cases allowed a comparative discussion and fostered mutual learning within the group. While in Vietnam fertilizer is often overused resulting in environmental problems. In Kenya, fertilizers are underused, resulting in soil nutrient mining, land degradation and declining crop yields. Prior to the session, underuse of fertilizers was primarily attributed to cost.

As a result of the discussions, it was noted that fertilizer costs aren't the only factor influencing use in both Vietnam and Kenya. The discussions highlighted that we should not only focus on fertilizers, but take related components (i.e., management practices) into account as well. These insights rose from the information exchange and mutual learning of the different participants. In this particular case, it was especially interesting to see people who were not involved in preparation of the case booklet engage in the discussions, thereby giving a new perspective.

Fig. 3: Forty farmers and practitioners from China and other countries and Chinese and international scientists spent one day in the Mutual Learning Session 1.2 Vegetable: Innovations on phosphorus management in Changping vegetable base (see text).

Conclusively, the MLS launched an innovative and valuable exchange, but there were several lessons learned. For example, follow-up measures are very much needed in order to effectively use the gained insights and to further investigate generated ideas. Also, for a more elaborated exchange, allowing sufficient time will be crucial. Finally, future activities should involve more people in the preparation process to increase the efficiency of such formats. Having a special day with MLS and DS with more than 100 international participants, including 43 practitioners from more than 16 countries and 69 scientists from over 11 countries, contributed to the students' perception that the first Global TraPs World Conference was a great experience."

Policy Orientations of MLS 1.1

Each of the MLS had to formulate a policy orientation which captured the most important conclusions and findings of the mutual learning process. The policy orientation of MLS 1.1 reads:

"There is an increasing need for manure management because of the increasing numbers of CAFOs (Concentrated Animal Feeding Operations) in China. This calls for a re-coupling of animal and crop production on an altered scale, for technology development, for spatial planning and balanced fertilization including utilizing the organic material.

"Further the following issues for future research, development, and implementation were identified:

- Reuse of water that avoids water scarcity and environmental pollution
- Development of composting and other treatment technologies
- Pelletilization
- Meaningful biogas and other energy production
- System view, including feed and resulting manure optimization
- Proper health protection, production, hygienization and use
- Proper government policy processes for transition (spatial planning, subsidies, recycling)"

Seven Focus Areas of Global TraPs, 2012-2015

by Dr. Amit H. Roy & Dr. Roland W. Scholz

The Seven Focus Areas identified as priority for the remainder of the Global TraPs project are related to three types of activity:

(i) (Identifying[1] and) filling knowledge gaps
(ii) Promoting technology development
(iii) Identifying policy options

A comprehensive system view, including the identification of knowledge gaps, is presented in the Springer book S*ustainable Phosphorus Management: a Transdisciplinary Roadmap*, will be published this year. The Focus Areas identify issues that have priority with respect to the *Guiding Question*, while recognizing that the success of the Global TraPs project in establishing the right processes is dependent on gaining knowledge from key practice actors and top scientists in sustainable resources management.

1. Ensuring supply security

Despite a severe critique by experts from industry, geology and resources management, and the incorrect use of mathematical models for predicting reserves and resources, the idea of Peak Phosphorus and **physical scarcity** in a few decades (put forward in 2009) has drawn much attention. Within Global TraPs, the Exploration Node launched a scientific discourse with some members independently producing published articles and papers that reveal there will be **no necessary supply-driven peak of phosphorus production** in the next decades or centuries[2]. However, there are many reasons for economic scarcity, in particular for developing countries, which have to be better understood and managed.

Future work of Global TraPs will focus to identify causes for potential bottlenecks of supply security due to **geopolitical risks, insufficient information about supply dynamics,**

[1]The identification of knowledge gaps has been the focus of the first 2 1/2 years of Global TraPs project. The development of strategies for filling them is the focus of the second half of the project.

