



Global foundations for reducing nutrient enrichment and oxygen depletion from land based pollution, in support of the **Global Nutrient Cycle**



Analysis, Synthesis and Interpretation - Improving Yields and Net Income for Small Landholders and Limited Resource Farmers

Prepared by: Water Stewardship, Inc

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Partners:



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About the GEF-Global Nutrient Cycle Project

Project objective: to provide the foundations (including partnerships, information, tools and policy mechanisms) for governments and other stakeholders to initiate comprehensive, effective and sustained programmes addressing nutrient over-enrichment and oxygen depletion from land based pollution of coastal waters in Large Marine Ecosystems.

Core project outcomes and outputs:

- the development and application of quantitative modeling approaches: to estimate and map present day contributions of different watershed based nutrient sources to coastal nutrient loading and their effects; to indicate when nutrient over-enrichment problem areas are likely to occur; and to estimate the magnitude of expected effects of further nutrient loading on coastal systems under a range of scenarios
- the systematic analysis of available scientific, technological and policy options for managing nutrient over-enrichment impacts in the coastal zone from key nutrient source sectors such as agriculture, wastewater and aquaculture, and their bringing together an overall Policy Tool Box
- the application of the modeling analysis to assess the likely impact and overall cost effectiveness of the various policy options etc brought together in the Tool Box, so that resource managers have a means to determine which investments and decisions they can better make in addressing root causes of coastal over-enrichment through nutrient reduction strategies
- the application of this approach in the Manila Bay watershed with a view to helping deliver the key tangible outcome of the project – the development of stakeholder owned, cost-effective and policy relevant nutrient reduction strategies (containing relevant stress reduction and environmental quality indicators), which can be mainstreamed into broader planning
- a fully established global partnership on nutrient management to provide a necessary stimulus and framework for the effective development, replication, up-scaling and sharing of these key outcomes.

Project partners:

- Chilika Development Authority
- Energy Centre of the Netherlands
- Global Environment Technology Foundation
- Government of India - Lake Chilika Development Authority
- Government of the Netherlands
- Government of the Philippines
- Government of the United States
- Intergovernmental Oceanographic Commission of UNESCO
- International Nitrogen Initiative
- Laguna Lake Development Authority
- Partnerships in Environmental Management for the Seas of East Asia
- Scientific Committee on Problems of the Environment
- University of Maryland
- University of the Philippines
- University of Utrecht
- Washington State University
- World Resources Institute

Implementing Agency: United Nations Environment Programme

Executing Agency: UNEP- Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities (GPA)



Analysis, Synthesis and Interpretation

Improving Yields and Net Income for Small Landholders and Limited Resource Farmers

Prepared for GETF as part of the Global Programme on Nutrient Management
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December 2013

Executive Summary

The two primary project tasks were to develop an initial synthesis of the current global best practices and experiences and projects in key nutrient “Hot-Spot” regions and utilize these findings to update the nutrient management learning module¹.

Previously, Water Stewardship recognized eight priority BEPs. These practices were determined under the Global Environment & Technology Foundation’s (GETF) execution of Component C: Policy Toolbox Development of the Full Size Global Environment Facility project “Global foundations for reducing nutrient enrichment and oxygen depletion from land based pollution, in support of Global Nutrient Cycle.” The priority BEPs included:

1. Nutrient Management
2. Manure Management
3. Wetland Restoration/Creation
4. Riparian Buffers
5. Conservation Tillage/Erosion Control
6. Cover Crops
7. Grazing Management
8. Ecological/Organic Production Systems

¹ The training module will not be completed until after this synthesis report has been reviewed, finalized and accepted by the project team. However, an update of the training module was partially completed during development of a training session for the International Waters Conference – 7 held in late October 2013. The presentation can be downloaded from the Water Stewardship website at: <http://www.waterstewardshipinc.org/downloads/Simpson IW-7 Training module 10-31-13.pd>

This report contains an expansion of each BEP, as case studies, using information from both the inventory of projects provided by GETF and a limited analysis of additional materials identified by Water Stewardship. Emphasis was placed upon scaling practices to fit the needs and criteria for small landholders and limited resource farmers.

No one BEP can stand alone and solve all nutrient pollution issues. Rather the key is to institute a suite of practices that can result in greater impact than the sum of the component parts. We devised a list of the top four scalable practices that when combined together will result in a high degree of nutrient and sediment control, be economically viable and thus acceptable to small landholders and limited resource farmers. These scalable practices should be considered funding priorities:

1. Keep soil covered
 - ✓ Cover crops, riparian buffers, grazing management, wetland restoration/creations
2. Minimize soil disturbance
 - ✓ Conservation tillage/erosion control, grazing management
3. Animal feed management
 - ✓ Manure management, grazing management
4. Plant nutrient management
 - ✓ Nutrient management, manure management

In order to attain scalability for implementation it may be necessary to provide incentives for implementation. To that end, we recommend that to initiate the top four scalable practices there needs to be incentive programs that funders should consider to help in implementing the practices identified. The top four incentive programs plus examples are listed below. These examples can be expanded upon or changed dependent on local conditions. However, development of incentive programs that help foster implementation of the priorities listed should have a high payback in reducing nutrient and soil loss.

1. Collaborative enterprises
 - ✓ To share the burden of land conversions for buffers & wetlands
2. Feed management
 - ✓ On-farm demonstrations, payment per kg N & P kept out of feeds
3. Novel cropping systems
 - ✓ On-farm demonstrations, seed & establishment costs
4. Mobile technologies
 - ✓ Crop & animal production information sharing plus emphasis on associated water quality protection practices



Taken together the top priority scalable practices plus incentive programs should assist small landholders and limited resource farmers in reducing their individual nutrient footprint while also impacting the larger goal of improving coastal water quality in large marine ecosystems.

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i. Introduction and report approach

Water Stewardship was given two primary tasks for this project:

- Task 1: Develop an initial synthesis of the current global best practices and experiences and projects in key nutrient “Hot-Spot” regions
- Task 2: Utilize findings from Task 1 to update the nutrient management learning module.
 - *The training module will not be completed until after the synthesis report has been reviewed, finalized and accepted by the project team.*

Task 1 was completed and is presented in Chapter 1 with the literature review included as Appendix A. Task 2 will be completed after approval of the final report but was partially completed during development of a training session for the International Waters Conference – 7 held in late October 2013. The presentation can be downloaded from the Water Stewardship website at:

http://www.waterstewardshipinc.org/downloads/Simpson_IW-7_Training_module_10-31-13.pdf

During the course of the literature review and synthesis, it became apparent that an interpretation of the synthesized information was critical to understanding the synthesized information in context to other issues and activities related to agriculture, food, energy, and water quality. It also allowed organization of the information and its application under the eight “Priority Best Agricultural Practices” developed previously as part of the GEF Living Water Exchange (<http://iwlearn.net/news/iwlearn-news/living-water-exchange-factsheets-on-nutrient-reduction-best-practices-available-online>) and identification of the most scalable practices for small landholders and limited resource farmers and identification of priority incentive funding opportunities. This discussion and interpretation is presented as Chapter 2.

Chapter 1 - Synthesis Summary

Task 1: Objective of Synthesis

- Develop an initial synthesis of the current global best practices and experiences and projects in key nutrient “Hot-Spot” regions

This Chapter represents the initial synthesis of the spreadsheet projects of the “Hot-Spot” regions and recommends items to be used in the modification of the learning module.

The output will be establishment of key priority BEPs and/or systems of BEPs in the selected sectors (i.e., agriculture, aquaculture and animal husbandry/livestock) to improve coastal water quality policies in large marine ecosystems (LMEs) and development of national nutrient reduction strategy. There is a need to evaluate the nutrient management best practices to prioritize the “low hanging fruit”/most cost effective and efficient practices for implementation and replication under the local agricultural conditions in key “Hot-Spot” regions.

The previously established eight priority BEPs were:

9. Nutrient Management
10. Manure Management
11. Wetland Restoration/Creation
12. Riparian Buffers
13. Conservation Tillage/Erosion Control
14. Cover Crops
15. Grazing Management
16. Ecological/Organic Production Systems

See website cited at the bottom of page 2 for details and descriptions of these eight BEPs.

The following synthesis report was based on information provided by the Global Environment & Technology Foundation (GETF) in spreadsheet format. Information contained in the spreadsheet was collected by GETF from a diverse range of public and private sources. A line item review for the three “Hot Spot” areas (Chilika Lake -19 references, Lake Victoria – 31 references, and Philippines/Manila Bay – 8 references) from the spreadsheet is attached as Appendix A.

For many of the inventoried references there was very limited information provided. Therefore, one of the initial tasks was to identify at least one reference per project for information by searching on project title, project manager’s name, etc.

Synthesis Overview

The provided spreadsheet information for the “Hot-Spots” contained limited cost/benefit information and quantitative or qualitative BMP efficiency information thus it was not possible to update this information on the eight priority practices in these areas.

This emphasizes the need:

1. To determine the applicability of information and project results from other regions and projects to the “Hot Spot” areas
2. To include collection of such information in new projects within the “Hot Spot” areas
3. To develop projects specifically focused on identification and quantification of impacts of BEPs along with cost and applicability information in these areas.

However there were similarities among the “Hot-Spot” areas and the associated BEPs gathered including:

1. Scarcity of fertilizers - thus the need to investigate bio-fertilizers, composts and concepts like micro-dosing.
2. Many of the areas are already degraded so there is a need to control erosion, keep the ground covered yet have a viable agriculture system. This is where the major projects appear to be headed.
3. The small size of farms presents an additional barrier to implementation of BEPs. Overcoming this will take a concerted effort by all parties. It will likely be necessary to adapt the systems approach to function at the small farm scale or to look at opportunities to aggregate small farm parcels into agro-environmental management systems to allow application of conservation systems at a landscape rather than parcel scale.
4. Alternatively, development of low cost “mini” versions” of the eight BEPs (and others) that could be adopted by small land holders with or without subsidy or external support should be pursued. Technical assistance could be provided in this scenario to help assure the BEPs are installed and/or managed to provide expected water quality impacts.

Brief Hot Spot Literature Reviews

1. Chilika Lake citations

The information provided fit well with the above cited eight Priority BEPs. This included work on wetland restoration, nutrient management, erosion control, keeping the ground covered, and buffers.

Alternatively, development of low cost “mini” versions” of the eight BEPs (and others), which could be adopted by small land holders with or without subsidy or external support, should be pursued. Technical assistance could be provided in this scenario to help assure the BEPs are adapted, installed and/or managed to provide expected water quality impacts. It would be useful to explore the 4R’s in relation to the use of bio-fertilizers especially at micro-dosing levels. Additionally, no information was found on the potential use of human and/or livestock based compost or digester waste as a safe and sanitary bio-fertilizer.

Monitoring is an important component of water quality improvement, and it is a way to set a baseline and then look at implementation impacts over time. This approach assists in answering the question - “How much would it be worth to improve water quality by ‘x’ relative to a baseline?”

The Sustainable Agriculture and Natural Resource Management Collaborative Research Support Program (SANREM) project contained the most available information pertaining to water quality improvement in Chilika Lake. The project website (<http://www.oired.vt.edu/sanremcrsp/partners/team-room/usaaid-info/>) provides the following project overview:

“Traditional agriculture in tribal and ethnic agricultural societies in India and Nepal is increasingly relegated to less productive land, often on steep slopes, resulting in lower productivity, degradation of soil and water resources, impairment of health, and loss of livelihood options... Environmental degradation has driven these tribal and ethnic communities engaged in subsistence agriculture into severe malnutrition and loss of livelihood options.

The research is organized by an innovative approach that is referred to as a "nested landscape systems approach." We begin with systems that are being used in the field, and from there we build through farm, enterprise, and watershed systems. Finally, our approach considers the broader ecological, governance, and policy systems that these other systems are nested in.”

