NSSI Natural and Social Science Interface

IFDC

The Global TraPs Project

Transdisciplinary Processes for Sustainable Phosphorus Management

(2010 – 2015)

Multi-stakeholder forum to guide and optimize future P use

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Swiss Federal Institute of Technology Zurich

Publisher

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Contents

"Phosphorus is one of the key nutrients necessary to human, animal and plant life. Phosphorus is also a finite resource that must be used more effectively and efficiently. By focusing on phosphorus from the supply chain perspective, the Global TraPs initiative seeks to bring greater understanding to a number of issues that confront humanity and our environment. We welcome your interest and involvement."

Dr. Amit H. Roy and Dr. Roland W. Scholz

Overview

Phosphorus (P) is a key human, animal and plant nutrient with enormous significance. Phosphorus is found in minerals and rocks in the form of phosphates. These phosphate rocks are processed into various fertilizers which are critical to global food security and also into many feed, industrial and other non-agricultural products. While knowledge on the production and use of phosphates is scattered among very diverse stakeholders – from chemical, fertilizer and food industries to farmers, academics in various disciplines and regulatory bodies, to name just a few – two broad issues surrounding phosphorus are increasingly being discussed and debated: the finite nature of phosphate rock resources vis-à-vis their importance in future food security; and the negative environmental impacts of excess phosphorus, particularly in freshwater and coastal marine ecosystems.

Concerns and opinions have been voiced in both scientific and popular media by individuals or groups often representing only a single stakeholder viewpoint. What has been lacking is a multi-stakeholder forum involving key actors with differing viewpoints, knowledge and concerns to guide and optimize future P use through an assessment of current information and knowledge gaps, and the development of options for the way forward. The Global TraPs Project (Global Transdisciplinary Processes for Sustainable Phosphorus Management; 2010-2015) is addressing this broad need. Focusing on the sustainability of future phosphorus use, Global TraPs will bring together "practice" (producers and users of phosphorus, along with those facilitating their efforts, such as extension and development organizations) and "science"[1] (researchers from various disciplines with an interest in phosphorus) to work towards a common aim, i.e., that future phosphorus use will be sustainable, improve food security and environmental quality, and provide benefits for the poor. This high-visibility international project with broad participation is led by the Swiss Federal Institute of Technology (ETH) and the International Fertilizer Development Center (IFDC), each assuming responsibility for leadership of one facet – science (ETH) and practice (IFDC) (for more information on the institutions see Text Box 12). It is expected that a large number of stakeholders will be involved – it is estimated that as many as 300 will participate during the project.

The project uses the transdisciplinary methodology which, through mutual learning involving 'science and society,' integration of diverse knowledge, and consensus-building, results in the development of socially robust options for the future. While focusing on the global situation, TraPs draws from location-specific, transdisciplinary case studies designed to address specific issues of interest. Study and discussions will take places in 'nodes' organized around the global phosphorus supply chain, i.e., from exploration of phosphorus resources to its utilization and recycling. These nodes are led by two leaders, one from practice, another from science. These leaders are cooperating with a transdisciplinary coordinator with in-depth experience in transdisciplinary methodology; participants in the node also come from science and practice in equal proportions.

The transdisciplinary methodology acknowledges and respects the differing interests and backgrounds of the stakeholders. Exchanges on views and values are integral to the process which operates in a precompetitive and non-politicized arena. Two rules of conduct will ensure constructive dialogue leading to results with benefits for all stakeholders: (1) confidentiality of information, when requested by any participant, is respected; and (2) he project will not engage in discussions, nor make recommendations on, specific, day-to-day political or geopolitical issues. Instead, the Global TraPs project deals with policy options supporting sustainable P access and management.

In addition, the project is framed within a human-environment system (HES) perspective (Text Box 1), assuming that human systems (e.g., individuals, industries, societies) are inextricably coupled to environmental systems (e.g., technical systems and ecosystems).

[1] Please see "Term for the two stakeholder groups in Global TraPs" on page 9 for a discussion on the terms used in transdisciplinary discussion, as well as their advantages and limitations.

Text Box 1. What is a Human Environment Systems (HES)-perspective?

Many of the past and contemporary environmental problems are related to human activities. Paul Crutzen stressed that phenomena such as climate change, the ozone hole and acid rain show that we are living in an age he calls the anthropocene, an age in which humans have become a geological factor with respect to their impact on the functioning of the Earth System[2]. Given that human and environmental dimensions of the earth's systems have become inextricably intertwined, sustainable science research need to examine the entire system. it is no longer enough to study nature's biophysical systems alone, nor is it enough to study the system's components, such as the soil, crop, livestock and farm household of an agroecosystem. The interactions between these components, and the dynamic changes over time and space, are keys to understanding how our world can function more sustainable. We assume that human systems on different levels (e.g., individuals, group, organization, society, supranational organizations) are complementary to and strongly interact with environmental systems (i.e., technical and natural systems).

Every node of the P supply chain can be investigated using this human-environment system (HES) perspective. The result is a study of interactions between human and environmental systems, such as unwanted feedback loops on longer time scales. Researchers at ETH-NSSI can support applying the HES framework to better study and understand the complexity of coupled human-environment systems by drawing on and integrating knowledge from relevant scientific disciplines[3].

Thus, Global TraPs will contribute, at the global level, to a constructive dialogue and sustainable P use in the future by defining, in a multi-stakeholder forum, the following:

- The current stage of knowledge on phosphorus and its use, and new knowledge which is necessary to ensure sustainability of its use;
- New technologies which are needed to better process, use and re-use phosphorus; and
- Most valuable areas for policy intervention to ensure sustainable P use in the future.

The outputs of Global TraPs will be made available globally for high-level decision-makers in policy and politics, industry, science and development. Specific case studies and their outputs will benefit particular locations.

[2] Crutzen, P. (2002). Geology of mankind. *Nature, 415*(6867), 23

[3] Scholz, R. W. (2011). *Environmental Literacy in Science and Society: From Knowledge to Decisions*: Cambridge University Press

Global Transdisciplinary Processes for Sustainable Phosphorus Management (2010–2015)

The Global TraPs Project works to ensure that future P use will be sustainable, improve food security and environmental quality, and provide benefits for the poor (see Text Box 2). While it is essential, most P is derived from non-renewable phosphate rock, therefore the amount and use of phosphorus is a global concern. This project seeks to make a contribution by assessing current knowledge, and by creating a high-level multi-stakeholder platform to develop consensus on best options for phosphorus management in the future. The project will use transdisciplinary methodology, which has been developed to assist society to deal with complex environmental issues, and will employ a supply-chain approach in its research, analysis, negotiation and consensus-building. The project will result in recommendations, derived on the basis of consensus, on policies and technologies which should be employed to ensure sustainable P management in the future. Given the multi-stakeholder process, the options proposed are expected to be socially robust, i.e., appropriate, effective and acceptable to the majority.

> **Text Box 2. 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?"

Why the focus on phosphorus?

Issues related to phosphorus have increasingly become a focus of concern, discussion and debate during the past five years. Two issues have received particular focus: the finite nature of phosphate resources vis-à-vis their essentiality in all biological and food production (Text Box 3) and the increasing pollution caused by P losses to the environment (see Text Box 4).