[2]Important papers are: Mew, M. (2011, 4 March 2011). Future Phosphate Rock Production – Peak or Plateau? Retrieved June 12, 2012, from http://www.fertecon-frc.info/page15.htm; Scholz, R. W., & Wellmer, F.-W. (2013). Approaching a dynamic view on the availability of mineral resources: what we may learn from the case of phosphorus? Global Environmental Change, 23, 11-27. Vaccari, D. A., Mew, M., Scholz, R. W., & Wellmer, F.-W. (2013). Exploration: What reserves and resources? In R. W. Scholz, A. H. Roy, F. S. Brand, D. T. Hellums & A. E. Ulrich (Eds.), Sustainable Phosphorus Management: a Global Transdisciplinary Roadmap (pp. 122-145). Berlin: Springer. Vaccari, D. A., & Strigul, N. (2011). Extrapolating phosphorus production to estimate resource reserves. Chemosphere, 84(6), 792-797. These papers show that the conclusions drawn by the often cited paper "Cordell, D., Drangert, J. O., & White, S. (2009). The story of phosphorus: Global food security and food for thought. Global Environmental Change-Human and Policy Dimensions, 19(2), 292-305 "are unsubstantiated."

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general market constraints, etc., and will reflect on **how supply security policy means** at local, national and international levels may be improved.

2. Improving efficiency and avoiding certain losses

Phosphorus (despite providing residual nutrients for subsequent crops and high levels of efficiency if one considers long-term crop production) is suspected to show **very low use efficiency** along the entire food production chain (which accounts for around 90 percent of total phosphorus use). According to current knowledge, only about 10 percent of the phosphorus that is anthropogenically mobilized for food production is taken up by humans annually.

Major 'losses' can occur in the use phase. Runoff and surface soil erosion (resulting from poor crop and nutrient management practices) are the major loss mechanisms associated with phosphorus; leaching through the soil profile is not an issue, with the exception of very sandy soils. There is also evidence of a **trend of large-scale inefficient use of manure**, which is primarily caused by the decoupling of crop and livestock production. This situation requires interventions related to technological innovations and the recoupling of plant and animal production.

Efficient nutrient use after harvest from **crop residues** and food waste, as well as **tradeoffs with energy** use must be considered as further options.

Until recently, the **potential and factual loss of phosphate rock during mining and beneficiation** has not received special attention. The USGS Mineral Commodity Survey data on annually consumed phosphate rock only reports the tonnage after beneficiation. There is some evidence that between 30 and 50 percent of P in each ton of phosphate rock, as recorded by USGS, may be lost from the value chain because it is associated with uneconomically mineable remnants, or concentrated in the tailings or other processing residues/by-products. Further, outdated or inefficient beneficiation technologies may cause additional losses.

3. Sustainable mining

Minerals are essential for modern living, and mining is still the primary method of their extraction. Phosphate rock mining is often heavily criticized as exploitive and detrimental to the environment. Because there is an exceptionally wide range of technological, environmental, social and economic performance variances among companies, one recognizes that the challenges for sustainable action vary among the different mining sites as well. Global TraPs promotes industry-to-industry and industry-to-science learning in ways to improve the physical and economic sides of mining. Currently, five mining companies are discussing ways to promote sustainable phosphate mining, focusing on three issues: i) helping each other to overcome barriers to sustainable mining in different domains (i.e., targeting "Intellectual Partnership" in sustainable phosphorus mining); ii) identifying pitfalls and unacceptable practices in mining that should be abandoned; and iii) preparing for new economically interesting technologies that may meet new societal standards such as purity (without cadmium, radionuclides), co-mining and innovation in fertilizer processing and products.