The project is also using CAPS (conservation agriculture production systems) as an approach that aims at increasing small farmer’s agricultural productivity and food security through improved cropping systems, including maintaining a year-round soil cover, minimizing soil disturbance by tillage, and use of crop rotation systems. These are all components of the eight priority BEPs.

Both the concept of "nested landscape systems approach" and CAPS should be considered for inclusion to the nutrient management training module.

The project information available also pointed out the short comings of scaling up plot level studies to the watershed scale.

An over-riding concept, the need to bring together all interested parties for a common goal to be recognized and implemented, is imperative. This concept should also be reinforced in the nutrient management training module.

“Adaptive Nutrient Management” by providing technical assistance for farmers to adopt efficient nutrient practices and monitor the implementation results of these changes in management respective to the individual farm. The goal is to have a nutrient management plan become the farmer’s nutrient management plan.

2. Lake Victoria citations

Similar to Chilika Lake, the information provided fit well with the eight priority BEPs. This included work on wetland restoration, nutrient management, erosion control, cover crops, and buffers.

Specifically, the value of soil testing was highlighted as a fundamental component of nutrient management. Knowing soil test results and having an association between soil levels and crop needs is invaluable to avoid situations where a valuable commodity, e.g., rock phosphate, can be used where most needed.

The “micro-dosing” approach is a tool that should be used in nutrient management planning to help optimize nutrient use efficiency as well as nutrient-source efficiency. This should be part of a 4R’s approach for specific Lake Victoria conditions. This approach should be added to the nutrient management training module.

The development of a model for organic and inorganic nutrient sources as a tool to make recommendations is a worthwhile goal. The current model will have a higher impact on phosphorous utilization on phosphorous-limited soils. Additional work is needed to refine the nitrogen utilization between different sources. This work also impacts the 4R’s and nutrient management in general.

A photograph is worth a thousand words. The Food and Agriculture Organization (FAO) final project report contains a landscape photograph which clearly depicts crop farming to the waters' edge (see the Transboundary Agro-ecosystem Management Programme for the Lower Kagera River Basin – references 94-99). There appears to be a need to reduce farming activities at the river edge. A continuous buffer zone along the river edge would greatly impact water quality. Ideally this would be a forest buffer since they are already being established for carbon sequestration efforts. The existence of small landowners would compound implementation of these buffers.

The SANREM CRSP project dealing with intensive maize production, plowing and soil depletion is an ongoing project. Status reports on the project were not readily available but from the information provided in the spreadsheet, it shows the value of nutrient management, crop rotations, and conservation tillage on increasing yields - in other words - the need for a systems approach.

3. Manila Bay citations

The Participatory Approach uses the premise that one does not come to the community with a solution to the problem when farmers do not know that they have a problem in the first place, and that farmers are part of the solution. Our minimum techno-demo farms are 25 hectares, with farmer average farm holding of 2 hectares. This approach should become part of the training module.

As with the other “Hot-Spots” the project information available covered nutrient management with emphasis on production of organic fertilizers and should be incorporated in the 4R's. Also, the Manila Bay has a SANREM CRSP project to develop conservation agriculture production systems (CAPS). The research is aimed at increasing smallholder's agricultural productivity and food security through improved cropping systems. In addition to increasing food security, CAPS will contribute to and take advantage of improved soil quality and fertility.

The farming systems with CAPS will:

- Maintain a year-round soil cover
- Minimize soil disturbance by tillage
- Utilize crop rotation systems

- Promote conservation agriculture as a technologically-feasible, economically-viable, environmentally-sustainable, and gender-responsive production system that will contribute to food security of small farm communities in the Philippines.

Relative Cost- Benefits for Major BEPs

There is very limited cost-benefit information for BEP or BEP system implementation for SL-LRFs. In fact, there is limited cost-benefit information on BEPs in general. Most available information looks only at the cost of practice implementation (and occasionally operation and maintenance) versus the kilograms or tons of nitrogen, phosphorus or sediment loss reduced. Collateral costs or benefits associated with BEP implementation are either not discussed or only mentioned briefly in a qualitative manner. Additionally, for SL-LRFs, little to no information on the applicability or special considerations that may apply to implementing specific BEPs on their lands is available. In many cases, BEPs either requires substantial land retirement or are only effective over relatively large areas (landscape or hill slope scale) while the SL-LRFs cannot afford retirement and do not control activities on a landscape or hill slope level. Such factors should be considered in cost and feasibility of implementing for SL-LRFs.

A synthesis report conducted for the GEF-Living Water Exchange Project (LWE) in Eastern Europe and West Central Asia presented a qualitative cost to benefit analysis for BEPs for SL-LRFs in that region. The information is included below and appears applicable to the three “Hot Spots” discussed in this report, and to SL-LRFs in general. It not only assesses the relative cost per unit of pollutant reduction, as typical of most analyses, but also looks at collateral costs and benefits and issues that impact applicability of the BEP for SL-LRF. Additional work is needed to refine and expand this type of information and to begin to develop quantitative estimates of all types of costs and benefits where possible. Since most BEPs have been developed for large land holders and intensive agricultural production systems, it is critical to use information, such as that presented below to successfully adapt available information BEPs, including adapting the BEPs or the production systems, so they are feasible for individual or groups of SL-LRFs at a landscape, hill slope or perhaps even small watershed scale.

**Summary of costs, benefits and additional considerations for SL-LRFs for the
eight priority BEPs
(Adapted from GEF-Living Water Exchange Project Synthesis)**

BEP	Benefit Notes	Cost Comments	Linkages
Riparian Buffer Grass or Trees	For either grass or tree buffers width is the most important criteria. 10 m width should be considered minimal. If land is limited smaller width buffers are better than no buffer but have reduced efficiency	-Requires land out of crop production. -Cost of establishing grass buffer low but maintenance moderate while forest buffer establishment may be high but maintenance may be low. - over long term, buffers are very cost effective practices	Use in combination with Grazing Management/Stream Fencing
Nutrient Management	Nutrient management is a fundamental practice for nutrient pollution control. It should be considered basic and essential.	Very cost effective BEP when properly implemented to minimize nutrient use and maximize use efficiency	Use in combination with Manure Management
Manure Management	Fundamental practice for the control of nutrient pollution, especially P. Manure and/or compost utilization as a crop nutrient provides a positive return to the producer. Capture and use of methane from anaerobic digestion can also provide a positive return to the producer.	Manure storage and/or compost pads are costly; implementation usually requires financial assistance	Use in combination with Nutrient Management
Ecological/Organic Production Systems (Ecological/organic production systems are not really BEPs. They are ecosystem systems approaches that rely on organic inputs. Requirements and consumer expectations may result in many water quality BEPs being implemented)	The primary water quality benefits will be accrued through rigorous implementation of nutrient and manure management, erosion control, buffers, etc. that should be part of ecological agriculture systems. Premium prices paid for ecologically grown products makes implementation more feasible for the farmer while still enhancing income.	Marketing produce with an “ecological” label would require a level of practice verification which could add a cost but the farmer should receive a premium for the product	Needs to be established as part of an integrated systems approach

BEP	Benefit Notes	Cost Comments	Linkages
Wetland Restoration /Creation	A properly designed and managed restored wetland can be very cost effective at nutrient and sediment removal. Constructed wetlands can provide similar reductions but may offer more management challenges and are usually more costly for comparable levels of reduction.	Implementation cost can be high; maintenance costs for constructed wetlands can be substantial. Over long-term, can be very cost effective BEP, if done properly	For agricultural lands, should be linked to field-based BEPs so that per ha nutrient load to wetland is low so wetland can treat larger area
Erosion Control & Conservation Tillage (Residue Management)	Reduces tillage trips; results in Soil carbon sequestration; reduces fuel and labor costs	May require new tillage equipment or technologies that are often expensive Structural improvements to water courses can be costly and require maintenance	Link with cover crops to maximize time fields have cover; minimize bare soil time – avoid fall plowing
Grazing Management (Stream Fencing / Animal Exclusion)	Maximizes livestock production from available pasture, reduces need to store manure and import/grow feed Exclusion of domestic waterfowl and livestock from streams can provide major water quality benefits where numbers are high (in many villages). Ponds and/or corralled areas to keep waterfowl out of streams has acceptance issues with farmers but as important as keeping livestock out of streams in many SL-LRF areas, at least at current livestock densities.	The cost of prescribed grazing can be offset by better performance & production by the animal. Stream fencing provides important benefits but can be costly, particularly in this region. Stream protection, without fencing (remote watering, shade, hardened crossings, etc.) can achieve about two thirds of the benefits of fencing at a much lost cost.	Link with Nutrient Management to assure maximum biomass production and proper crediting of manure deposited on pastures
Cover Crops	Cover crops are an excellent practice to assist in utilizing residual soil N and reducing pollution potential. Additionally, cover crops reduce soil erosion, improve soil quality, creates wildlife habitat, conserves soil moisture and helps to suppress weeds.	There is a moderate cost for seeds and planting and requires either tillage or killing by herbicide or cutting of the growth in spring before summer crop is planted	Links with Erosion Control, Nutrient Management (especially if legumes used as cover crop)

Concluding Remarks

For many of the inventoried references there was little information provided. Therefore, one of the initial tasks of this review was to identify at least one reference for project information by searching on project title, project manager's name, etc. This was not always successful as noted in Appendix A. Additionally, there were references that should have more information readily available. For example, in reference 124, it would have been very helpful to have additional information readily available on scaling up pilot studies and getting all parties together.

However, there are a number of possible updates to the nutrient management learning module, as noted above. Future activities should also concentrate on 'scalable BEPs' in order to take into account the small land owner issue yet result in a significant impact on lowering nutrient pollution potential.

Further additions to the global inventory should contain a project summary URLs to bolster the other information provided which would greatly facilitate reviews and the extraction of significant information. This initial review of Hot-Spot references also was devoid of any easily identifiable cost/benefit information. As noted only 66 of the 290 global inventory references contained 'practice cost' information (column L in spreadsheet). None of the Hot-Spot references reviewed for this synthesis contained any readily available 'practice cost' information. Again, a future requirement of funded projects should include practice cost data and relevant nutrient reduction impacts.

Chapter 2 - Interpretation and Explanation of Synthesis

While the primary task of this analysis/synthesis was accomplished in Chapter 1, it became apparent that interpretation and analysis of the information in context of other agricultural activities and issues was important. It was also decided that developing specific Case Study examples with supporting discussion for each of the eight priority BEPs would provide information that could be inserted directly into the evolving Nutrient Management Toolbox. Information on practices that are more easily scalable and recommendations on priority funding incentives was also compiled from the synthesis and other sources. Chapter 2 puts the synthesis in the context of what is occurring relative to food, agriculture and the environment globally and adapts this information and previous work into materials that should be of value in the “toolbox”.

During the research stage of this project, there appeared two headlines on www.SciDev.net (weekly update 22 July 2013) that bring to the fore the underlining issues in the control of nutrient pollution: how do you reduce nutrient pollution when there is increased pressure for higher production and how does one assure that technologies from developed countries are adapted to the realities present in less developed countries.

Food security and ecologically optimum yields: The first article, [Global crop yields fail to keep pace with demand](#), argues that there is a “looming agricultural crisis” as population increases faster than yields. In Case Study #1 we present the concept of Ecological Optimum Yield versus maximum yield as a way of reducing potential N loss from agronomic crops for small landholders and limited resource farmers (SL-LRFs) while increasing yields from current low levels to the point where returns from added nutrients *begin to decrease* and losses of nutrients to water begin to increase exponentially. However this is not equivalent to maximum economic yield where nutrients are added until the cost of the nutrient equals the increase in yield generated. Ecologic Optimum Yield is a good target yield for SL-LRFs and, if applied to all low nutrient input areas, could result in major increases in total global production of a particular crop. However, if food security remains a threat once all farms are at Ecologically Optimum Yield, the question must be raised whether this is a viable approach in a higher demanding yield world. Should maximum economic yield be the long term target for these SL-LRFs despite the well documented increase in the rates of nutrient losses to water? This is a long term question since access to nutrients and efficient management of those nutrients remains an impediment to achieving Ecologically Optimum Yields will remain a challenge for decades but one that must be considered if food security remains a major concern once SL-LRFs reach Ecologically Optimum Yields.