While Global TraPs focuses on these two issues, it has additional, important emphases:

- Phosphorus has a tremendous positive impact on food production (and therefore upon food security), but much can be done to improve this impact.
- Sustainability of P resources has become a serious, worldwide concern and therefore needs attention (see Text Box 5).
- A great deal of knowledge exists on ways to manage phosphorus without harmful effects on the environment. However, in many places management leaves a great deal to be desired.
- Given the central role of phosphorus in food security and human well-being, and the low use of phosphorus among some smallholder farmers, access to P by the poorest has to be improved.

> **Text Box 3. Phosphorus and the world's food production**
>
> Over the next 40 years, global food output has to increase by at least 70 percent to keep up with the world's population, which will grow from 6.8 billion people to over 9 billion by 2050. Equally importantly, the future agricultural productivity growth needs to benefit the developing country smallholder farmers, who rely on agriculture for their food security and income. Fertilizers will continue to be key way to increase food production in the future.
>
> Fertilizers are nutrients that plants must have to grow, in a form they can use. The main nutrients in fertilizers are three essential elements: nitrogen (N), phosphorus (P) and potassium (K), with 20 or so nutrients commonly referred to as micronutrients, many of which are also necessary for normal plant growth. Phosphorus is essential to all plant growth. As a component of ATP, it is essential for photosynthesis. It encourages blooming and root growth and is involved in formation of oils, sugars and starches, among others.
>
> Globally, it has been estimated that since the 1960s, fertilizer has accounted for 30 to 60 percent of the rise in average yields and 30 percent in total production. Roughly 50 percent of the yield growth in Asia during the Green Revolution can be attributed to fertilizers. Phosphorus has had a key role in such gains in food production.

Text Box 4. Phosphorus and the environment

In the natural environments, P is supplied through the dissolution of low-soluble rocks and minerals, and through weathering, a slow process. Therefore, in natural environments phosphorus is limiting, and boosting phosphorus supply usually means higher productivity, both on land and in water.

Unlike carbon, nitrogen and sulphur, phosphorus cannot be transported by the atmosphere at large scale as it lacks volatile forms. It is mainly transported through erosion and runoff, and typically into waterways.

Modern humans have more than tripled global P flows, with additional P largely originating from mined phosphate resources. Such intensification has happened in four major ways (Smil, 2000[4]): (1) accelerated erosion and runoff due to deforestation and grassland transformation; (2) recycling of organic waste; (3) discharge of human waste, detergents and manure; and (4) applications of inorganic fertilizer. It is in the waterways where the additional P has its negative impacts through eutrophication, advancing from mere increase in phytomass to blooms of algae and cyanobacteria, and at times resulting in dead zones. This happens in both freshwaters and in marine, typically coastal waters.

Whereas in the industrialized countries sewage and detergent discharge to waterways has been greatly reduced, they continue to be important avenues for eutrophication in developing countries. Phosphorus from eroded fertilized fields (by inorganic fertilizers and animal manure) is the major pollutant of waterways in industrialized countries and in developing countries with significant P fertilizer use.

Sustainability of P resources has become a serious, worldwide concern and therefore needs attention

Phosphorus is an essential element of life: it is an indispensable element in human and animal bodies, natural and agricultural systems, and in numerous natural and industrial processes and products. As it is highly reactive, it is never naturally found in its elemental form. Phosphorus is present in all living cells, in compounds such as phospholipids in the cell membranes, and in life-maintaining materials such as DNA, RNA and ATP. Without phosphorus, there would be no life on earth as we know it.

Text Box 5. Global TraPs working definition of sustainability

The Global TraPs project works with the following understanding of sustainability (see Laws et al., 2004[5]): *Sustainable development* can be conceived as (1) an "ongoing inquiry" for (2) "system limit management" (i.e., preventing unwanted collapses, breakdowns and crises) in the (3) "frame of inter- and intra-generational justice."

Sustainability learning on the level of society can be seen as a process of acquiring "sustain-abilities" (such as reading the potential of the environment, anticipating and coping with rebound effects and tipping points, etc., see Scholz, 2011[6]) that can establish a sustainable management of P.

The essentiality of P in food production and the finite resources of phosphate rock (see Text Box 6) have resulted in concerns about the medium- to long-term economic accessibility of high-quality, inexpensive phosphate rock for fertilizers which are essential in the modern agricultural production system.

Specific concerns have been the timing of "peak phosphorus" and the impacts of dwindling phosphate resources. It has become clear that current resources and reserves (the latter defining the currently exploitable phosphate rock, given today's economic and technology contexts) are far greater than those previously documented (IFDC, USGS) (see Text Box 7).

At the same time, it is equally true that phosphate rock is a non-renewable element on which humankind is already highly, and increasingly, dependent. The sustainability of the P resource base is therefore an issue that merits attention, and Global TraPs will assess discussion to date, data available from diverse stakeholders, and make a significant contribution to the issue of the sustainability of the P resource base.

4 Smil, V. (2000). Phosphorus in the Environment: Natural Flows and Human Interferences. *Annual Review of Energy and the Environment, 25*, pp. 21-51.

5 Laws, D., Scholz, R.W., Shiroyama, H., Susskind, L., Suzuki, T., & Weber, O. (2004). Expert Views on Sustainability and Technology Implementation. *International Journal of Sustainable Development and World Ecology, 11*(3), pp. 247-261.

6 Scholz, R.W. (2011). *Environmental Literacy in Science and Society: From Knowledge to Decisions*. Cambridge: Cambridge University Press.

Text Box 6. How much phosphate rock is left?

In recent years, concern has surged over the amount of remaining phosphate resources. Many have argued that phosphate production would follow a similar bell-shaped curve as Hubbert has postulated for petroleum. According to Hubbert, rates before peak increase as infrastructure is added and new discoveries are made; after peak, resources are depleted, and rates go down. However, the appropriateness of the theory to global P resources has been contested. Applications of the Hubbert curve or other, more adequate mathematical models for assessing global phosphate reserves seem currently not possible because of the insufficiency of the data on reserves and resources in all regions of the world. A 2010 study by IFDC, "World Phosphate Rock Reserves and Resources," revised reserve estimations upwards, from 16 to 60 billion tons of rock, indicating that the more pessimistic scenarios discussed are not correct, and P will be available likely for hundreds of years at minimum. Consequent to the report, the United States Geological Survey (USGS) has revised its estimates to agree with those of IFDC. Despite increased reserves estimates, given the fact that P is an essential element for food production, sustainability and efficiency across the supply chain continue to be important issues.

Text Box 7. Geography of resource

The majority of the world's usable phosphorus resources is in the form of phosphate rock. Guano, bone meal and other sources of organic phosphates are of minor importance. Three types of phosphate rock exist – sedimentary, igneous and metamorphic. Sedimentary phosphate deposits account for over 80 percent of the current production. Igneous phosphate ores are often low in grade, but can be upgraded.

Currently, some phosphate rock can be applied directly on fields as an annual P source. However, most are limited in ability to supply P to plants by factors including total P concentration, reactivity and interaction with soil type, crop, climatic factors, timing and method of application and particle size. Most phosphate rock is currently processed into fertilizers.