4. Innovation in fertilizer processing and products

Phosphorus is a key nutrient. But replenishment of the nutrient must be seen in relation to other nutrients, organic matter, soil parameters, agricultural practices and environmental impacts. Current production of phosphoric acid-based phosphorus fertilizers with high levels of water-soluble phosphorus, which remains plant-available over a wide range of soil properties, are generally very effective from an agronomic and economic perspective. However, the production and management of the associated by-products (phosphogypsum and process water) of the phosphoric acid process are the source of a number of environmental concerns. In addition, when the highly water-soluble phosphorus fertilizers are applied to the soil, they react with soil components to form reaction products of lower water solubility. Only about 10-20 percent of the applied phosphorus is taken up by the first crop. The remainder contributes to the build-up of beneficial soil phosphorus reserves, with a significant amount becoming available to crops over the long-term. The nutrient efficiency of plant uptake in the long run is estimated to range from about 40 percent up to more than 90 percent. If long-term uptake is around 40 percent, it should be increased[3]. These two outcomes from the production and use of the current suite of phosphoric acid-based fertilizer products suggest a need for an examination of phosphate fertilizer solubility requirements and identification of technologies that reduce rapid conversion of the water soluble phosphorus to less soluble phosphorus forms via reactions with the soil. Possible technological avenues may include coatings, combination with organic sources of nutrients, etc., but solutions will need to result in agroeconomically efficient, economically attractive phosphorus fertilizers that do not negatively affect environmental quality. IFDC's and IPNI's previous and current research in this domain can serve as a starting point.

In addition to technology development, there is a challenge to develop and provide reliable and economically affordable procedures for soil testing and assign the use of proper site-, soil- and crop-specific fertilizer.

The efficient use of phosphogypsum and the extraction of cadmium and radionuclides (in particular, uranium and thorium) are specific challenges.

5.Promoting economic recycling along the supply demand chain

Recycling and secondary mining are of interest from a resource conservation (phosphate rock is a finite resource), environmental impact (i.e., avoiding eutrophication) and socioeconomic (there may emerge new industries and working places) perspective. There are options of recycling or secondary mining of P along all stages of the supply chain, ranging from recovery to sewage recycling. Manure recycling from animal factory production – as one type of organic waste – seems to have a very high potential in areas with concentrated livestock operations. The potential of recycling options will be explored and evaluated in a forthcoming Global TraPs study.

The **recycling of sewage** as nutrient sources has seen progress. Currently, the first technologies are entering the economic competition stage with mineral fertilizer production in some parts of the world[4]. However, while recycling of sewage is important, one must acknowledge that it is a minor part (less than 10 percent, of which two-thirds may be recycled with good technology) of the whole cycle. The eco-efficiency of recycling of sewage requires special attention in areas with conducive sewage management systems.

6. Redefining the planetary boundaries of phosphorus emissions

Human activities have almost tripled natural phosphorus flows, increasing the phosphorus load, particularly among aquatic systems. This implies a massive change in the Earth's natural regulatory capacity, as may be witnessed in the eutrophication of lakes. Some researchers suggest that the global planetary boundary for phosphorus is at the tenfold of the natural inflows into the oceans to the sea. Others argue that such a rationale may not be applied, as phosphorus flows (contrary to the more homogeneous atmospheric nitrogen flows) are much more linked to sensitive freshwater and seawater layers.

What inputs of anthropogenic phosphorus flows may have what impact on what aquatic, terrestrial and biotic systems (including biodiversity), is certainly a question that calls for environmental research.

7. Launching proper transdisciplinary processes and policy process

The core of transdisciplinarity is relating different types of knowledge from science (i.e., science disciplines) and the experiential knowledge from practice. As with most transdisciplinary processes, Global TraPs includes a multi-stakeholder discourse, and thus relates the interests and values from different societal perspectives.

The first 30 months of the project have shown that many principles of Global TraPs, such as not dealing with day to day policy actions, remaining in a precompetitive stage, providing a protected discourse arena, accepting the 'otherness' of the others, targeting capacity building and consensus formation (e.g., about priorities and focus domains) for 'socially robust orientations' (and not only on the technology side), etc., were acknowledged.

The Global TraPs case studies and proposed projects bring insight into how to overcome critical barriers of sustainable phosphorus management and how to develop proper policy options. These case studies shall offer a learning forum for sustainable phosphorus management.