Technologies and skill sets: The second article, Algae biofuels deemed unsuitable for developing nations, points out the difficulty that developing nations have in implementing new use technologies due to a lack of skills and in-country research. Although the article is aimed at biodiesel production from algae the same dynamic exists for other technologies. Consider the whole range of plant sensing technologies as predictive tools for crop nitrogen status.

These two paradoxes, yield versus food security and technology versus skill sets, are slowly being resolved. Technologies such as mobile phones are making it easier to provide guidance and advice to farmers in remote areas and the sharing of new developments (crop varieties, soils information, etc.). In the future, this type of basic farm information should be enriched with approaches that help to minimize water quality impacts.

Dealing with the paradoxes: The European Community as a case study: It is worthwhile to take a gross look at the nutrient management situation in the European Community (EC). The EC nations vary in the level of water quality protection implementation as we will use Germany and the Danube River Basin as comparative examples. This will be followed by a brief look at transboundary issues in respect to Large Marine Ecosystems (LMEs).

The EC Approach: The EC adopted, in 1991, the Nitrate Directive. It is designed to reduce water pollution by nitrates from agricultural sources and to prevent such pollution occurring in the future. In 2000, the EC adopted the Water Framework Directive which acts as an umbrella for a number of related directives with the main goal being that all European water bodies should achieve “good ecological status” by 2015.

An EC funded project called EUROHARP (2006-2009) encompassing 22 research institutes from 17 European countries was to provide end-users with guidance for choosing the appropriate quantification tools that will satisfy existing European requirements on harmonization and transparency for quantifying diffuse nutrient losses.² The scientific outcome of the EUROHARP project will assist in the implementation of the EC Directives in two ways: (1) It provides a resource base for choosing the right model at any one location and for any specific issue; (2) the criteria for choosing a model could be adapted as part of the Directive implementation processes, thus harmonizing implementation procedures throughout Europe. The project developed an online EUROHARP Toolbox that provides information about the nine quantitative

² Towards European harmonized procedures for quantification of nutrient losses from diffuse Sources - the EUROHARP project, 2009. B. Kronvang, S. A. Borgvang and L. J. Barkved, J. Environmental Monitoring 11:503-505.

models (tools) used and the 17 European catchments current under study. (Note: An online search for the tool box did not find evidence of its existence.)

The Common Agricultural Policy (CAP) in Europe is providing a platform to start “turning away from increasing productivity”³ and the Water Framework Directive, which forms a framework for the implementation of a Common European Water Policy, now includes all farmland. In the past, nutrient pollution from farmlands was associated with the previous design of the common agricultural policy which was slanted towards increasing productivity and the extensively indeterminate term of "Good Farming Practice"¹.

For example, in Germany an analysis of best management practices to reduce diffuse nutrient pollution from agriculture ranked those from most to least cost effective. The results of that analysis are depicted in the following two text boxes.

Most Cost-Efficient Practices – Germany²

Livestock Farms

- * Protein adapted feeding (reduce animal N)**
- * Optimize manure storage & application**

Crop Farms

- * All season crop cover**
- * Conservation tillage**

³ German Federal Ministry of Environment (2006) Evaluation of policy measures and methods to reduce diffuse water pollution - Forschungsbericht 201 24 222/01 - /04 UBA-FB 000727
<http://www.umweltdaten.de/publikationen/fpdf-l/3117.pdf> (Reference #206 in 2013 spreadsheet)

Least Cost-Efficient Practices - Germany

Livestock Farms¹

- * Reducing stock density**
- * Water margin buffer strips (expensive)**
- * Mineral N tax**

Crop Farms¹

- * Converting arable land to grassland**
- * Water margin buffer strips (expensive)**
- * Mineral N tax**

The above results show the general conclusion that water quality protection measures which have a high potential to reduce nutrient losses and, simultaneously, have only a marginal influence on farm incomes, have a higher farmer acceptance.

As will be seen in this report, the most cost-effective practices, for either farm operation type are in agreement with our results. In fact, these practices should also be scalable and adaptable to SL-LRFs.

In contrast, the Danube River Basin countries such as Moldova, Romania and Croatia are approaching nutrient management from a totally different baseline compared to Germany. Recently (November 2010) we completed a report titled Best Practice Review and Recommendations to Assess Priorities for Replication in Central and Southeast Europe and Central Asia⁴.

⁴ See the Water Stewardship, Inc. website for a copy of this report:

The report reviewed a number on projects in the Basin and summarized categories of pressures and measures of nutrient reduction practices that have been observed by existing projects. The pressures in the agricultural land sector are primarily diffuse sources while agricultural industry sources tend to be point source pressures. There are gray areas, such as manure storage platforms (a practice implemented in a range of projects), which can become point sources. We ranked nutrient/manure management as the top agricultural land practice that can most influence nutrient pollution. This may have been assumed to be part of the Codes for Good Agricultural Practice. If so we feel that nutrient /manure management should be singled out. One specific project in Romania concluded that nutrient management was the most cost effective practice to implement. This analysis agrees with similar conclusions from the Chesapeake Bay Basin.

As with the German priority listing for most cost effective practices, nutrient and manure management are also scalable and adaptable for small land holders. We consider both of these fundamental BEPs.

Transboundary Approach: Besides scalability and adaptability of BEPs to SL-LRFs projects involving Large Marine Ecosystems (LMEs) have an additional component; that is dealing with transboundary issues.

GEF and other partners have established a Transboundary Waters Assessment Program (TWAP) to facilitate work on LMEs. A series of reports (six volumes) have been published on methodology for assessment.⁵ There is no current single global program focusing on transboundary water assessment and no regular monitoring or assessment program. Therefore, baselines for assessing the health of these water bodies, or changes in them, have not been established. The goal of TWAP is that countries will integrate TWAP assessment protocols into their respective institutions.

Another outcome of the TWAP has been the development of indicators for water stress and nutrient pollution. The International Union for Conservation of Nature (IUCN) recently posted a news article on their website dated 11 June 2013 titled "Using Red List Data for Transboundary Water Resource Management". The article states that "Each transboundary river basin will use 21 simple indicators, ranging from water stress and nutrient pollution to human vulnerability and river basin governance arrangements, and will be presented as a scorecard for each basin."

⁵ GEF Transboundary Waters Assessment Programme Volume 1 Methodology for the Assessment of Transboundary Aquifers, Lake Basins, River Basins, Large Marine Ecosystems, and the Open Ocean, 2011 <http://twap.iwlearn.org/publications/databases/volume-1-methodology-for-the-assessment-of-transboundary-aquifers-lake-basins-river-basins-large-marine-ecosystems-and-the-open-ocean>

The score card results were presented as a summary of problems facing 28 LBMI Lake Basin Management Initiative) lakes. Of interest for this report were the results for Chilika Lagoon and Lake Victoria. Chilika Lagoon was currently doing worse in excessive sediment inputs, non-point source nutrients, agro-chemicals & effluent & storm water among all the 21 indicators. Lake Victoria, according to the score card, was doing worse in loss of wetlands, excessive sediment inputs, and non-point source nutrients.

It should be noted that UNEP and the University of Maryland have developed an Ecosystem Health Report Card for Chilika Lake.⁶

Of the 28 LBMI lakes studied, 21 were facing excessive sediment inputs. This was the indicator with the worse performance among the 21 indicators. It was closely followed by non-point source nutrients (16 of 28 lakes) and loss of wetlands (11 of 28 lakes).

These data show the importance in agriculture of “keeping the soil covered” and that nutrient and manure management are high impact BEPs which need to be scaled and adapted to small land holders.

Introduction to Scalable Technologies: As noted earlier the objective of this analysis/synthesis is to identify BEPs that are scalable and adaptable to small land holders and should be included in the Nutrient Management Toolbox.

There is growing interest in the adaptation and scaling of technologies for small land holders and limited resource farmers as well as the extension of new technologies (such as mobile phones) to further implement these technologies.

Of note, is the recent late 2012 USAID initiative on Scaling Agricultural Technologies to small land holders (see: <http://agrilinks.org/library/scalable-agricultural-technologies-livestock-and-aquaculture>). It is part of the USAID Feed the Future initiative and brings together a number of international partners to drive widespread adaptation, dissemination, and adoption of critical agricultural technologies. There are seven thematic tables of practices (listed below) containing a technical evidence base to scale up appropriate technologies to greater numbers of

⁶A short report on the Chilika Lake score card developed by the University of Maryland can be found at <http://www.orissadiary.com/CurrentNews.asp?id=39245>

A more in depth report can be found at: <http://www.gpa.unep.org/index.php/global-partnership-on-nutrient-management/publications-and-resources/global-partnership-on-nutrient-management-gpnm/235-chilika-lake-ecosystem-health-report>

smallholder farmers. The inventory was developed to provide examples of technologies that may be good candidates for widespread adaptation and adoption.

The information listed is still a work in progress but it does contain some practical guidance on scaling practices. The six of seven topics covered are interactive links that can be examined (click on a topic link and then search the PDF for that topic):

1. ICT and Insurance (ICT = Information and communication technologies)

<http://agrilinks.org/sites/default/files/resource/files/Technology%20Inventory%20-%20ICT%20and%20insurance%2020May13.pdf>

The use of ICT is cited for information on climate, markets financial information. The example on rice extension through mobile technology is provided here.

Example: ICT for agricultural extension services: expert advice, problem diagnosis, regulatory information

Description: Text messages to farmers to provide timely advice tailored by crop, weather conditions, and drought or flood events Databases and call centers for extension agents to receive and respond to farmer queries.

Key Impact by Region: ICT enables frequent feedback from farmers and extension agents so the services can be honed to be more useful and targeted, increasing farming precision and yields.

Constraints to Widespread Adoption: Scalability depends on availability of content as much as delivery channels. Distribution of expert services can be sustainable through direct electronic access to experts, and database access can meet some needs.

For Further Information: Modernizing Extension and Advisory Services (MEAS)
<http://www.measMextension.org/>

2. Cereals

<http://agrilinks.org/sites/default/files/resource/files/Technology%20Inventory%20-%20Cereals%2020May13.pdf>

Most of the listed items are for drought or disease resistant varieties. However, the example for nutrient management of rice is illustrative of the use of mobile technologies

Example: Nutrient Manager for rice and maize

Description: Software for web or mobile phones to make field-specific fertilizer recommendations for rice in the Philippines, Indonesia, Bangladesh, China and 4 countries of West Africa

Key Impact by Region: Use can increase yield (typically by 10-20%), nutrient use efficiency and farmer profit (performance target is at least \$100/ha extra profit).

Constraints to Widespread Adoption: Need to develop self-sustained business models for wider rollout, including packaging with other mobile phone or ICT services.

For Further Information: International Rice Research Institute (IRRI) <http://irri.org/>

3. Sustainable Intensification

This topic area covers fertility management techniques and notes a novel double legume system that “doubles” soil nitrogen and carbon storage. Below is a more detailed look at one topic, Conservation Agriculture, which does highlight the need for soil cover.

<http://agrilinks.org/sites/default/files/resource/files/Technology%20Inventory%20-%20Sustainable%20intensification%20May13.pdf>

Example: Conservation agriculture

Description: locally adapted soil cover, crop rotation, and minimal tillage practices to increase soil organic matter and moisture while decreasing erosion and runoff

Key Impact by Region: Practices produce higher and more stable yields, decreased plowing and labor requirements, long-term soil fertility, and increased rainfall capture.