Only a few countries in the world possess significant phosphate rock resources. Currently, the largest phosphate producers are China, USA, Morocco, Russia and Tunisia. From highest to lowest, the top five P fertilizer-consuming regions are: East Asia, South Asia, Latin America, North America and West/Central Europe.

Phosphorus has a tremendously positive impact on food security, but much can be done to improve this impact.

Phosphorus is the eleventh most abundant element in the earth's crust, and present in small amounts in nearly all rock types. Soils of natural and agricultural systems contain widely varying amounts of total phosphorus, from about 100 to over 4,000 kilograms/hectare (kg/ha), with an average of about 1,000 kg/ha; certain regions, in particular many areas of Africa, have very low amounts of available P (see Text Box 8). However, only a small part of this P, estimated to average about 1 percent, is available to crops. The variability in the available phosphorus is also large, and is caused by diverse factors, from management (including applications of P and manure), to soil types and others. The low available P soil content explains why crops usually have a marked response to fertilizer.

Text Box 8. P imbalances in world's croplands

Large spatial variability in P balances characterizes the world's croplands. A study by MacDonald et al. (2011)[7] focuses on P inputs (as manure and fertilizer) and outputs (as harvested crops) for 123 crops grown globally in 2000. That year, on average inputs of P fertilizer (at 14.2 teragrams [Tg] P) and manure (9.6 Tg P) exceeded P outputs as harvested crop. Ten percent of croplands had large deficits (-3 to -39 kg P); they were mainly in South America (especially Argentina and Paraguay), Northern USA and Eastern Europe. Another 10 percent had large surpluses (13-840 kg P); they include the majority of East Asia's cropland, large areas of Western and Southern Europe, coastal USA and southern Brazil. Large surpluses only occurred on less than 2 percent of cropland in Africa.

Authors conclude that these areas could have reduced P fertilizer use by 21 percent without any becoming P-deficient; at a global level, 1.2 Tg of P (or 8.5 percent of the P fertilizer applied) would have been saved.

Most of the P applied does not directly benefit crops, but instead is immobilized in the soil or ends up as a pollutant in the waterways. A significant percentage of agricultural soils are either over- or under-fertilized with P, greatly reducing the efficiency of the

[7] MacDonald, G.K., Bennett, E.M., Potter, P.A., and Ramankutty, N. (2011). Agronomic Phosphorus Imbalances Across the World's Croplands. *Proceedings of the National Academies of Sciences of the United States of America, 108*(7), pp. 3086-3091.

applied P. Global TraPs will assess ways to efficiently manage P, and therefore, increase the impact it can have on food security.

Although a great deal of knowledge exists on ways to manage phosphorus without harmful effects on the environment, in many places, management leaves much to be desired.

It has been estimated that through the intense use of phosphate rock products – primarily fertilizer – humans have roughly tripled global P cycling. Phosphate rock use will further increase, given growing phosphate fertilization rates. According to the International Fertilizer Industry Association, to keep up with agricultural production, an annual increase of some 3 percent in global P demand is expected until 2015/16, with further increases likely. Given the extraordinarily dissipative structure of P it easily escapes into nature, causing pollution.

Both pollution and scarcity problems around unsustainable P-use call for closed-loop approaches requiring, amongst others, increased recycling efforts. Many models and technologies for environmentally sustainable P management exist and are being practiced in many locations, including effective manure management, use of urban sludge as fertilizer and harvesting of P from sludge as struvite. Such models will be assessed by Global TraPs and proposals for upscaling and improvements will be made.

Given the central role of phosphorus in food security and human well-being, and the low use of phosphorus among some smallholder farmers, access to P by the poorest has to be improved.

Poor smallholder farmers worldwide, but particularly in Africa, use insufficient amounts of phosphorus, with subsequent negative impacts on food security and income. Average use of fertilizer in Africa is extremely low, with 2009 use application of the main nutrients (nitrogen, phosphorus and potassium) at 8 kg/ha; of this amount, P use averaged 2 kg/ha. Numerous constraints limit smallholder farmers' access to fertilizers, including their high cost, limited availability in small communities, and insufficient knowledge of farmers on best ways to use fertilizer and get the maximum benefit from it. The impacts from limited access to fertilizer are clear: low yields (in the case of Africa, average cereal yields are only 1.2 metric tons [mt]/ha), causing food insecurity and poverty, and reduced soil fertility as nutrients removed in crops are not replenished.

Increased fertilizer use, including phosphorus (see Text Box 9), will be key to meeting the food needs and ensuring income growth of the poor. Particular attention by Global TraPs will be paid to improving access to fertilizer among the poorest.

Text Box 9. Phosphate fertilizer supply and demand

World demand for phosphoric acid – from which phosphate fertilizer and many other phosphate-based products are made – was 38 million mt in 2010, while its supply was 40 million mt. Annual growth is expected to average 4 percent and 4.8 percent for demand and supply, to reach 44 and 47 million mt by 2014. Almost half of phosphorus-based fertilizers are applied on cereal crops. Fruits and vegetables (18 percent) and soybeans (7 percent) are other large P consumers.

Why focus on the entire P supply chain?

The project takes a supply chain approach (see Figure 1) to ensure a global, comprehensive understanding of the issues surrounding P. To date, much of the focus on P has been on its use, waste and recycling. Issues related to other facets of the phosphorus supply chain (i.e., exploration, production and processing of P into fertilizers and other products, and its trade, transport and finance) have received far less attention. However, the most effective interventions to improve sustainability in P management can only be identified after an assessment of the issues across the entire supply chain. In addition, supply chain steps are linked, influencing each other, and therefore, interventions based on knowledge derived from a single step likely will not have the desired, maximum effect.

Analysis of each step of the supply chain is only the first step in Global TraPs. The project will then integrate new knowledge from the nodes into a discourse among all project participants to reveal opportunities and pitfalls around P use. This can reveal knowledge gaps and links between and within nodes, and therefore lead to an increased level of understanding about system dynamics such as critical feedback loops and awareness between various stakeholders. This integrated analysis of the knowledge from all supply chain nodes will also allow Global TraPs to strive for a closed loop design (i.e., develop elements of future systems that are efficient and, to the extent possible, waste-free). Issues considered will include energy use, productivity of land and water, waste management and ecosystem health.