Until now, policymakers have not been included. At the current stage, one important goal is to step into a sort of second track diplomacy, i.e., a kind of informal exchange of opinions and values with members of national agencies and public figures who may later introduce policymakers and governmental actors into the challenge of sustainable phosphorus management. According to the original agenda, Global TraPs should be completed in 2015. In what way this may be done, and what type of international, UNEP or even UN conference may result, must be discussed and developed.

[3]See Sattari, S. Z., Bouwman, A. F., Giller, K. E., & van Ittersum, M. K. (2012). Residual soil phosphorus as the missing piece in the global phosphorus crisis puzzle. Proceedings of the National Academy of Sciences of the United States of America, 109(16), 6348-6353.

[4]See e.g. Egle, L., Rechberger, H., & Zessner, M. (2013). Technische, ökologische und ökonomische Bewertung von Phosphorrecyclingverfahren. Paper presented at the 46. Essener Tagung, Aachen. The most economic precedures are struvite extraction from water in sewage plants. Various companies are providing such products in Canada, Belgium, Germany, etc.

SMAP Vietnam: 'Overuse and Underuse of Fertilizers in Vietnam'

by Tran Tien and An Bui

The workshop opened with Dr. Tien giving an overview of the SMAP Vietnam project, noting in particular the financing by Syngenta and the embedding of Global Traps with the local institute.

Building partnerships with local stakeholders

After intense preparation and learning by the researchers at Soils and Fertilizer Research Institute (SFRI) (see Figure 1) on how principles of transdisciplinarity may be used for sustainable phosphorus management, Professor Scholz gave a presentation on both the regional and global aims of Global TraPs to the steering committee, directors and the science team of SFRI in Hanoi. The initiation of the local project triggered an interesting discussion, with numerous questions and helpful input from all stakeholders. A workshop of the science team (led by Dr. Tran Minh Tien, see Figure 1) was used to discuss various reasons for overuse and the resulting implications, challenges and opportunities. Generally, the overuse of fertilizers is prevalent. From a financial standpoint, it is estimated that more than half of all fertilizer use can be classified as unnecessary overuse. A main reason for the excessive use is the cheap price of fertilizers (about 75 percent cheaper compared with world prices). Furthermore, soil testing has been a widely neglected measure and is rarely recommended to farmers, as the majority of the cultivated land plots are very small (about 0.4 ha per smallholder).

The following day, the SFRI organized dialogues with local farmers, traders and members of the agricultural extension of the Luong Phong Commune (See Fig. 2). This meeting provided a possibility to obtain more information about the farmers' customs and practices concerning fertilizer use and to discuss previously held assumptions. Furthermore, the discussions offered detailed insight into the relationships between the farmers and traders, especially concerning the advice traders provide to the farmers about the application of the fertilizers.

Fig. 2: Discussion are held between Vietnamese smallholder farmers and traders about the goals and benefits of the SMAP Vietnam project.

Additionally, the role of the members of the Department of Agricultural Extension as an essential source of information became more apparent (See Fig. 3).

In general, the project and its aims received positive feedback from all stakeholders. Most of them are willing to participate in the project for the next six months. However, among the farmers there exists some scepticism, especially regarding possible financial losses due to the reduced use of fertilizer. Instead of a control group, it was suggested by a farmer to split their land into two parts. One part will be used following the traditional farmer practice in fertilizer application. Simultaneously, the other portion will be treated with new methods using recommendations provided by the science team. During the process, weekly reports on the use of fertilizer will be delivered by the farmer and reviewed by the science team. The initial comparison of the two land plots concluded at the end of October 2013. Additional activities are ongoing, with a defined group of stakeholders and a detailed action plan through mid-May 2014.

Fig. 1: The SMAP Vietnam Science team of the Vietnam Soils and fertilizer Reserarch Team (front row, left to right: Nguyen Thanh Huyen, Bui Hai An, Roland W. Scholz, Tran Minh Tien; back row, left to right: Dinh Van Ha, Hoa San Cuong, Pham Duc Thu and Nguyen Toan Thang.