Constraints to Widespread Adoption: Training and technical support are needed. Locally adapted small mechanization is helpful for planting into stubble

For Further Information: CGIAR <http://www.cgiar.org/>

4. Vegetables, Fruits, Roots and Tubers

<http://agrilinks.org/sites/default/files/resource/files/Technology%20Inventory%20-%20Vegetables%20fruits%20roots%20and%20tubers%20May13.pdf> Cites work on higher yielding, disease resistant varieties

5. Livestock and Aquaculture

<http://agrilinks.org/sites/default/files/resource/files/Technology%20Inventory%20-%20Livestock%20and%20aquaculture%20May%202013.pdf> Two systems mentioned here, cage-cum-pond integrated fish culture systems and rice-fish culture, would be good examples of Ecological Production Systems

6. Legumes

<http://agrilinks.org/sites/default/files/resource/files/Technology%20Inventory%20-%20Legumes%20May13.pdf> A common constraint is that scaling is limited by lack of quality seed of improved varieties.

Eight Priority BEP Case Studies:

Working with the Living Water Exchange, a GEF/UNDP project promoting nutrient reduction best practices in Central and Eastern Europe, we developed a list of eight priority BEPs. These practices were presented in [Best Practices for Central and Eastern Europe and Central Asia⁷](#).

The eight priority BEPs are;

- ✓ Nutrient Management
- ✓ Manure management
- ✓ Wetland Restoration & Creation
- ✓ Riparian Buffers
- ✓ Conservation Tillage & Erosion Control
- ✓ Cover Crops
- ✓ Grazing Management
- ✓ Ecological / Organic Production Systems

For the current inventory analysis we have taken each of the eight BEPs and developed them as case studies. These case studies are discussed in Chapter 3.

The Top 4 Priorities for Small Land Holders

No one BEP can stand alone and solve all the nutrient pollution issues. Rather the key is to institute a suite of practices that can result in greater impact than the sum of the component parts. We devised a list of the top four scalable practices that when combined together will result in a high degree of nutrient control, be economically viable and thus acceptable to the farm community in most cases.

⁷ For a copy of this document see: <http://www.waterstewardshipinc.org/downloads/BEPs-2-pager-Final-GETF-Version.pdf>

TOP 4

SCALABLE PRACTICE FUNDING PRIORITIES

- 1. Keep soil covered**
 - ✓ Cover crops, riparian buffers, grazing management, wetlands
- 2. Minimize soil disturbance**
 - ✓ Conservation tillage, grazing management
- 3. Animal feed management**
 - ✓ Manure management, grazing management
- 4. Plant nutrient management**
 - ✓ Nutrient management, manure management

The components of the top four are listed along with the overlapping BEPs that should be considered. Although we consider both nutrient and manure management as fundamental BEPs it is also as important to control soil loss. Therefore keeping the soil covered and performing agricultural tasks with minimal soil disturbance are equally important. Feed management is included in the list since maximizing production of milk or meat should be done with concern for dietary inputs of nitrogen and phosphorous. Keeping excess nitrogen and phosphorous out of feeds reduces the levels in manures.

Complimentary to the top four scalable practices are the top four incentive programs that funders should consider to help in implementing the practices identified.

TOP 4 INCENTIVE FUNDING PRIORITIES

1. Collaborative enterprises

- ✓ To share the burden of land conversions for buffers & wetlands

2. Feed management

- ✓ On-farm demonstrations, Payment per kg N & P kept out of feeds

3. Novel cropping systems

- ✓ On-farm demonstrations, Seed & establishment costs

4. Mobile technologies

- ✓ Crop & animal production information sharing plus emphasis on associated water quality protection practices

Development of incentive programs that help foster implementation of the priorities listed should have a high payback in reducing nutrient pollution and soil loss.

Concluding Remarks

The synthesis in Chapter 1 summarizes the information from the database relative to its application in the three “Hot-Spots” but it is important that the information also be put in context with food, agriculture, energy, and water quality globally. Food security, global or regional mandates and transboundary management issues all may play key roles in how and what we will do to minimize water pollution from agriculture, be it small landholder-limited resource farmer or larger scale, intensive, high technology farming. Considering these factors is important at all scales.

While the synthesis was focused on the three “Hot-Spots” and small landholders and limited resource farmers, the “Nutrient Management Toolbox” needs to be filled with tools that can be

used by similar farm types globally. A toolbox is only as good as the quality and diversity of tools it contains. In Chapter 2, we offer tools for using the eight priority BEPs for small landholders and limited resource farmers and priorities for scalability and incentive funding that we hope will be more broadly applicable than just to the three “hotspots”.

In Chapter 3, the eight priority BEPs are presented as priority “tools” that can start to fill the toolbox. The eight priority BEPs are key tools in addressing nutrient (and sediment) losses to water from agricultural activities and thus should be some of the first and most used tools in the toolbox. As the toolbox continues to be filled with tools for farms of all sizes, types, geography and climate, its usefulness will grow and, in all likelihood, tools developed for one set of conditions can provide the knowledge base to refine other tools, including the application of the eight priority BEPs to SL-LRFS and farms of all types and sizes.

Chapter 3 - Adding Tools to the Toolbox

Key Points, Supporting Data and Information for the 8 Priority BEPs

This chapter expands the discussion of the eight priority BEPs in Chapter 2 by creating case studies, with supporting data and information, for these priority practices. These case studies provide “tools” for the toolbox for the eight highest priority practices. While the “tools” use examples from, and are somewhat focused on, small landholders and limited resource farmers, most of the information could be applicable to agriculture at any scale with some adaptation. Thus, the “tools” presented below can serve as “base tools” for each of the eight priority BEPs with subsections added that explain how the tool would vary, be applied differently and have different environmental and production impacts for different scales, types, climates and geographic settings of agricultural production.

Each case study or “tool description and use instructions” below contains information on definitions, applicability, efficiencies and examples with a focus on options for scaling the BEPs for small land holders and limited resource farmers. Each case study is prefaced with a bullet list of “take home’ messages for each BEP. These will be useful for quickly relaying key information to policy makers, farmers and other stakeholders and can also be used in training non-technical project managers. These key points should provide a useful tool for funders in deciding what practices to emphasize and what types of incentive programs would be most beneficial to fund.

A case study discussion with supporting information on use, application and scientific and other considerations each of the eight priority BEP tools is presented below.

Toolbox BEP #1: Nutrient Management

GLOBAL PARTNERSHIP ON NUTRIENT MANAGEMENT
TOOL BOX CASE STUDY #1
NUTRIENT MANAGEMENT - "IMPACTING THE YIELD CURVE"

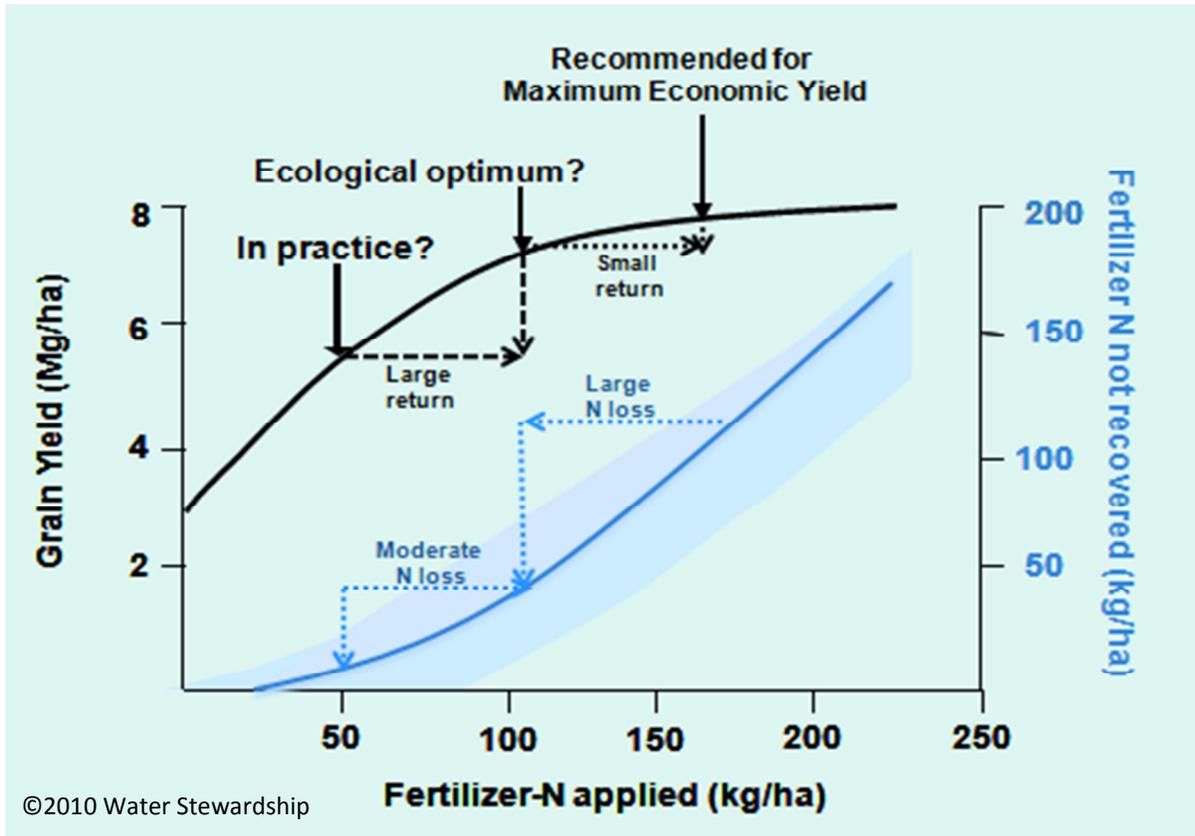
Nutrient Management – Take Home Message

- * **A fundamental BEP – “Balancing the soil and the crop”**
- * **Aim for the most efficient use of nutrients – follow the 4R’s**
 - ✓ **“right source – right rate – right time – right place”**
 - ✓ **Develop a soil testing protocol**
- * **Strive to obtain an Ecological Optimum yield goal**
 - ✓ **Devise incentive program to compensate for yield losses when Ecological Optimum yield is achieved versus maximum yield**
- * **Combine with Manure Management when livestock are present**
- * **Numerous decision support tools exist**

Overview

As agricultural production increases with increased use of nutrient inputs, a “diminishing returns” yield response curve is often used to estimate maximum economic yield. This is the point at which the yield increase from an additional unit of N has the same value as the cost of the unit of N (no return on input). This is shown schematically below.

Grain yield response curve for corn (maize) (in black) with N loss (or unaccounted for N) at different application rates showing differences in yield change versus N loss (in blue) at different N rates.



Based on a graph originally developed by the US National Research Council in 1993

As yields approach the maximum economic yield, the return per additional unit of N decreases the economic efficiency of adding additional units of N declines.