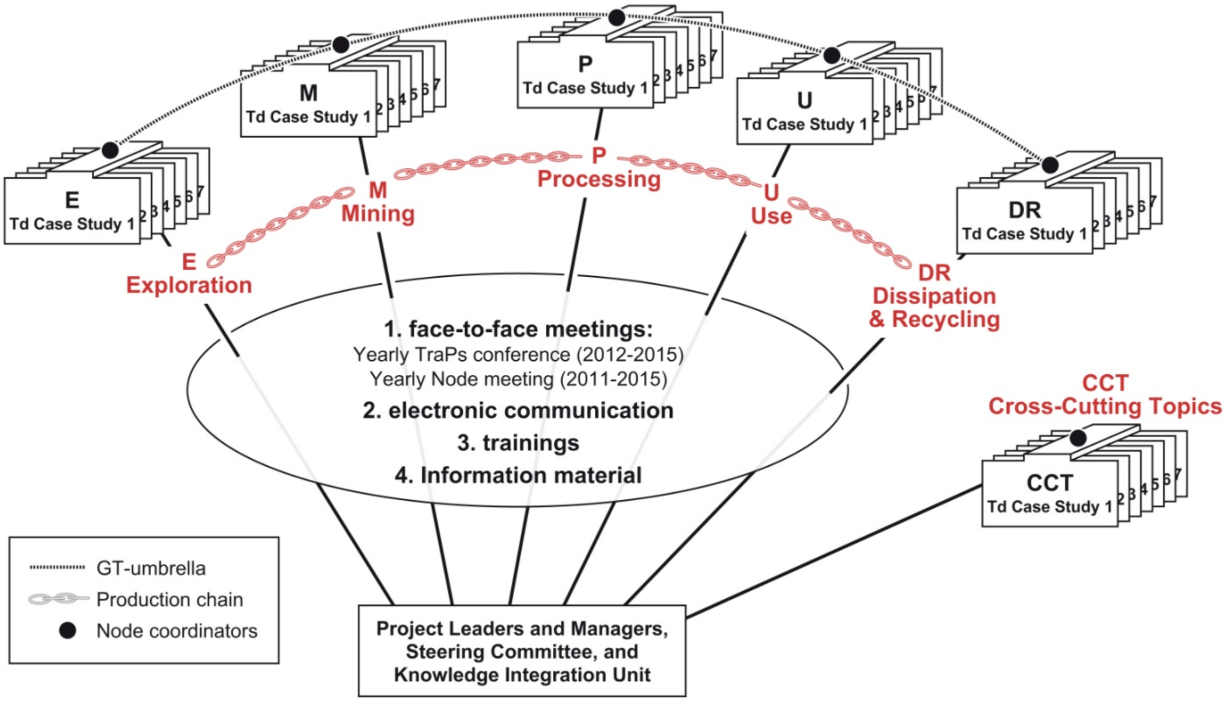

Figure 1: Design of the global transdisciplinary process for sustainable phosphorus management 2010–2015.

Why the transdisciplinary methodology?

The Global TraPs process follows the model of the NSSI ETH Case Studies on sustainable development, which have relied on the transdisciplinary methodology (see Text Box 10) developed and refined by ETH and its partner institutions since 1993. The transdisciplinary methodology has been extensively used to make progress on the management of complex environmental problems called 'ill-defined problems.' Such problems have certain characteristics: (1) both their initial state and their target state cannot be precisely described; (2) barriers to be passed through are unknown; and (3) normative issues are at stake. Examples of transdisciplinary studies[8] completed by NSSI ETH include:

- Pathways Towards a Sustainable Agriculture in the Swiss Vegetable Gardening Region "Grosses Moos" (ETH Zurich, 1993).
- Responsible Soil Use in German and Swiss Klettgau Region (ETH Zurich, 1993).
- Mobility and Sustainable Urban Development – Lundby on the Move (Chalmers University Gothenburg, 2004).
- Society and Radioactive Waste: Decision Processes in Switzerland and Sweden (ETH Zurich, 2008).

The integration of knowledge available on P management among different stakeholders is a main task and benefit of the Global TraPs project. The stakeholders in Global TraPs, as in any transdisciplinary project, have been placed into two professional groupings, each with different professional orientations. In transdisciplinary literature to date, different terms have been used to describe these groupings: science-practice, science-society and theory-practice. None of the term pairs is exact, and each has its disadvantages and advantages.

[8] Transdisciplinary case studies and other related literature can be found under www.uns.ethz.ch/translab/cs_former.

The Global TraPs project primarily will use the science-practice terminology, in particular when defining the project organization and roles. Limitations and strengths of this, and other terminology, are discussed below. (It should be noted that in transdisciplinary literature to date, different terms have been used to describe these groupings. None of the term pairs is exact, and each has its disadvantages and advantages [as discussed in Text Box 11]).

Text Box 10. Transdisciplinarity

Transdisciplinarity strives to bridge the growing gulf between many areas of research and the public. Practice and science have different reference systems. Transdisciplinary methodology initiates from a situation where decision-makers and science community participants realize that they have a joint interest in a complex, relevant phenomenon that can be better understood and dealt with if knowledge from practice and from science is integrated. Steps in the transdisciplinary process are:

- Defining a guiding question.
- Faceting (or splitting into sub-systems) the case.
- System analysis, through diverse methods, from desk studies to interviews.
- System representation, including its dynamics.
- Creating scenarios for the system.
- Multi-criteria assessment of the scenarios.
- Development of robust options.

The multiple-stakeholder/multiple-reference system operating mode transforms the process and results in diverse outcomes:

- Capacity-building for coping with ill-defined socially relevant problems.
- Consensus-building and mediation among stakeholders with conflicting interests.
- Legitimization of decisions, due to science-practice cooperation.

The transdisciplinary methodology has several advantages in comparison to more conventional research or development focused projects, and is expected to greatly help in taking the discussion and management of P forward at the global level. While much of the discussion on P during the past five years has been within diverse stakeholder groups, these stakeholders rarely interact and very seldom, if ever, come together.

Text Box 11. Reflection on the Terminology for the Two Groups in Transdisciplinarity

Science-practice: A specific strength of transdisciplinarity is that it provides knowledge integration between the discipline-based science system and practical knowledge about real world systems. Here, science represents the body of knowledge available in different scientific disciplines and in institutions established for research and the production of scientific knowledge. In contrast, practice denotes the professional organizations and the knowledge and actions produced by them, such as industry, business, agricultural organizations, and non-governmental organizations (NGOs) in Global TraPs. A strength of the science-practice terminology is that it delineates scientists as members of scientific institutions whose primary reference system is the production of knowledge and theories, published in scientific publications. A limitation is that it may seem to imply that practice is not based on science. This is definitely not true as there is a great deal of research done by such “practice” organizations as industry and governmental agencies. This research is in general more focused on industrial products and is generally not within the public domain as is generally the case for knowledge originating in “science” institutions.

Science-society: Here, science – as one part of society – is distinguished “from the rest of society.” Science denotes the people and institutions whose primary task is research and the production of knowledge, which can be used by other groups of society. This terminology has the advantage that the term “society” clearly represents the wider society, and not only stakeholder groups, and includes the fact that applied scientists are also involved in practical activities. A disadvantage of this terminology is that it may give the misperception that the “science” community is not part of society.

Theory-practice: Theory is conceived as a body of coherent hypothetical, conceptual and pragmatic principles which may form a general frame of knowledge for reasoned practical action. In contrast, practice represents the proficient actions, customs and knowledge which have developed in various domains of society. The theory-practice terminology identifies these two groups, the theorists oriented towards ideas, concepts, models and theories, and practitioners oriented towards putting those ideas into action. A disadvantage of this terminology is that it would seem to imply that the first group is only focused on theories – in contrast, much of research is done with "practice" in mind. Equally, good practice is based on some theory.