Fig 3: Professor Scholz, Dr. Tran Minh Tien and Mr. Dam, the Chien (director of Research Center for Midland Soils and Fertilizers), discuss the interaction of soil and fertizer type for rice in the Hiep Hoa region.

On the third day, a meeting with members of Agribank and the manager of the Luong Phong Commune took place at the People's Committee Office of the Luong Phong Commune. It was made known that micro credit loans are hardly used by farmers, but widely spread among the traders. Furthermore it became apparent that within the system, most of the stakeholders work separately and independently. Although the stakeholders make great efforts within their individual work, these entities have not yet managed to agree on a common approach to find solutions for sustainable developments. Members of Agribank contributed with input on how to raise the awareness of farmers regarding reasonable use of fertilizers. For example, they recommended extension services provide training for traders on the proper use of fertilizers. The training could be made mandatory in order for the traders to receive credit from the bank. The manager of the commune also promised full support. He is willing to contribute to the project by assuming the role of the practice leader of the case study in Vietnam (See Fig. 4).

Fig 4: One of the principles of Global TraPs is co-leadership between practice and science on equal footing on all levels of the project. The community major of Luong Phong, Mr. Tran Quang Han (left) is the practice leader and Dr. Tran Minh Tien (right) is the science leader of the SMAP Vietnam case study.

Improving Access to Fertilizers in Sub-Saharan Agriculture: The SMAP Kenya Case Study Builds Partnerships

by Rhoda Birech, Anthony Kioko, Christopher Mutisya and Ruth Njaoroge

From El Jadida (Morocco) to Eldoret (Kenya)

During the 4th Global TraPs Workshop held in El Jadida, Morrocco, in May 2012, Kenya was identified as a case study (project) on phosphorus underuse. The Cereal Growers Association (CGA) that represents grain producers in Kenya was selected to coordinate the project. The project case study is located in Uasin Gishu County, which is the heart of the grain basket in Kenya. From the science side, the universities of Eldoret and Egerton were identified to conduct the case study.

The main objective of the project is to improve smallholder farmers' access to phosphorus fertilizer. This will be accomplished by focusing on four areas: i) supporting smallholder farmers and agro-dealers to gain knowledge on phosphate fertilizer needs for farms in the project area; ii) promoting closer business interaction between agro-dealers

Fig. 1: Participants working at the Launch meeting in Eldoret May 2012 included farmers, traders, local governmental authorities, representatives of tthe Ministry of Agriculture, representatives of Néstle, IFDC East and Southern Africa, and Syngenta Foundation.

SMAP Kenya and SMAP Vietnam: Two Global TraPs Case Studies Financed by SFSA

syngenta foundation for sustainable agriculture

SMAP Kenya and SMAP Vietnam are two of the Global TraPs case studies that have been launched to address critical questions on sustainable phosphorus use. One of the questions that was formulated in Global TraPs workshops 3 and 4 focuses on smallholder farmers' knowledge and access to phosphorus fertilizer. Thus, the acronym SMAP reflects the challenge of SMallholder farmers' Access to Phosphorus fertilizer.

While the SMAP Kenya project only considers the underuse of phosphorus fertilizers for crop production, SMAP Vietnam deals with both under- and overuse, the latter being particular important in urban smallholder farmer vegetable gardening and peri-urban smallholder vegetable production for urban markets.

The SMAP project takes a supply chain perspective, and incorporates farmers, fertilizer traders, financial institutions and municipal authorities (extension offices) who collaborate with local universities or academic institutions. The project is a transdisciplinary one (equal engagement of science and practice stakeholders) on all levels and is co-led by Professor Roland Scholz (Fraunhofer IWKS, a public research institute) and Dr. Amit Roy (IFDC, a non-profit international organization). The project commenced in January 2013 and is scheduled to be completed in December 2014.

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SMAP Kenya Case Study Builds Partnerships *(continued from page 9)*

and smallholder farmers; iii) identifying financing opportunities for both the smallholder farmers and agro-dealers; and iv) understanding socioeconomic dynamics that hinder sustainable fertilizer use. The expected results will include, among others, better interaction between scientists and farmers, improved yields for participating farmers and increased incomes to both smallholder farmers and agro-dealers.