How to control N loss

- Stay at or below the Ecological Optimum
 - Perform site specific trials on N rates to determine Ecological Optimum
 - If using decision support tools select a non-maximum yield goal for you area
 - Avoid N application above the maximum recommended as an “insurance policy”
- Use slow release N inputs such as manures & composts
- Follow the 4R’s for nutrient inputs – right time, right source, right amount, right location
- Remember: the rate of N loss is a mirror image of the amount of N applied and losses increase exponentially as maximum yield is approached

Yield Curve Adaptability

Location/ Terrain: Any

Crop(s): Field crops, cereal crops

Nutrient(s): Nitrogen

Practice Efficiency

- Efficiency is a function of the level of nutrient management employed. The upper end of our current range of efficiency (16 percent) is a reduction estimate for good nutrient management using standard nutrient use and production approaches. Efficiencies could be higher in situations where there is no recent history of soil fertility planning, soil or manure testing or guidelines for agronomic use of nutrient sources. Further efforts should be made to define region or country specific nutrient management criteria for different crops and then efficiencies different from what has been developed for intensive agriculture could be developed.
- Preventing the application of N to crops at rates where high losses can occur should be a major component of the Nutrient Management Toolbox
- High efficiency

Input Costs

- Conducting rate/yield trials in site specific areas for different cropping systems
- Using available decision support tools
- Compiling/analyzing data to enhance predictability

Incentives for Implementation

- Reimburse farmer for yield loss from reduced N application that results in lower yields

Cost Effectiveness

Rank: High

Complimentary Practices

- Nutrient Management is a fundamental part of the Nutrient Management Toolbox
 - Practices such as site-specific nutrient application should also be included under the broad Nutrient Management umbrella
 - The IPNI 4R's
- All of the other 7 Priority BEPs can impact nutrient management

Dissemination of Information

- Mobile technology adaptable
- Decision support system adaptable
- Available support tools – there are any number of decision support tools for Nutrient Management. Many of these tools allow for the selection of a yield goal and can be

adapted to other crops and regions. With increased usage the datasets, thus the tool, becomes more robust. Among these are:

- **6 Easy Steps for the wet tropics** – for sugarcane producers in environmentally sensitive areas based on six steps: 1) knowing and understanding your soils; 2) understanding and managing nutrient processes and losses; 3) regular soil testing; 4) adopting soil-specific nutrient management guidelines; 5) checking on the adequacy of nutrient inputs; 6) keeping good records to modify nutrient inputs when and where necessary (reference 365 in 2013 spreadsheet)
 - <http://www.reefwise farming.qld.gov.au/pdf/smart-sugar-practices.pdf>
- **Nutrient Expert** – is a fertilizer recommendation method based on yield response and agronomic efficiency for hybrid maize, Nutrient Expert (NE), was tested in North China from 2010 to 2011 and is also known as NEHM
 - See International Plant Nutrition Institute Case Study 7-4-2 (reference #344 in 2013 spreadsheet)
 - See also <http://seap.ipni.net/article/seap-3057> (reference #264 in 2013 spreadsheet)
 - Nutrient Expert is also available for other crops including cereals in Indonesia and the Philippines, see [http://seap.ipni.net/ipniweb/region/seap.nsf/0/0A175E9C262EFBB848257B6B0026B326/\\$FILE/Nutrient%20Expert%20for%20Maize%20Manual%2002Mar10.pdf](http://seap.ipni.net/ipniweb/region/seap.nsf/0/0A175E9C262EFBB848257B6B0026B326/$FILE/Nutrient%20Expert%20for%20Maize%20Manual%2002Mar10.pdf) (reference #264 in 2013 spreadsheet)
 - There is also a 4R Nutrient Stewardship Certification Program, see <http://www.nutrientstewardship.com/>

“Hot-Spot” Example

The “Hot-Spot” example presented points out the need to build the nutrient management toolbox with information for both inorganic and organic nutrient sources. It also highlights the fact that simulation models can be applicable to small land holders.

“Hot-Spot” Project Example -Lake Victoria

Modeling Release of Nutrients from Organic Resources Using APSIM

M.E. Probert* and J.P. Dimes, pages 25-31 (Ref. number 214 in 2013 spreadsheet)

This book (see #1 on reference list) contains a series of articles on the use of a simulation model to aid in the nutrient management of both nitrogen and phosphorous from either inorganic or organic (usually manures) sources. One premise is that in tropical regions, organic materials are often more important for maintenance of soil fertility than fertilizers, yet current fertilizer recommendations and most crop models are unable to take account of the organic inputs and the different qualities of these organic inputs used by farmers.

Many of the soils in Africa are P-fixing and/or P deficient, and this book presents further modeling capability for P dynamics in these farming systems.

Analysis: The development of a model for organic and inorganic nutrient sources as a tool to make recommendations. The current model will have a higher impact on P utilization on P-limited soils. Additional work is needed to refine the N utilization between the different sources.

(APSIM – Agricultural Production Systems Simulator – a modeling framework)

Linking Simulation Modeling to Participatory Research in Smallholder Farming

Systems Peter Carberry, Christy Gladwin and Steve Twomlow pages 22-44

(See reference #2 below)

The same simulation module as cited above was also shown to be usable for smallholder farmers. The farmers found the simulation outputs to be credible and meaningful in a manner that allowed ‘virtual’ experiential learning to take place.

Options for Implementation & Scale-Up in “Hot-Spot” Areas

In order to reduce excess nitrogen inputs we need the ability to implement results from simulation models as demonstrated in the Lake Victoria case with the Yield Curve presented at the beginning of this case study and simultaneously trying to attain the Ecological Optimum yield. The pushback is that the Ecological Optimum will not necessarily be the highest yield which can impact the farmer’s economic gains and might be worrisome to those concerned with food security. As noted, an incentive program to pay farms the difference in “maximum”

versus “ecological optimum” yield is one way to overcome this potential pushback. Any payment scheme needs to take into account the beneficial impact of limiting excess nitrogen that may cause detrimental effects elsewhere.

The ability to perform both soil tests and manure analyses noted in a number of projects coupled with the establishment of Codes of Good Agricultural Practices are essential steps in achieving nutrient management. Options include:

- Matching nutrient use to the yield potential based on other aspects of management such as weed control, plant population, pest management, and other factors. As an example, do not feed the weeds, if weeds or other management factors are going to limit yields.
- Assuming the management required in the above is met, then match nutrient additions with yield potential based on soil, rainfall and temperature regime. From the yield response curve discussed above fertilizer applications should be calculated to achieve the Ecological Optimum yield. In so doing the potential for nitrogen pollution is greatly lowered and one achieves better nitrogen use efficiency.
 - Many farmers in “Hot-Spot” regions are probably below recommended or ecological rates due to economic constraints. As nutrient application rates increase, yield goals should be based on the ecological optimum which will greatly reduce nitrogen loss and the return on additional fertilizer diminishes above that point.
- In addition to the amount of nutrient to apply, the timing and method of application need to match the crop needs (the 4R’s)

“Hot-Spot” References

1. Modeling Release of Nutrients from Organic Resources Using APSIM, M.E. Probert and J.P. Dimes, pages 25-31, In: Modeling Nutrient Management in Tropical Cropping Systems, 2004, Editors: R.J. Delve and M.E. Probert, <http://aciar.gov.au/files/node/542/pr114.pdf>
2. Linking Simulation Modeling to Participatory Research in Smallholder Farming Systems, Peter Carberry, Christy Gladwin and Steve Twomlow, pages 22-44, In: Modeling Nutrient



Management in Tropical Cropping Systems, 2004, Editors: R.J. Delve and M.E. Probert,
<http://aciar.gov.au/files/node/542/pr114.pdf>

Toolbox BEP #2: Manure Management

GLOBAL PARTNERSHIP ON NUTRIENT MANAGEMENT
TOOL BOX CASE STUDY #2
MANURE MANAGEMENT

Manure Management – Take Home Message

- * Along with Nutrient Management a fundamental BEP**
- * Optimize animal nutrition for both nitrogen & phosphorous**
 - ✓ Incentive programs to optimize animal diet have high return**
- * Provide proper collection/storage to maximize nutrient content**
- * Manure handling structures are scalable to community level**
- * Devise an incentive program to construct storage facilities**
- * Can reduce/replace costs of synthetic fertilizers**
 - ✓ Develop a manure nutrient testing protocol**
- * Can be part of an organic production system**
- * Composting is a viable option**

Overview

In livestock and poultry production areas manure management is an important tool in the Nutrient Management Toolbox. Manure management is critical to the efficient use of nutrients but mismanagement can become a critical source of nutrient pollution. Except for grazing animals manures and litter are stored prior to use. The storage facility may be a simple concrete cement pad & walls structure for composting manures, as seen below, or a more formidable structure, as depicted above, for storage of semi liquid dairy manure. In either case the goal is to retain as much of the nitrogen in the manures as possible due to its volatility and solubility as compared to phosphorous. The later 'moving' primarily associated with particulate matter.



Demonstration composting pad in Slobozia Mare, Moldova (T. Simpson 2012)



Looking across the top of a concrete manure storage facility (WSI photo)

Manure management deals primarily with the proper collection, storage and handling of manures and the management of animal confinement area runoff, where animals are confined for significant periods. This includes the ability to evenly apply the manure at the appropriate agronomic rate, as determined in the nutrient management plan. Managing the amount, source, placement, form and timing of the application of manures is usually done in combination with fertilizer planning as part of the nutrient management plan.

Another important component of Manure Management is the nutritional regime of the animals when supplied supplemental feeds, and, in the case of phosphorous, the addition of Phytase to poultry feeds. Phytase, which is a microbial produced enzyme, can increase the utilization

plant-based phosphorous. This higher utilization negates the need to supplement poultry feeds with phosphorous thus reducing phosphorous in poultry litter.

Nutritional changes which do not impact animal health and productivity but reduce excreted nitrogen and phosphorous should be a high priority. It is always easier to keep excess nutrient out of the environment than to deal with them once they are part of the environment.

How to Manage Manures

- Develop a Manure Management Plan – These plans usually include the following information: storage and handling, testing (see below), how and where of land application, nutrient management, avoidance of sensitive areas (e.g., highly erodible sites). The overall goal is to optimize crop production.
 - There are numerous examples of Manure Management plans, some examples:
 - <http://www.iowadnr.gov/Environment/LandStewardship/AnimalFeedingOperations/Confinements/ManureManagement.aspx>
 - <http://www1.extension.umn.edu/agriculture/dairy/manure/manure-management/>
 - <http://www.agronomytech.com/nutrient-management-plans>
- Manure testing – when large numbers of animals are involved it is essential to obtain the best estimate of nutrient content and unless there are operational changes that effect manure composition a test should be taken about once every three years.
 - An example of the correct procedure for manure testing can be found at: http://www.sera17.ext.vt.edu/Documents/BMP_manure_testing.pdf
- Composting – composting manure is an ancient practice that has both advantages and disadvantages
The Us Environmental Protection Agency has an information website on composting that can be a useful tool, see <http://www.epa.gov/compost/>
 - Advantages
 - Concentrates Nutrients
 - Easier to transport
 - Composting Kills Parasites
 - Usable in organic systems.
 - Usable on land where food is grown for direct human consumption
 - Kills weed seeds
 - No odor when spread

- Disadvantages
 - Loses about half the available nitrogen
 - Releases greenhouse gases
 - Need to have a composting area
 - Need to control rainfall runoff from the composting area
 - Difficult to do with liquid manure

Manure Management Adaptability

Location/ Terrain: Avoid sensitive sites

Crop(s): Any

- Note: In the U.S.A. certified organic farmers are prohibited from using raw manure for at least 90 days before harvest of crops grown for human consumption

Nutrient(s): Effects both nitrogen and phosphorous

Practice Efficiency

- In intensive confined animal agriculture, it is assumed that only 15 percent of swine and poultry manure (since they are usually confined) and 20 percent of beef, dairy, sheep, goat, and horse manure have the potential to be lost during storage and handling. This is assumed for all manure loads, with or without an Animal Waste Management System (AWMS). If an AWMS is in place, the nitrogen and phosphorus load from manure that can be lost during storage and handling is reduced by an efficiency of 75 percent for nitrogen and phosphorus. These assumptions and efficiencies will likely only apply to large scale or “industrial” animal operations.
- For smaller scale animal operations efficiencies should be higher due to the greater attention by small operators to their herds.

Input Costs

- Structural costs for handling and storage
- Equipment costs for proper application, newer techniques use injection
- Technical assistance especially for proper compost production.

Incentives for Implementation

- Incentive program to construct handling and storage facilities

- Incentive program for compost platform construction

Cost Effectiveness

- Rank: High

Complimentary Practices

- Nutrient Management
- Grazing management
- Organic production systems

Dissemination of Information

- Mobile technology adaptable
- Decision support system adaptable
-

“Hot-Spot” Example

Anatolia Watershed Rehabilitation Project - Turkey

(Reference number 64 in 2013 spreadsheet)

Project Objective

To reduce the discharge of nutrients (nitrogen and phosphorous) and other agricultural pollutants into surface and ground waters of Turkey and the Black Sea through integrated land and water management and ecologically sustainable use of natural resources-

Project Approach

Farm-based manure storage platforms with a goal of establishing manure management systems for 10 percent of the households in the project area.