In Global TraPs, the transdisciplinary process is used to bring together all main stakeholders in the P supply chain, allowing for mutual learning and cooperation, as well as a common assessment of knowledge, values and goals. Participants of Global TraPs, as any transdisciplinary project, come from both the "practice" side (producers and users of phosphorus, along with those facilitating their efforts, such as extension and development organizations) and the "science" (researchers from various disciplines with an interest in phosphorus). Importantly, leadership between practice and science is shared, and problem definition, problem representation and problem transformation are done together.

The recent discussion on P has tended to take place within disciplinary groups or perspectives, whether economic, environmental or technical. In contrast, the transdisciplinary methodology will allow Global TraPs to go beyond disciplinary perspectives, to create a "meeting of the minds" from different disciplines and perspectives. transdisciplinary process starts with knowledge generation – from understanding to conceptualization and to analysis. It is followed by knowledge integration which takes place across not only disciplines (e.g., natural, social and engineering sciences), but also systems, modes of thought (e.g., intuitive and analytic) and finally, across different interests. Transdisciplinary methodology aims at an efficient use of the knowledge available by relating different epistemologies, in particular scientific and practice-based experiential knowledge.

Transdisciplinary methodology differs from both disciplinary and interdisciplinary methods. While disciplines are characterized by clear-cut objectives and core methods, interdisciplinarity corresponds to the fusion of concepts or methods from different disciplines. Transdisciplinary methodology, on the other hand, goes beyond the scientific knowledge. It integrates knowledge from practice with state-of-the-art interdisciplinary knowledge. Knowledge is produced within the discipline according to their individual scientific disciplinary standards and then in a second step, contrasted to each other and thus integrated in the overarching framework of the transdisciplinary methodology using a set of well-established methods such as Formative Scenario Analysis, Area Development Negotiations and Integrated Risk Management.

Most importantly, the transdisciplinary process allows Global TraPs to integrate study, knowledge generation and reflection with normative considerations – recommendations for future action. The transdisciplinary process moves beyond the sciences by incorporating decision-makers and the overall public into the research process (see Figure 2). In the process, transdisciplinary methodology integrates not only knowledge, but also values from both practice and science and emphasizes that in the theory-practice discourse, both practice and science spheres have equal rights. Global TraPs enables a process in which different stakeholders with various values and interests will meet and deliberate in a 'protected arena' about global P management and generate 'socially robust options for the future' – i.e., options that have been generated and vetted by parts of the society itself. Thus, potentially consensus is produced and interest conflicts can be mediated. These options meet the complexity of real-world problems, and can promote a sustainable development.

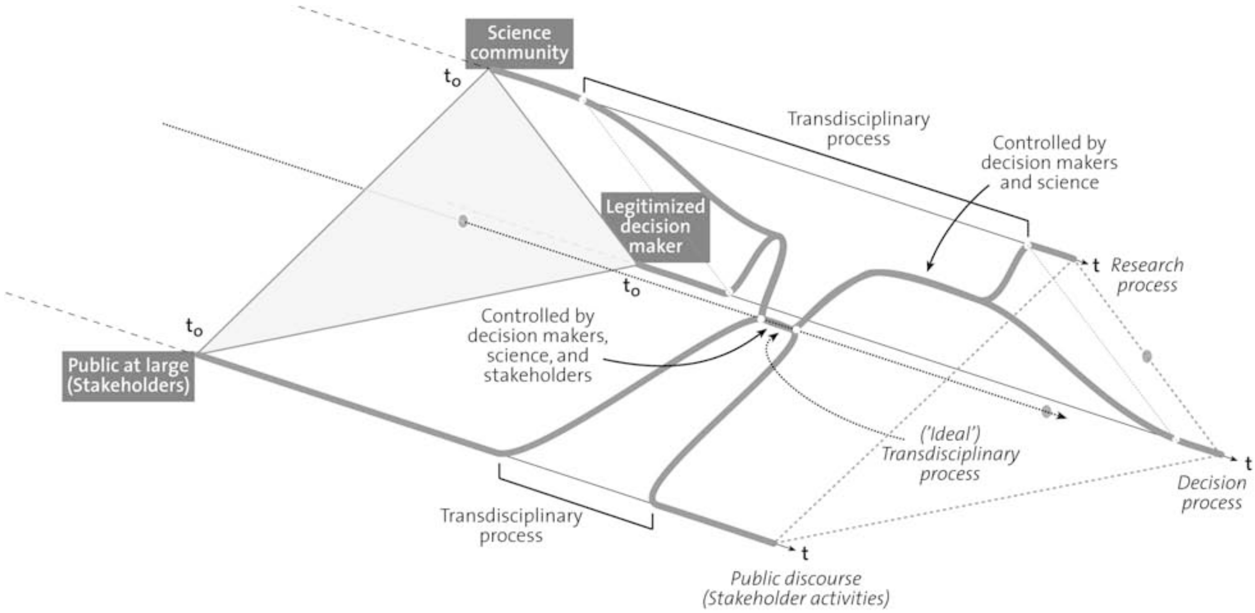

Figure 2: In an ideal transdisciplinary process the research process is controlled by science, decision-makers and the overall public – all with equal rights (Scholz, 2011).

Global TraPs participants and activities

In an ideal transdisciplinary process, there is a balanced involvement of experts from science and those from practice at each node of the P supply chain. This science-practice co-leadership and membership takes place throughout the project, with about half of participants from scientific institutions and another half coming from the practice side (i.e., industry, NGOs, business and government groups and representatives from the practice at large).[9]

Much of the preliminary effort of Global TraPs is conducted within nodes. Five of the nodes focus on the steps in the P supply chain (exploration, mining, processing, use and recycling/dissipation), and at least one on cross-cutting issues (including finance, trade and transport). Nodes are led by two leaders, one from practice, and another from science. A transdisciplinarity coordinator supports the work of the node, ensuring that perspectives and standards of transdisciplinary methodology are kept.

Within each Global TraPs node, there is roughly an equal number of science and practice participants, and a diversity of disciplines and perspectives. The number of participants in each Global TraPs node will vary, but it will typically be from 10 to 20. At the onset, each node will define a set of guiding questions for its work, which will set the direction for future efforts.

An important part of the knowledge generation process within the nodes are the case studies – location-specific, transdisciplinary studies designed to address critical questions (i.e., challenges, potential traps and opportunities around P issues in that node). A variable number of case studies per node will be conducted, but most nodes are expected to have five to seven case studies. When critical issues identified span issues in two or more nodes, case studies are organized in a collaborative manner.

Case studies in the Global TraPs project are always transdisciplinary. Most case studies are co-led by a Science and Practice Leader, but if this is not possible, substantive contribution from the other facet is sought by including a 'primary partner.' The transdisciplinary methodology coordinator of the nodes supports case study participants in the transdisciplinary methodology aspects.