To achieve this objective, a team of four professionals has been commissioned (on a part-time basis) to guide the Kenyan project. They include David Nyameino, an agricultural economist (and Local Project Leader), and Anthony Kioko, an agriculturist (and Local Project Manager), both from CGA, Ruth Njoroge (soil scientist) from the University of Eldoret and Dr. Rhoda Birech (socio-economist) from Egerton University. The team assisted in the identification of stakeholders to work to achieve project objectives that include farmers, fertilizer agro-dealers, financiers, government institutions and other partners.

Much agreement by the stakeholders on goals and methodology

On April 4, 2013, the project held its inaugural workshop in Eldoret, Kenya (Fig. 1), which was attended by 36 participants, including farmers, government extension staff, financial institutions, university researchers, agro-dealers, local project partners from Syngenta FSA, IFDC and Nestlé, the media and the Global TraPs project team members, Professor Roland Scholz and Dr. Olaf Weber. Four main presentations were made on: i) Transdisciplinary Approach for Improving Smallholder Farmers' Access to Phosphorus Fertilizer; ii) Financing Sustainable Farming; iii) Role of Soil in the Farming Business; and iv) The Socio-economic and Institutional Indicators Measuring Sustainable Agricultural Productivity.

Plenary discussions resulted in identification of the main areas of focus: soil testing, building partnerships among stakeholders, establishing an information-sharing mechanism, promoting interactions and an attitude change among the value chain actors and building the capacity of three masters students who will conduct surveys. The survey methodology has been discussed, and MSc students have been identified and are awaiting funds to commence the surveys.

Consenting the goals and the design of the transdisciplinary process in December 2013

On December 19, 2013, the project team met in Eldoret, Kenya. The team included Professor Roland Scholz, Anthony Kioko (Local Project Leader), Christopher Mutisya (Local Project Manager), Rhodah Birech (socio-economist), Ruth Njoroge (soil scientist), Mark Korir (MSc student, socio-economics) and Chebet Arusey (Masters student, soil science). The team was joined by a group of farmers and representatives for traders (Wilchem and Eldoret Packers), the National Cereals and Produce Board, the Ministry of Agriculture and Equity Bank.

SCIENCE		PRACTICE
Project Leaders		
Dr. Rhoda Birech, Ruth Njoroge		Anthony Kioko, Project Leader (CGA)
Steering Committee		
Prof. Roland Scholz , Prof. Olaf Weber, Dr. Debbie Hellums		Abraham Bett, Prof. Robert Okalebo, Thomas Oangah
SMAP Project Managers		
Mrs. Arusey Chebet, Mr. Mark Korir		Mr. Christopher Mutisya
Subsystems	Science Group	Practice Group
Farmer Group	Ruth Njoroge (responsible), Dr. Rhoda Birech, Mark Korir and Chebet Arusey	Abraham Bett - Farmers spokesperson
Trader Group	Dr. Rhoda Birech (responsible), Ruth Njoroge, Mark Korir and Chebet Arusey	Susan Chemweno, Raj C. Kachela - Traders spokespersons
Financial Institutions	Prof. Dr. Olaf Weber and Prof. Dr. Roland Scholz y	Jane Gathukia, Financial Institutions spokes- person
Interdisciplinary Science Clusters		
Socio-economic Group	Dr. Rhoda Birech (responsible) and Mark Korir	
Soil-science Group	Ruth Njoroge (responsible) and Chebet Arusey	

Fig. 2: Organizational Chart of the SMAP Kenya project

The project team discussed and drafted a one-page flier as a tool to market the objectives of the SMAP project. The team also discussed and developed a draft of the SMAP Kenya workbook to be used to guide the Td process and the project. A steering committee representing both the science and practice aspects was appointed to guide the transdisciplinary (Td) process in the project. The steering committee will be composed of representatives from banks, traders, farmers and members of the SMAP project team (See Figs. 2 and 3).