The platforms are also being used for composting. In areas with limited animal numbers per farm, community-scale manure storage/handling facilities may be more economical.

Project Results

The Turkey Anatolia Watershed Rehabilitation Project has constructed about 335 farm-based manure storage platforms with a goal of establishing manure management systems for 10 percent of the households within each of the 28 micro-catchments in the project area. The platforms in addition to helping store manure are also being used for composting. Both manure and compost use is gaining interest due to high fertilizer prices. Implementation of these manure management strategies is being complimented by increased water quality monitoring.

Options for Implementation & Scale-Up in “Hot-Spot” Areas

Projects that include the installation of manure storage platforms should consider that these platforms can also be used, when modified, for improved storage or for composting. The utilization of stored or composted manure should follow nutrient management guidelines for rates, incorporation, timing and amounts. Farm or community scale manure storage and management is critical both to environmental and economic improvement.

Options include:

- Composting as a management option
 - Consider manure storage/composting as a community-scale operation since amounts of manures may not justify single producer use for small scale livestock units
 - Proper management and monitoring of placement and removal of materials at a community compost site is very important. If cost prohibits having an individual act as site monitor, farmers should be asked to sign an agreement to record all materials emptied onto the pad and compost removed from the pad. The pad should also only receive manure or other pre-determined easily compostable material. The ability to maintain proper moisture content and turn the composting material once every week or two is also critical to creating good compost.
- Manure storage in tanks, lagoons, or bins helps to stabilize the material including the nitrogen content.
- Farm or community scale anaerobic digesters to stabilize manure and generate methane for heat or energy should also be considered

Toolbox BEP #3: Wetland Restoration or Creation

GLOBAL PARTNERSHIP ON NUTRIENT MANAGEMENT

TOOL BOX CASE STUDY #3

WETLAND RESTORATION / CREATION

Wetland Restoration / Creation – Take Home Message

- * **Design and maintenance are critical for successful operation**
- * **Wetlands have their greatest application as the final component of a multi-step treatment system that reduces nutrient and suspended solids in runoff from diffuse sources.**
- * **Other BEPs can significantly impact function of wetlands by reducing inputs before reaching the wetland including:**
 - ✓ **Riparian buffers**
 - ✓ **Conservation tillage & erosion control practices**
 - ✓ **Nutrient and manure management**
 - ✓ **Cover crops**

Overview

It is important to distinguish wetland restoration from wetland creation. Agricultural wetland restoration activities re-establish the natural hydraulic condition in a field that existed prior to the installation of subsurface or surface drainage. In contrast, “wetland creation” establishes a wetland in a place where none previously existed. Created wetlands may use artificial or highly engineered hydrology. Often created wetlands have regulated water inputs, with water being pumped or fed in at steady controlled rates. In contrast, restored wetlands generally have natural or unregulated water inputs, with water entering through surface or subsurface flows at variable uncontrolled rates.

Wetland Restoration: Returning natural/historic functions to a *former* wetland results in a gain in wetland acres. Nutrients and suspended particles are removed via settling. Nitrogen is further removed primarily via plant and microbial uptake and nitrification-denitrification reactions, while phosphorus is further removed by soil sorption.

Wetland Creation: Developing a wetland that did not previously exist on upland or deep water site results in a gain in wetland acres. Nutrients and suspended particles are removed via settling. Nitrogen is also removed primarily via plant and microbial uptake and nitrification-denitrification reactions, while phosphorus is further removed by soil sorption.

There are four primary situations in which wetlands, when properly designed and operated, can be very efficient at nutrient and suspended solids removal. The first two situations are for treatment of flows from small to medium towns and for treatment of non-toxic industrial discharges. These usually have reasonably consistent flow rates so a wetland treatment system designed and operated to handle the flow and total nutrient and suspended solids loads could be efficient and cost effective. However, such a system will not provide pathogen removal or disinfection at needed levels.

The other application of constructed or restored wetlands would be to treat storm water runoff or drainage flow from agricultural or urban catchments. There are numerous examples of such wetlands that could provide guidance on their design and efficiency. When properly designed, constructed, operated and maintained, they can be very effective; however, they must be designed and managed differently. Unlike wastewater discharges which are relatively uniform in flow, runoff and drainage varies from nil to extremely high flows during the course of a year. As a result, some open water retention basins are usually required to allow capture of runoff from a “design storm” (usually 1-5 year return frequency) and the subsequent distribution of that water over time through the associated wetland. The other difference is that runoff treatment wetlands can go through prolonged periods where no water will enter the system. It is critical to design the wetland treatment system so that it maintains its wetland function through such dry periods or can rapidly recover when water enters it following rainfall events. Constructed wetlands have been used successfully in many locations for diffuse pollutant control. Constructed or restored wetlands may have their greatest application as the final component of a multi-step treatment system that reduces nutrient and suspended solids in runoff from diffuse sources.

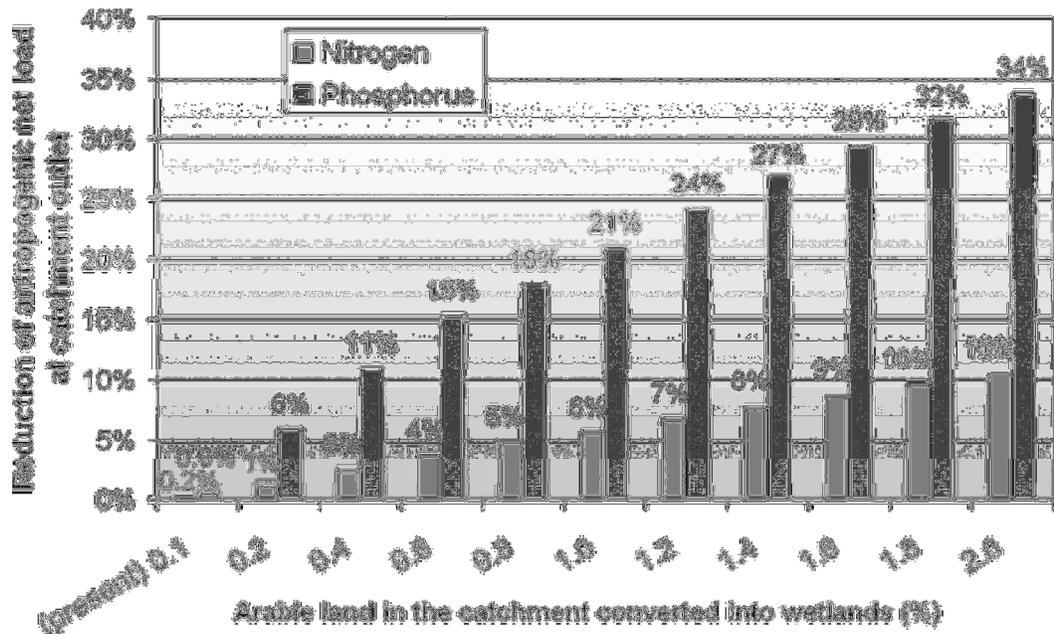
Wetlands Benefits

- Improves infiltration and runoff characteristics
- Improved water quality by collecting and filtering sediment, nutrients, pesticides and bacteria in runoff
- Reduces soil erosion and downstream flooding by slowing overland flow and storing runoff water
- Wetland plants and ponded conditions utilize trapped nutrients, restore soil organic matter and promote carbon sequestration

- Provides food, shelter and habitat for many species and enables the recovery of rare or threatened plant communities
- Connects fragmented habitat when part of a larger complex of wetlands
- Increased groundwater recharge

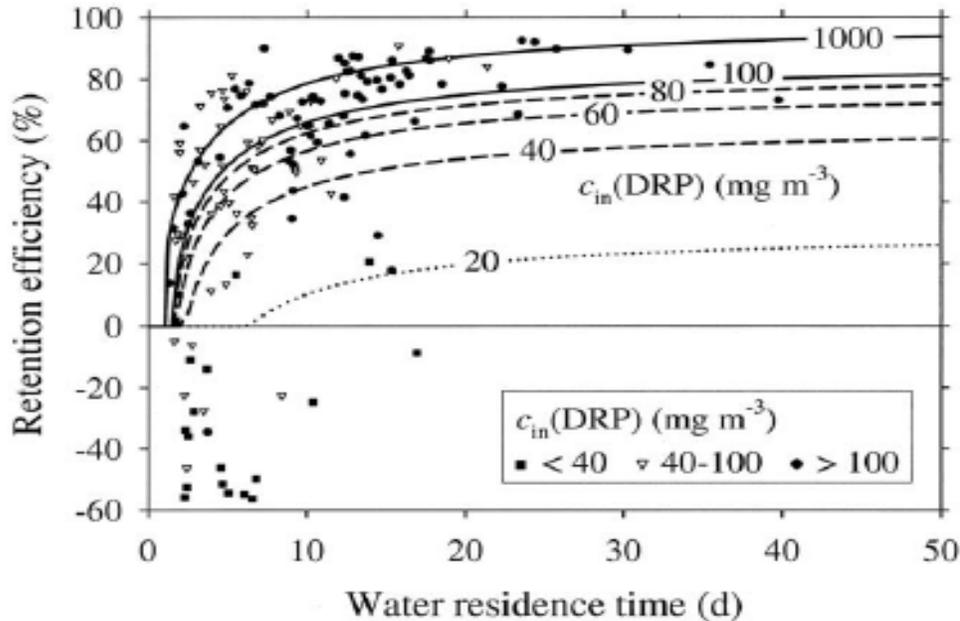
Practice Efficiency

- Total nitrogen and total phosphorous removal depends on wetland size compared to catchment area and/or flow. Understanding temporal flow conditions is absolutely necessary to provide estimated effectiveness. The graph below depicts the effectiveness of nitrogen and phosphorous removal from wetlands as the ratio of land in wetland to watershed size increases. There is a nearly linear increase in removal efficiencies as the percentage of the watershed area occupied by wetlands increases.



Reduction efficiency based on wetland as percent of small catchments

For all treatment wetlands, but particularly constructed wetlands, efficiency is a function of retention time, with generally 3-7 days retention required for optimal efficiency. The figure below shows the removal of dissolved reactive phosphorus as a function of retention time. Nitrogen removal would be similar and suspended solids are removed more quickly (about 50 percent as much detention time).



Removal rates of dissolved reactive phosphorus (DRP) as a function of water residence time in a constructed (or restore) wetland.

Input Costs

- Size and scope dependent
- Restored or created dependent

Incentives for Implementation

- Incentive programs to help defray costs

Cost Effectiveness

- Rank: High when properly constructed and maintained

Complimentary Practices

- Nutrient management
- Manure/pasture management
- Erosion control

Dissemination of Information

- Numerous designs/systems available
- Decision support system adaptable

“Hot-Spot” Examples

Wetlands Restoration to Reduce Nitrate Pollution Bulgaria – GEF/World Bank Wetland Restoration and Pollution Reduction Project

Objective: to demonstrate reduction of transboundary nutrient loads and other agricultural pollution in the Danube River and the Black Sea Basin through wetlands restoration and protected areas management programs.

Expected Outcomes: Based on a technical assessment of the nutrient trapping capacity of the wetlands to be restored in Belene Island and Kalimok/Brushlen marshes, an expected maximum of 800 tons of nitrogen and 40 tons of phosphorous could be reduced annually.

This would account for approximately 5 percent of Bulgaria’s total nutrient contribution to the Danube.

Analysis: a good example of a cost effective use of restored wetlands.. Over time, a better quantification of nutrient reductions will be gained but the project presently is a model with a high replication value.