Case study duration varies: some are more limited in scope and others are large and ambitious. In all, the planning and conduct of case studies are expected to take about two years, from January 2013 to February 2014. As the Global TraPs project advances, an increasing amount of effort will be spent on an interlinked node analysis, conducted in an interdisciplinary manner, and designed to facilitate knowledge creation, networking, dialogue and awareness rising

[9] For a list of current participants, see Text Box 12. This list is subject to constant updating, available on the project homepage http://www.uns.ethz.ch/gt/about/partners/affil.

between science and practice. For that purpose, Global TraPs has a "Knowledge Integration Unit" which integrates isolated initiatives to leverage a comprehensive assessment of all aspects of the P cycle, including how such issues, in turn, affect individual nodes along the supply chain projects, networks and committees with a focus on P. Such interest is welcome as it will certainly result in greater understanding about P as a global resource, the challenges in current P management, as well as better ways to manage it in a sustainable manner.

The unique features of Global TraPs

In this context, Global TraPs has a unique approach and objectives. It takes up the challenge of phosphorus as an important global issue by engaging at a truly global scale. Spanning over six years and expected to involve in its activities up to 300 participants from a minimum of 150 institutions and from all regions of the globe, Global TraPs has the potential to make a significant, global contribution. At the same time, region- and country-specific case studies will contribute to better understanding and management of P at these levels.

Through its use of the transdisciplinary methodology, Global TraPs will involve stakeholders from the entire P supply chain. Global TraPs participants will represent fertilizer, food and feed industries, research and development (R&D) organizations, mining companies and regulatory bodies, and environmental organizations (Text Box 12). Linkages, and therefore information flow and discussion among those involved in P efforts, have been limited particularly between certain supply chain nodes – especially exploration, mining and processing – and those working on other aspects of P. Given differences in institutional cultures, orientations and interests, the dialogue and consensus-building is not always expected to be easy, but offers a good basis for progress. As one of the first global transdisciplinary processes on a significant biochemical cycle, Global TraPs will also generate methodological lessons for future, similar processes.

Finally, although Global TraPs will have a strong emphasis on knowledge generation, within the transdisciplinary process, this knowledge will have partly an instrumental value as a basis for analysis and discussion and to lead to recommendations on the way forward (i.e., policy and technology options for sustainable P use). Therefore, the final goals of the project are the generation of proposals for action, as well as engagement of the actors to ensure consensus and support.

Project-level leadership and coordination

The project is a joint effort between the Zurich-based Swiss Federal Institute of Technology (ETH) and the U.S.-based International Fertilizer Development Center (IFDC). Each represents one of the important facets of the transdisciplinary process: ETH the science and IFDC the practice. The Science Project Leader is Prof. Roland W. Scholz, an expert in transdisciplinary processes and sustainable resources management (see Text Box 12). The Practice Leader is Dr. Amit H. Roy, President and CEO of IFDC (see Text Box 12). The principal project leaders have the overall responsibility for the project, including overseeing the final integration and synthesis of the project results. The project managers, Désirée Ruppen from science, and Deborah Hellums from practice – assisted by a coordinating group involving ETH and IFDC staff – assist the project leaders in their work. An ETH-IFDC project management committee assists with the operational aspects of the project. Distinguished researchers and practitioners who together represent a wide range of interests, competencies and cultural perspectives essential for the project are members of the steering committee and will oversee the project activities. The steering committee is involved in the essential decisions on goals, structure, schedule, communications and membership. Finally, other distinguished members of science and practice who support and share the goals of Global TraPs may be asked to join in as project advisors. The group of advisors will be diverse. Certain advisors may be asked to support the project because of their ability to broadly reflect on the challenges of sustainable P, while others may bring in specific, narrow expertise.

About ETH-NSSI

The Natural and Social Science Interface group (NSSI) was founded in 1993 with the mission to organize interdisciplinary research regarding cause-impact relationships of environmental problems and developing strategies for integrated research at the human and environment interface, and to conduct large-scale transdisciplinary case studies in cooperation with other research entities, corporate sector, administration and the public. The investigation and the strategic management of human-environment systems is the core subject of environmental sciences. A major challenge is the conceptualization of different levels in human and environment systems and their interaction. The complexity and contextualization of real-world problems ask for organizing transdisciplinary processes, i.e., the symbiosis of practice/experiential knowledge and science/theoretical model-based knowledge. This requires sound theoretical, methodological and procedural foundations.

An essential contribution in that respect is the book "Embedded Cases Study Methods – Integrating Qualitative and Quantitative Knowledge" published by Scholz and Tietje (2002)[10]. A blueprint to cope with this challenge is the book "Environmental Literacy in Science and Society – From Knowledge to Decisions" authored by Roland W. Scholz (2011).

NSSI collaborates with numerous scientific groups and networks nationally and internationally, including the International Transdisciplinarity Net on Case Studies for Sustainable Development (ITdNet) founded in 2002. A significant proportion of ITdNet's funding is from competitive academic funds and from industry. With industry, the group favors project funding/sponsoring over contract research to ensure independence in the research process.

Important research achievements can be ordered along three different interfaces:

- Interface of natural and social sciences, i.e., the integration of natural science oriented modeling (material flux) with social research approaches (agent analysis); integration of different socio-economic contexts in the future in life cycle assessment using scenario analysis; and review of scenario analysis as a tool to integrate knowledge from the natural and social sciences.
- Interface of the human and the environment system: the assessment of human land use impacts on the natural environment, analysis of the influence of different management strategies on long-term yield in response to the natural environment; and the impact of decisions on soil remediation and the environment.
- Interface of science and practice: contrasting exposure measurement of soil contamination with people's perception of it; integration of scientific expertise with stakeholder knowledge on bio-waste as a conceptual contribution for an improved science-society interface in sustainable landscape development; a regional learning process involving different actors from science and practitioners sustaining traditional industries in rural areas.

Thematically, the research focuses on the following topics: energy systems and technology, resource scarcity/scarce raw materials, ecosystem services, cell-environment interactions and urban and regional transitions. Though broad, the different topical fields are all investigated from a coupled human-environment perspective and thus contribute to the further theory development here. NSSI is also strongly involved in educational activities within the department through transdisciplinary case studies, special education in the Anthroposphere, major in Human-Environment Systems, and social science education.

Knowledge and Technology Transfer (KTT) is among the primary strengths of the NSSI group. The unique approach, denoted as transdisciplinarity, links research to practice and thus creates a closer and more integrated KTT. Knowledge transfer should be understood as mutual exchange and learning among theory and practice. The research presently tackles ill-defined problems and strongly relies on experiential knowledge of practice. In total, more than 1,800 stakeholders have been involved in the group's transdisciplinary projects, an important tool in public outreach.

[10] Scholz, R.W., and Tietje, O. (2002). *Embedded Case Study Methods: Integrating Quantitative and Qualitative Knowledge*. Thousand Oaks: Sage Publications, 392 p.

Text Box 12. About the Leaders

Principal Science Leader:

Roland W. Scholz is Chair of "Environmental Sciences: Natural and Social Science Interface" (NSSI) and a full professor since 1993. He is also adjunct professor of psychology at the University of Zurich (Privatdozent), and Extraordinary Professor of Management and Planning at Stellenbosch University, South Africa. He was elected as the 5th holder of the King Carl XVI Gustaf's Professorship 2001/2002 hosted at the Centre of Environment and Sustainability at Chalmers University of Technology and Gothenburg University (Sweden).