Following the Td meeting, 70 participating farmers were identified and selected, soil samples taken and analyzed and a draft questionnaire for baseline data collection finalized. The next steps include setting up the farmer experiments, creating business linkages with traders and banks and finalizing baseline data collection on farmers, traders and banks.

Fig 3: SMAP Kenya Workshop II in Eldoret, Kenya, December 20, 2013, with representatives for farmers, fertilizer traders, financial institutions, Kenya Cereal Farmer Organization, Eldoret and Egerton University and Fraunhofer IWKs.

Technology Innovations in Recycling Require Adequate Evaluations

by Christian Kabbe and James Cooper

For sewage and organic waste, including animal manure, there are increasing efforts in many European nations, Japan and other developed countries such as Canada to recycle phosphorus. Regardless of the level of economic development, P losses can and do occur. Unfortunately, current technologies do not always offer a proper solution. One of the biggest challenges is to find suitable ways to close the nutrient cycle on the regional or even local level, which can prove to be more challenging than recycling in urbanized and industrialized areas, where the losses of P from food production and consumption is more localized and distinct.

In the case of sewage, the recycling technologies fundamentally differ with respect to the age and type of infrastructure available for sewage treatment and the treatment process (i.e., sludge valorization, chemical or thermal processes, etc.) applied. Additionally, there are other significant P losses in waste flows from fertilizer production (gypsum) or concentrated livestock operations (manure, carcass waste) that require new technology development and identification of possible synergies in order to be cost-effective.

Currently, various technologies for P recovery and recycling are available, but have not been widely integrated into the market for various reasons. To access the feasibility of these technologies, critical questions must be asked. These questions include:

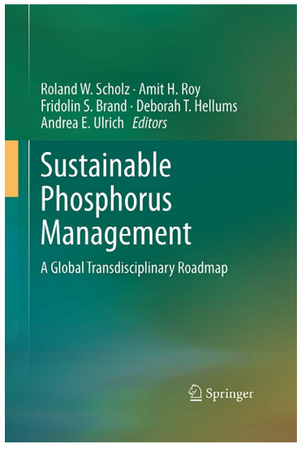
What hampers widespread implementation of available and feasible technologies? What policy options should be considered that affect framing conditions to promote P recovery and recycling in scientific research and in practice? What are the socio-economic implications associated with implementation? How can the ecologic and economic impacts of the relevant technologies be reasonably assessed and what conclusions and recommendations can be expected?

For some countries, P recycling is of interest because phosphate mining is limited to few countries, and recycling options can help alleviate total dependency on imports of this crucial nutrient for food production. Other incentives include financial collateral benefits resulting from diminishing waste products and the abatement of over-fertilization.

During the Global TraPs Beijing meeting, key stakeholders from science, practice and policymakers participated in a Dialogue Session (DS) on the prospects of Technology Innovations in Recovery and Recycling. The leading questions for the DS were: *What new technologies for efficient P recycling are available? How can obstacles be overcome in the technical and social transition from not only removing the pollutant P but also towards recovery of the precious resource? How can important related knowledge be categorized from first-hand experience and transformed into action?* Through these discussions, diverse perspectives and knowledge gaps were addressed, which provided the foundation for formulating different hypotheses. Continuing discussions and mutual learning processes are expected to lead to policy orientations that will provide guidance for key actors on which technologies that foster recycling are feasible.

Springer Book Provides a Unique System Analysis for Sustainable Phosphorus Management: 50 Global TraPs members from industry and science contribute to effort

The Springer book, *Sustainable Phosphorus Management - A Global Transdisciplinary Roadmap*, was originally planned as a 100-page Springer Briefs volume. Plans were for it to be completed soon after the 4th Global TraPs Workshop in El Jadida, Morocco. The first draft of the chapters on the supply-demand chain as well as the crosscutting issue of trade and finance that were to compose for this brief was intensely discussed in March 2012. But, as it may be characteristic of transdisciplinary projects, there were many issues that required a deeper discursive process. Furthermore, a few contested issues that emerged during the discussions, such as health risks, losses in the anthropogenic phosphorus cycle before use and the role of mineral phosphorus fertilizer compared with organic P inputs, required additional discussion, clarification or explanation. These discussions resulted in the development of 10 Spotlights to supplement each book chapter dedicated to a node of the P supply-demand chain.