Nutrient Pollution Reduction of Urban Effluent and Rehabilitation of Floodplain Wetlands Hungary - GEF/World Bank Nutrient Reduction Project

Objective: to decrease nutrient discharges into the Danube River and loads to the Black Sea, by improving the nutrient reduction performance of the N. Budapest sewage treatment plant and re-establishing nutrient retention capacity of the downstream Danube flood plains

Expected Outcomes: Expected Outcomes:

Total Nutrient Reduction from North-Budapest Wastewater Treatment Plant:

- N total 2,945 tons/year
- P total 310 ton/year

Total nutrient reduction of Wetland Restoration/Flood Area Revitalization:

- N total 5,500 tons/year
- P total 264 tons/year

Analysis: Restoration of wetlands, particular in riverine floodplains, is of high importance to the restoration of coastal waters. Given the ample capacity they have to act as nutrient filters, wetlands generate significant N and P load reductions.

However, to date the impact of such floodplains and wetlands connected to rivers on nutrient reduction has not been systematically documented (water depth, timing of flooding, vegetation etc.) and hence the outcomes remain difficult to predict in quantitative terms.

This project is developing knowledge and technical data to better understand the mechanism of nutrient reduction and facilitate their replication.

Options for Implementation & Scale-Up in “Hot –Spot” Areas

Wetlands are used to treat agricultural runoff and raw wastewater. The wetland needs to be designed and sized to allow adequate water residence time in the wetland to provide treatment.

For agricultural wetlands, there needs to be adequate storage capacity to account for storage of water from a “design storm” or if design and management allowed wetland hydrology, biology and vegetation to remain viable during dry periods so the wetland would function properly when runoff events did occur.

For wastewater treatment, wetlands are usually only cost effective for relatively small villages and towns. It is desirable that the wastewater be disinfected before entering the wetland.

Options include:

- Wetlands provide limited pathogen removal or disinfection capacity and do not replace primary wastewater treatment followed by disinfection when used for nutrient removal.
- Consideration needs to be given to the amount and composition of the water entering the wetland and the retention time of the water within the wetland.
- Biomass production by the wetland can be harvested.

Toolbox BEP #4

GLOBAL PARTNERSHIP ON NUTRIENT MANAGEMENT TOOL BOX CASE STUDY #4 RIPARIAN BUFFERS

Riparian Forest or Grass Buffers – Take Home Message

- * The first 10m of width is critical for nitrogen removal
- * Buffers have a low to moderate phosphorous removal efficiency
- * Requires conversion of arable land
 - ✓ Incentive programs to offset land conversion
- * Use with cover cropping systems and erosion control practices to keep soil covered
- * An adaptable BEP
- * May require “pooling” of resources to spread farmer impact

Overview

Riparian Buffers

These can be either forest or grass. They should receive no fertilizer or manure addition, livestock should be excluded (including geese) and runoff should be controlled so it enters the buffer as sheet rather than channelized flow.

***The first 10m of width it critical for nitrogen removal.

***Buffers generally have a low to moderate phosphorous removal efficiency.

Riparian Forest Buffers

Riparian forest buffers are defined as areas of trees, usually accompanied by shrubs and other vegetation, that are adjacent to a body of water which is managed to maintain the integrity of stream channels and shorelines; to reduce the impacts of upland sources of pollution by trapping, filtering, and converting sediments, nutrients, and other chemicals; and to supply food, cover, and thermal protection to fish and other wildlife. The recommended buffer width



for riparian forest buffers on agricultural land is 30m. In the Chesapeake Bay watershed a 10m minimum width is required for nutrient reduction credit.

Operation and Maintenance: Must control invasive species annually for first 5-10 years; New plantings must be protected from grazing during establishment; Weeds should be controlled; Survival should be checked and areas should be replanted as necessary; Maintenance mowing may be needed

Co-Benefits: Stabilizes stream banks and reduces erosion; Creates wildlife habitat; Enhances aquatic habitat by shading, filtering, and moderating stream flow; Improves aesthetics; Improves soil quality and increases soil organic matter; Sequesters carbon; Improves ground water and local surface water quality; Improves stream water temperature; Increases biodiversity; Provides recreational activity opportunities; Reduces air pollution

Riparian Grass Buffers

Riparian grass buffers are defined as areas of grasses that are adjacent to a body of water which is managed to maintain the integrity of stream channels and shorelines; to reduce the impacts of upland sources of pollution by trapping, filtering, and converting sediments, nutrients, and other chemicals; and to supply food, cover, and thermal protection to fish and wildlife. The recommended buffer width for riparian grass buffers on agricultural land is 30m In the Chesapeake Bay watershed a 10_m minimum width is required for nutrient reduction credit.

Operation and Maintenance: Must control invasive species annually for first 5-10 years; Eroded areas should be identified, repaired, and reseeded; Weed control by mowing and prescribed burns may be necessary

Co-Benefits: Creates and/or enhances wildlife habitat; Provides stream bank protection; Sequesters carbon; Improves groundwater and local surface water quality; Increases biodiversity; Provides recreational activity opportunities; Reduces air pollution; Improves soil quality

Riparian Buffer Adaptability

Location/ Terrain: Any

Crop(s): Any

Nutrient(s): Most effective for nitrogen, lower for phosphorous
Sediment/soil loss

Riparian Buffer Efficiencies

- A land use conversion from cropland or hay/pasture to forest or unfertilized (native) grass is applied for each hectare converted to buffer. In addition, efficiencies are applied to the upland hectares that the buffers treat. For each hectare of buffer, four upland hectares are treated with the total nitrogen efficiency and two upland hectares are treated with the total phosphorous efficiency.
- Riparian Forest Buffer – when implemented as defined it should result in about a 46 percent reduction in nitrogen and a 36 percent reduction in phosphorous entering the waterway in addition to the landuse conversion for the buffer itself.
- Riparian Grass Buffer - when implemented as defined it should result in about a 32 percent reduction in nitrogen and a 36 percent reduction in phosphorous entering the waterway, in addition to the landuse conversion for the buffer itself.

Input Costs

- **A Special Case - Buffer Width versus Available Land**

Practices such as buffers and tree plantings, when newly installed, usually involve removal of land area from agricultural production. This is always a farmer concern but when the majority of land holdings are small, 5 hectares or less, this becomes a much larger issue. Research indicates that buffers need to be at least 10 m wide to effectively remove nitrogen. While this may not be practical, it should be done where possible and buffers implemented should be a minimum of 5 m wide.

The efficiency of the buffer decreases substantially when it is less than 10 m wide. This reduction in cropping land can be offset to some extent by using the buffers for fruit production (plum tress) or other tree species (for fuel) and/or harvesting the buffer grass as hay. Where appropriate grass and/or trees buffers should be linked to animal grazing to assure the long-term stability of the buffers and that they provide maximum nutrient removal.

Development of private farmer cooperatives could increase the size of farm operating units and allow more widespread implementation of buffers.

- Costs vary depending on type of vegetation established
- Requires maintenance

Incentives for Implementation

- Incentives to offset land conversion costs
- May require a pooling of resources to lessen the burden of conversion on one farmer
- Support buffer schemes that are mixed use such as
 - Grass and orchard tree plantings
 - Grass and fencing to allow “flash grazing” by livestock
 - Grass and biofuel crops such as Jatropha
- Environmental services payments for reduced land degradation and permanent wildlife habitat

Cost Effectiveness

Rank: High (over long-term; may have moderate to high initial establishment cost)

Complimentary Practices

- Erosion control practices
- Nutrient and manure management

Dissemination of Information

- Mobile technology adaptable
- Field demonstrations

“Hot-Spot” Examples

The UNDP/GEF Danube Regional Project – Strengthening the Implementation Capacities for Nutrient Reduction and Transboundary Cooperation in the Danube River Basin – is an example of the use of grass and tree buffers. In the Lower Elan Valley, to help restore the floodplain, a number of tree species were planted to control soil erosion and protection from agricultural practices. Elsewhere, additional afforestation was implemented. In The Olsavica Valley, grasslands were restored to act as a buffer between agricultural land and the stream. The Living Water Exchange Project in the Western Ukraine established a 5 m wide plum tree buffer along the Irshavka River. Planting trees is a good practice to retard soil erosion and should be encouraged. When trees and/or grasses are used to intercept water from agricultural lands it is imperative that information be provided on the width of the planting. Effectiveness of buffers for nutrient removal is greatly dependent on width.

Options for Implementation & Scale-Up in “Hot-Spot” Areas

- Care should be taken to better describe the type and width of buffers implemented in projects. Emphasis should be placed on not adding fertilizer or manures to buffers and excluding animals.
- Grass or forest buffers are ideal candidates for community-based action in the design, implementation and use.
- Options include:
 - Flash grazing – allow cows and other cattle to graze the buffer in spring and fall but move frequently (daily) to maintain grass cover. This would reduce efficiencies 25 percent from those above. It could be organized as a community activity. As possible, efforts should be made to minimize animals getting into the stream (graze on cool days, tethered livestock, “herdsman” to direct animal grazing, etc.).
 - Hay harvesting – once a year harvest the hay from the buffer, would not impact efficiencies, could be organized as a community activity; recommend that harvest be delayed until after nesting birds fledge to maintain the wildlife and biodiversity benefits of the buffer.
 - Mini-Buffer – 5m width – when land is limited, this would result in a 50% or greater reduction of efficiencies. Mini-buffers could be cut for hay manually or with walk behind mowers, with timing as described above; flash grazing not recommended.

Toolbox BEP #5

GLOBAL PARTNERSHIP ON NUTRIENT MANAGEMENT

TOOL BOX CASE STUDY #5

CONSERVATION TILLAGE & EROSION CONTROL - "KEEPING THE SOIL COVERED"

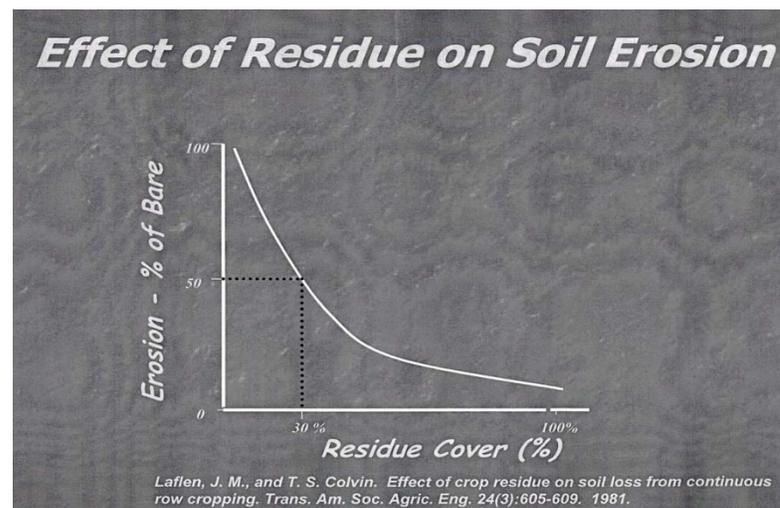
Conservation Tillage & Erosion Control

Take Home Message

- *Discontinue convention tillage (plowing)**
- *Minimize soil disturbance**
- *Leave crop residues on soil surface**
- *Incentive program for carbon sequestration**
- *Use with cover crops and riparian buffers to keep soil covered**
- *An adaptable BEP**

Overview

Soil loss is yield loss and food capacity/security loss. The importance of keeping the soil covered cannot be over emphasized. When the crop(s) are harvested the amount of residue coverage is also critical. This is depicted in the following graph.



Relationship between percent residue cover and erosion

Practices such as fall tillage and moldboard plowing leave bare soil exposed for loss to erosion during the winter, carrying much phosphorus and some nitrogen with it. The harvest of corn stalks/residue for bedding and/or fuel may be viewed as necessary at a subsistence level but it has substantial negative soil and water quality impacts. Reducing the removal of crop residue and/or instituting the use of winter cover crops, as discussed below, could greatly reduce erosion and sedimentation in the region.

Both water runoff and velocity decrease with increased residue cover and the effect on soil loss can be very dramatic as shown in the table below. The data is from a site in Indiana, USA.