Born in April 1950, Roland W. Scholz graduated in mathematics, psychology and educational sciences (Dipl.-Math., University of Marburg, Germany, 1976), social psychology (Dr. phil., University of Mannheim, Germany, 1979), and cognitive psychology (Dr. phil. habil., University of Mannheim, Germany, 1987). He specialized in decision sciences and systems analysis, cognitive and organizational psychology, and environmental modeling, evaluation and risk assessment. His current research field is the theory of human-environment systems, environmental literacy and environmental decision-making. Specifically, he works with the theory, methodology and practice of transdisciplinary sustainable transition processes. Since 1993 he has conducted annual transdisciplinary case studies on sustainable urban, regional and organizational transitions.

Principal Practice Leader:

Dr. Amit H. Roy has been the President and Chief Executive Officer of IFDC since 1992. Under his leadership, IFDC's programs have broadened to help create sustainable agricultural productivity around the world, alleviating hunger and poverty and ensuring global food security, environmental protection and economic growth.

Roy's work has taken him to more than 100 countries. He is now leading IFDC in the development of the next generation of fertilizers, which will more effectively release nutrients when crops need them. Roy is also working to expand IFDC's successful fertilizer deep placement (FDP) technology from Bangladesh to Sub-Saharan Africa.

Before coming to IFDC, Roy was a process engineer at the Georgia Institute of Technology in Atlanta. While at Georgia Tech, he developed an innovative thermal storage system for a solar energy power plant and researched basic premises for converting water and carbon dioxide into useful fuels using high temperature solar energy. He also developed an innovative heat shield that was used by NASA in the U.S. Space Shuttle program to protect critical optical and electronic components of the shuttle.

Roy earned a doctorate and a master's degree in chemical engineering from Georgia Tech. There, he served as a charter member of the Lions Club and was elected to the Graduate Student Senate. He received a bachelor's degree with honors in chemical engineering from the Indian Institute of Technology in Kharagpur, India.

Figure 3: Global TraPs team members: 1 Roland W. Scholz (Project lead), 2 Michael Stauffacher (Td coordination), 3 Bao Quang Le (Content advisory), 4 Andrea Ulrich (PhD student), 5 Sandro Bösch (Technical support), 6 Fridolin Brand (Content advisory), 7 Maria Rey (Administration), Missing on photo: Pius Krütli (Td coordination), Désirée Ruppen (Project management)

About IFDC

IFDC's mission is to increase and sustain food security and agricultural productivity through the development and transfer of effective and environmentally sound crop nutrient technology and agribusiness expertise. Founded in 1974, IFDC is a public international organization governed by an international board of directors and supported by bilateral and multilateral aid agencies, foundations and private enterprises. More than 800 IFDC staff work in over 30 countries worldwide.

Across Africa and Eurasia, IFDC implements development projects focused on increasing the productivity and profitability of smallholder agriculture. Key areas include value chain development, introduction of best crop management practices and agro-input market development through agro-dealer development and policy support. IFDC also relies on regional, national and local partners to ensure sustainability. Across R&D efforts, training – from farmers to researchers and policy-makers – is a key activity.

Since its inception, research has been central to IFDC. The majority of IFDC's research focuses on fertilizers and soil fertility. While much of its current research is conducted at IFDC headquarters, IFDC projects are critically important for field testing.

IFDC Approach to Fertilizer Development

Fertilizers are critical to current and future food needs. Estimates are that since the 1960s, fertilizer has accounted for 56 percent of the rise in average yields and 30 percent of total production. Fertilizers also have had a key role in increasing agricultural productivity in developing countries during the "Green Revolution," which transformed agriculture in much of Asia and Latin America in the decades after World War II. Nobel Peace Prize Laureate Dr. Borlaug, characterized as the "Father of the Green Revolution," called fertilizers "the fuel that has powered [the Green Revolution's] forward surge."

Although the currently used fertilizer products enabled the great surge in agricultural production, they are often inefficient in utilization in energy and resources, and efficiencies at crop-level are often low. For the future, as aptly expressed in a recent article on food production, meeting this challenge requires new approaches and new tools: "simply using more of everything to produce more food will not work." Greater efficiency from available fertilizer resources is central to IFDC's approach to fertilizer development.

IFDC pursues improved fertilizer efficiency through diverse research efforts, including assessment and characterization of fertilizer raw materials, development of new fertilizer technologies, agronomic testing and economic analysis of fertilizer products, development of fertilizer recommendations and integrated soil fertility management practices that combine fertilizers together with organic matter for greater efficiency.

IFDC also has resources to benefit fertilizer research in developing countries. These include continued publication of scientific works on fertilizers, development of crop simulation models and decision support systems (e.g., Phosphate Rock Decision Support System [PRDSS], which predicts agronomic effectiveness and economics of phosphate rock in a given site, and FertTrade, a simulation model assessing fertilizer trade), a fertilizer pilot plant used to develop new products or improve current processes and an extensive library collection. Closely tied to these research efforts is IFDC's support and technical backstopping role in diverse areas, including in fertilizer policies and regulations at regional and national levels.

Increasingly, IFDC's fertilizer development work will be conducted through the Virtual Fertilizer Research Center (VFRC), a research initiative established by IFDC in 2010. Initial research efforts have started, including on the use of phosphate rock as direct application to reduce processing losses and cost, on low-cost, slow-release nitrogen fertilizers, on fertilizers containing micronutrients, and on multi-nutrient fertilizer from municipal sewage sludge.

Figure 4: A representative sample of the IFDC team.

Project phases and events

The project's three distinct phases span the duration of six years:

- Startup Phase (2010-2012): This includes conceptualization of the project and its process, the formation and cementing of partnerships, and definition of problems and case studies, and their processes. Securing funding for different project activities will be an important emphasis. During this phase, most case studies are initiated.
- Core Phase (2013-2014): This includes strong focus on the finalization of case studies, and thereafter, knowledge integration.

Wrap-up Phase: Focus will be on synthesis and on developing and articulating the outcomes for policy, science and public at large. There will be a strong emphasis on publishing and on participation in high-visibility fora to ensure that project outcomes are effectively communicated.

Across the three phases, several node meetings and full project meetings will take place. Approximate schedule of the planned meetings is as follow:

- Node meetings: August 2011, September 2012 and September 2013.
- Global TraPs conferences: February 2012, January 2013, January 2014 and January 2015.

The project outcomes

The Global TraPs project involves mutual learning processes on sustainable P management among science, industry and other stakeholder groups, resulting in socially robust knowledge for future P management. Numerous case studies addressing critical questions of P in all supply nodes will contribute knowledge and information to the global P discussion. In itself, the transdisciplinary learning processes of Global TraPs will build capacity at local and global scales; therefore, an important product of the Global TraPs project is the process itself.

Figure 5: The project timeline including milestones.