Sustainable Phosphorus Management
A Global Transdisciplinary Roadmap
Editors: Roland W. Scholz · Amit H. Roy · Fridolin S. Brand · Deborah T. Hellums Andrea E. Ulrich
http://www.springer.com/environment/sustainable+development/book/978-94-007-7249-6

Finally, the editors noted that a comprehensive system analysis of global phosphorus flows was missing. This system view on sustainable phosphorus management is presented in the opening chapter. These changes resulted in the development of an inclusive Global TraPs book on sustainable phosphorus management. The book is scheduled to be available as hardcopy in March 2014.

The contents of the book in brief

The book describes a pathway for sustainable phosphorus management via the Global Transdisciplinary Processes for Sustainable Phosphorus Management project (TraPs). The book offers insight into economic scarcity and identifies options to improve efficiency and reduce environmental impacts of anthropogenic phosphorus flows at all stages of the supply and demand/use chain.

The opening chapter provides a comprehensive survey describing, "what is wrong with the current anthropogenically-driven phosphorus cycle, based on a material flow analysis." Five chapters address such challenges of sustainable phosphorus management; as understanding the dynamics of reserves, elaborating when economic scarcity may become physical scarcity, the multiple costs of mining and the challenge of innovation in fertilizer products and production. Chapters on use and on dissipation and recycling establish that phosphorus has a dissipative structure and is subject to significant losses along the entire length of its value chain. These chapters also identify constraints and options for closing the anthropogenic phosphorus loop. A concluding chapter on trade and finance discusses the causes of price volatility of phosphorus products. Fifty key stakeholders from industry and science have contributed to this volume, writing full chapters and related spotlights on critical points. Their wide-ranging expertise helps to establish a transdisciplinary perspective, as they identify the knowledge and the key stakeholders that must be included in a successful transition from current phosphorus management toward sustainability.

Fraunhofer Institute for Interface Engineering and Biotechnology (IGB) Hosts Global TraPs in 2014

With more than 20,000 employees, Fraunhofer is Europe's largest application-oriented research organization (http://www.fraunhofer.de/en/about-fraunhofer.html). The Fraunhofer Project Group for Materials Recycling and Resource Strategies IWKS hosted Global TraPs in 2013 and will continue to be the home of the SMAP Project, which is financed by Syngenta Foundation. Beginning in January 2014, the Fraunhofer Institute for Interface Engineering and Biotechnology (IGB), located on the campus of Stuttgart University, took the role of the science hosting institution.

Fraunhofer IGB (http://www.igb.fraunhofer.de/ en.html) has long experience with research on phosphorus recycling and processing, as well as with nutrient management, and is a leading partner in the Fraunhofer Sustainability Network.

Phosphate Rock Reserves and Resources-the Discourse Continues

In the age of open access journals, science is exploring new ways to publish peer reviewed journals. For instance, the Earth System Dynamics Journal makes unreviewed papers available, thereby allowing the scientific community to follow the discourse during the review process. For the issue of sustainable phosphorus management the paper "Recent revisions of phosphate rock reserves and resources: reassuring or misleading?" is of special interest. The paper by J. D. Edixhoven, J. Gupta, and H. H. G. Savenije criticizing the current classification and reporting of UNFC, USGS and IFDC receives thorough critique by reviews of Peter P. Cook, Julian Hilton and a joint review by Roland W. Scholz and Friedrich-Willhelm Wellmer. This discussion, and in particular the elaborated and well researcherched reviews are worth reading. See http://www.earth-syst-dynam-discuss.net/4/C686/2014/esdd-4-C686-2014.pdf

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