The Global TraPs project will engage an array of participants from science and practice to produce specific, rigorously developed, actionable outcomes around the issue of P sustainability. Global TraPs combines a high-level, multi-stakeholder platform to discuss various institutions' activities on P and a supply-chain approach in assessing the activities to produce consensus on recommendations on policies and technologies required to ensure sustainable P management. Diverse organizations and individuals will conduct research activities which are linked to Global TraPs; the outcomes of such activities will remain intellectual property of the institutions and organizations concerned. The outcomes of Global TraPs are assessments derived from the transdisciplinary process. These anticipated assessments include the following:

- The current stage of knowledge on phosphorus and its use, and new knowledge which is necessary to ensure sustainability of its use. Global TraPs will provide a forum to revisit and possibly revise estimations of resources and current reserves, including defining the term reserve in a universally acceptable way. Global TraPs will also assess current understanding of phosphorus use efficiency in agricultural systems. The project will also review methods to recycle phosphorus, based on experiences worldwide.
- New technologies which are needed to better process, use and re-use phosphorus. These include technologies on mining efficiency, crop management practices to increase use efficiency, and appropriate, location-specific ways to efficiently recycle phosphorus.
- Most valuable areas for policy intervention to ensure sustainable P use in the future, including institutional arrangements, incentives, and roles, responsibilities and commitments of stakeholders such as governments, industry, NGOs, donors and academia.

The outputs of Global TraPs will be made available for high-level national and global decision-makers in policy and politics, industry, science and development. Specific case studies and their outputs will benefit particular locations. An important outcome will be the identification of knowledge gaps to be addressed by research, whether disciplinary, interdisciplinary and/or transdisciplinary. The Global TraPs project will identify these gaps and will approach science foundations for funding needed to address them.

Core values of Global TraPs

The participants in the Global TraPs project are extremely diverse due to the many cultures, educational and technical backgrounds, and roles and interests in the society which they represent, as well as the stages of supply chain where they operate. The transdisciplinary methodology acknowledges and respects the differing interests and backgrounds of the stakeholders. Open exchanges on views and values are integral to a successful transdisciplinary process.

To be successful, the transdisciplinary process needs to operate in a precompetitive and non-politicized arena. Two rules of conduct of Global TraPs will ensure constructive dialogue leading to results with benefits for all stakeholders:

- Confidentiality of information, when requested by any participant, is respected; and
- The project will not engage in discussions, nor make recommendations on, specific, day-to-day political or geopolitical issues. Instead, the Global TraPs project deals with policy options supporting sustainable P access and management.

Text Box 13a. List of Partners from Academia

Europe

- ETH Zurich: Institute for Environmental Decisions, Institute of Energy Technology, Institute of Agricultural Sciences, Agri-Food & Agri-Environmental Economics Group (Switzerland)
- Chalmers University of Technology (Sweden)
- Federal Institute of Aquatic Science and Technology EAWAG (Switzerland)
- Institute for Social-Ecological Research ISOE (Germany)
- *Instytut Uprawy Nawożenia i Gleboznawstwaw Puławach IUNG (Poland)
- Julius Kühn Institute JKI, Institute for Crop and Soil Science (Germany)
- Leuphana University Lüneburg (Germany)
- Ludwig-Maximilians University Munich (Germany)
- Maastricht University (Netherlands)
- Norwegian University of Science and Technology NTNU (Norway)
- RWTH Aachen University (Germany)
- Tallinn University of Technology (Estonia)
- Technische Universität Darmstadt (Germany)
- University of Applied Sciences Northwestern Switzerland (Switzerland)
- University of Birmingham (UK)
- University of Graz (Austria)
- University of Natural Resources and Life Sciences BOKU (Austria)
- University of Skövde, Social Psychology Research Group (Sweden)
- University of Surrey (UK)
- Wissenschaftszentrum Umwelt, University Augsburg (Germany)

Africa

- Stellenbosch University (South Africa)
- University of the Witwatersrand, Centre for Sustainability in Mining and Industry CSMI (South Africa)

Americas

- Arizona State University (USA)
- Colorado School of Mines (USA)
- Columbia University (USA)
- Florida Industrial and Phosphate Research Institute FIPR (USA)
- Harvard University, Harvard Kennedy School of Government (USA)
- McGill University (Canada)
- Stevens Institute of Technology (USA)
- University of Arkansas (USA)
- University of British Columbia UBC (Canada)
- University of Guelph (Canada)
- University of Waterloo (Canada)

Asia

- Chinese Academy of Sciences (China)
- Hanoi University of Science (Vietnam)
- National Agriculture and Food Research Organization NARO (Japan)
- Osaka University (Japan)
- Royal University of Bhutan (Bhutan)
- Soils and Fertilizers Research Institute SFRI (Vietnam)
- Tohoku University (Japan)
- University of Tokyo (Japan)

Australia

- *University of Queensland, Sustainable Minerals Institute (Australia)
- University of Adelaide, School of Agriculture, Food and Wine (Australia)

* = Participation is currently under discussion

Text Box 13a. List of Partners from Practice

Global
- AleffGroup
- Food and Agricultural Organization FAO
- International Fertilizer Development Center IFDC
- International Plant Nutrition Institute IPNI
- United Nations Environment Programme UNEP

Europe
- Agrecol (Germany)
- AWEL Canton Zurich (Switzerland)
- *Berliner Wasserbetriebe (Germany)
- *Bioforsk (Norway)
- *Chemische Fabrik Budenheim KG (Germany)
- *Federal Institute for Materials Research and Testing (Germany)
- Federal Office for Agriculture FOAG (Switzerland)
- *Federal Office for the Environment FOEN (Switzerland)
- Fertecon Research Centre Ltd. (UK)
- Geological Survey of Estonia (Estonia)
- German Federal Institute for Geosciences and Natural Resources BGR (Germany)
- Global Phosphate Forum (Belgium)
- Greenpeace/Greenpeace Research Laboratories (United Kingdom)
- ICL Fertilizers Europe (Netherlands)
- *International Federation of Agricultural Producers IFAP (France)
- International Fertilizer Industry Association IFA (France)
- International Scientific Centre of Fertilizers CIEC (Germany)
- Keytrade (Switzerland)
- KompetenzZentrum Wasser Berlin GmbH (Germany)
- Outotec (Finland)
- Rothamsted Research (United Kingdom)
- Syngenta Foundation (Switzerland)
- Thermphos (Netherlands)
- Wuppertal Institute for Climate, Environment and Energy (Germany)
- *WWF Switzerland (Switzerland)

Africa
- Alliance for a Green Revolution in Africa AGRA (Ghana)
- Cereal Growers Association (Kenya)
- *Fertilizer Society of South Africa FSSA (South Africa)
- Foskor (South Africa)
- Namibian Marine Phosphate Ltd (Namibia)
- *Office Chérifien des Phosphates OCP (Morocco)
- Southern African Confederation of Agricultural Unions SACAU (South Africa)

Americas
- Brazilian Agricultural Research Corporation Embraba (Brazil)
- *CF Industries (USA)
- *Coca Cola (USA)
- International Institute for Sustainable Development IISD (Canada)
- *Kraft Foods (USA)
- Mosaic (USA)
- *Ostara Nutrient Recovery Technologies (Canada)
- Ressources d'Arianne Inc. (Canada)
- United States Geological Survey USGS (USA)
- *Worldwatch Institute (USA)

Asia
- Que Lam Corp. Ltd. (Vietnam)
- Research Institute for Humanity and Nature RIHN (Japan)

* = Participation is currently under discussion

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For updates about the Global TraPs effort, visit http://www.uns.ethz.ch/gt.

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