Effects of Surface Residue Cover on Runoff and Soil Loss				
Residue Cover (%)	Runoff (% of rain)	Runoff Velocity (feet/minute)	Sediment in Runoff (% of runoff)	Soil Loss (tons/acre)
0	45	26	3.7	12.4
41	40	14	1.1	3.2
71	26	12	0.8	1.4
93	0.5	7	0.6	0.3

Source: Hill, P. R. and Mannering, J. V., 1995. "Conservation Tillage and Water Quality," *Water Quality*: 20. <https://www.extension.purdue.edu/extmedia/WQ/WQ-20.html>

How to control Soil Loss

- Avoid conventional tillage (plowing) operations
- Leave crop residue on field
- Grow winter cover crops
- Utilize Conservation Tillage
 - By definition conservation tillage involves the planting, growing and harvesting of crops with minimal disturbance to the soil surface through the use of minimum tillage, mulch tillage, ridge tillage, or no-till.
 - Conservation tillage systems have traditionally required two standard components:
 - A minimum of 30 percent of the soil surface covered by crop residue and/or organic residues immediately following the planting operation
(Refer to graph above)

Conservation Tillage & Erosion Control Adaptability

Location/ Terrain: Any

Crop(s): Any

Nutrient(s): Effects both nitrogen and phosphorous
Sediment/soil loss

Practice Efficiency

- Typical efficiencies for conservation tillage are about 8 percent for nitrogen and 22 percent for phosphorous and sediment.
- Reduce erosion and transport of nutrient enriched sediment and particulates
- Improve water infiltration and nutrient (phosphorous) adsorption to the soil matrix
- Improve stabilization of soil surface to impede wind and water erosion detachment and transport of nutrient enriched sediment and particulates
- Reduce the volume of runoff water reaching surface waters
- Increase temporary nutrient sequestration in soil organic matter
- High efficiency

Input Costs

- Outreach/extension service to demonstrate practices
- Operational changes to enhance crop diversity using catch crops, alley crops, etc.

Incentives for Implementation

- Buy-back program for moldboard plows and other equipment that is very disrupted to the soil surface
- Incentive program to limit use of crop residues as fuel
- Carbon sequestration payments
- Environmental services payments for reduced land degradation

Cost Effectiveness

- Rank: High

Complimentary Practices

- Living covers
 - Under certain climatic conditions such as dry winter season, farmers are prevented from the successful adoption of sustainable no-till systems. Therefore, intercropping of cereals with tropical forages has been successfully adopted in

several regions of Brazil as a means to protect the soil and obtain higher yields and higher economic return.

- This may require higher N recommendation due to plant competition
 - See :Carlos A.C. Crusciol, Rogério P. Soratto, E. Borghi and G. Mateus, 2010, Benefits of Integrating Crops and Tropical Pastures as Systems of Production (Brazil), Better Crops with Plant Food 94:2, pp. 14-16
- Alley crops, catch crops, intercropping
 - For an example of alley cropping in the U.S.A. see http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_026696.pdf it is a USDA, Natural Resource Conservation Service Practice Code for alley cropping including a schematic on practice effects (see reference 45 in 2013 spreadsheet)
 - For an example of intercropping in Brazil see: Crusciol, C.A.C., et al. 2010. Better Crops with Plant Food. 94:2, pp. 14-16 (Reference #76 in 2013 spreadsheet), Cereals are intercropped with forages to overcome dry winter seasons which prevent farmers from successful adoption of sustainable no-till systems. The system aims to protect the soil and obtain higher yields and higher economic return and improved nutrient use efficiency. However, the system may need higher N recommendation due to plant competition

Dissemination of Information

- Mobile technology adaptable
- Decision support system adaptable – train the trainer type programs

“Hot-Spot” Examples

The Kagera River Basin project takes an integrated ecosystem approach using Sustainable Land Management including practices to help keep the land covered.

The SANREM CRSP project, in part, is looking at minimum and no-till systems to move away from plow-based tillage. An interesting project result was the work using Adlai grass (*Coix lacryma-jobi* L.) which has proven appealing from a conservation agriculture production systems (CAPS) perspective because the plant is a large biomass producer that provides mulch to control weeds and provides cover on sloping lands to minimize soil erosion.

“Hot-pot” Project Example –Kagera River Basin

Transboundary Agro-Ecosystem Management Programme (TAMP) for the Kagera River Basin. (Reference number 259 in 2013 spreadsheet)

This FAO-GEF project aims to adopt an integrated ecosystems approach for the management of land resources in the Kagera basin to restore degraded lands, increase carbon sequestration and adapt to climate change adaptation thereby leading to improved agricultural production and increased food security.

One of the benchmarks in the project is Sustainable Land Development (SLM). In order to initiate the program some traditional practices were no longer considered viable such as shifting cultivation and nomadic livelihoods and some were known to have negative environmental impacts such as burning and repetitive tillage.

New practice implementation to include improved land cover, nutrient recycling, reduce biomass losses; and to enhance systems’ diversification and resilience. Improved practices include agro-forestry, crop-livestock integration, intercropping, conservation agriculture, pasture improvement and sustainable harvesting.

An April 2013 report highlighted one of the difficulties in transboundary projects and the implementation of concepts such as SLM. The report states “...that competition for land and other natural resources are a result of peoples need to sustain their livelihoods, what differs is the dimension, level and intensity of these conflicts that vary from country to country... There are also Trans boundary resource related conflicts in the four countries besides in country conflicts.”

SANREM CRSP

Sustainable Agriculture and Natural Resource Management
Collaborative Research Support Program

LTRA-12: Conservation Agriculture for Food Security in Cambodia and the Philippines – Annual Report 2012

http://www.oired.vt.edu/sanremcrsp/documents/annual-reports/SANREM_AnnualReportFY12.pdf

This is a USAID supported project run by Virginia Tech University. After 3 years, conservation agriculture production system (CAPS) showed increasing yield of maize in CAPS compared with decreasing yield of maize grown in a plow-based system. The gross profit margin of CAPS was less than plow-based in the first two years but greater than plow-based by the third year. Furthermore, there was severe rain deficit during the first part of the 2012 cropping season and farmers saw that CAPS are more resilient to drought compared with plow-based systems. These results demonstrate the impacts of conservation tillage on both yields and soil water retention properties.

In the Philippines, although maize yields were generally the same as independent of tillage regime the general comparison of five CAPS treatments with the plow-based treatment indicated possible signs of soil quality improvement under CAPS; higher soil organic matter levels, elevated surface pH levels, and significantly higher residual soil moisture contents.

A number of models used in the study estimated that maize yield would increase by as much as 10 percent under CAPS and decrease by as much as 29% under the plow-based system. And that the time-to-peak solute availability would be delayed under CAPS which suggests that soil nutrients from fertilizers would tend to be retained at a relatively longer time under CAPS than plow-based systems thereby maximizing nutrient uptake by crops under CAPS.

Finally, results showed that Adlai grass has a huge potential for CAPS in sloping degraded acid upland soils which are prevalent in many parts of the Philippines as well in many Southeast Asia countries.

Options for Implementation & Scale-Up in “Hot-Spot” Areas

Where fall tillage and moldboard plowing are very common this leaves bare soil exposed for loss to erosion during the winter, carrying much phosphorus and some nitrogen with it. Maintenance of crop residue or a winter cover crop could greatly reduce erosion and thus sediment and phosphorus losses. For example, the harvest of corn stalks/residue for bedding

and/or fuel may be viewed as necessary at a subsistence level but it has substantial negative soil and water quality impacts. Reducing the removal of crop residue and/or instituting the use of winter cover crops could greatly reduce erosion and sedimentation.

Systems changes at times will bring to the fore a competition for resources. The research and demonstrations noted above are long term projects. If the goal is enhance productivity and food security that should over ride short allocation of resource issues.

Bring new crops, such as Adlai grass, into conservation agriculture systems also requires time to be able to identify year to year variation, soil/topographic adaptation issues and farmer acceptance.

Toolbox BEP #6

GLOBAL PARTNERSHIP ON NUTRIENT MANAGEMENT TOOL BOX CASE STUDY #6 COVER CROPS

Cover Crops – Take Home Message

- *Vital in keeping soil covered**
- *Reduces sediment movement & utilizes excess nutrients**
- *Use with reduced tillage & nutrient management BEPs**
- *Devise an incentive program for seed costs and establishment**
- *An adaptable BEP**

Overview

Cereal cover crops reduce erosion and the leaching of nitrogen to groundwater by maintaining a vegetative cover on cropland and holding nutrients within the root zone. This practice involves the planting and growing of cereal crops with minimal disturbance of the surface soil.

In order to qualify as a true cover crop, nutrients must not be applied (e.g., manure, commercial fertilizer, compost). If possible, the cereal can be harvested early for hay or silage and the subsequent crop can be planted directly into the residue, thus providing erosion control through “no-till”. If the cereal is not harvested as hay, it can be killed/suppressed early in spring by mowing or with herbicides, and the summer crop can be planted into the residue. If the residue is left, it will provide nutrients to help the summer crop grow.



Cereal cover crop planted after maize harvest. Note how well ground is covered.

If ecologically optimum nutrient application rates are made, they should be adjusted for the nutrient provided by the residue.

In addition to cereal cover crops, legumes may be used as cover crops. In addition to providing a vegetative ground cover they can provide up to 100 kg/ha of nitrogen for the following crop.

Benefits of Cover Crops

The significant benefits listed below vary by location and season, but at least two or three usually occur with any cover crop

- Reduce fertilizer costs – especially with legume (nitrogen fixing) cover crops
- Suppresses weeds therefore reduces the need for herbicides and other pesticides
- Improve yields by enhancing soil health
- Reduces soil erosion
- Conserve soil moisture
- Improves soil quality, increase soil organic matter
- Protect water quality
- Improves water infiltration
- Creates wildlife habitat

Cover Crop Adaptability

Location/ Terrain: Any

Crop(s): Varying depending upon location and adaptability

Nutrient(s): Primarily nitrogen surface coverage reduce phosphorous runoff potential
Reduce soil erosion

Practice Efficiency

- Fall planted cover crops. Effectiveness varies based on planting date, species, and planting method. In the Chesapeake Bay watershed states in order to qualify as early planted, the cover crop must be planted earlier than 14 days prior to the average date of the first killing frost in the fall, while standard planted cover crops must be planted 0-14 days prior to the average date of the first killing frost in the fall. Late planted cover crops must be planted between the average date of the first killing frost in the fall and 3 weeks following that and they must be incorporated with a no-till drill system.
- Fall planted commodity cover crops. Commodity cereal cover crops differ from cereal cover crops (above) in that they may be harvested for grain, hay, or silage and may

receive nutrient applications, but only on or after March 1 of the spring following their establishment. Commodity cover crops may also be referred to as small grain enhancement crops. In order to qualify as early planted, the cover crop must be planted earlier than 14 days prior to the average date of the first killing frost in the fall. Standard planted cover crops must be planted 0-14 days prior to the average date of the first killing frost in the fall.

- For either true cover crops or commodity cover crops they need to be seeded to a high density, timely planting needed to minimize the time between crop harvest and cover crop establishment
- Summer cover crops. In the U.S.A., there is growing interest in the use of short-season summer annual legumes or grasses as cover crops and green manures in vegetable production systems. Land does not have to be taken out of production in order to incorporate cover crops into cropping systems. Cover crops are usually grown in the off-season to provide benefits to the subsequent cash crop.
- Inter-seeded cover crops. Under certain conditions it is advantageous to seed a cover crop before a cash crop is harvested to provide time for the cover crop to become established

Input Costs

- Costs for seed and establishment on an annual basis
- Costs will vary but in some USA areas seed coat is ~\$64 USD per hectare and establishment costs ~\$38 per hectare

Incentives for Implementation

- Incentive payments on a hectare basis can cover seed cost and/or seed cost plus establishment costs to reimburse farmer for any yield loss from reduced N application that results in lower yields

Cost Effectiveness

Rank: High for nitrogen
Low for phosphorous
High for sediment

Complimentary Practices

- Nutrient Management should be considered a fundamental building block for the Nutrient Management Toolbox
- Manure management for spring application to commodity cover crops

Dissemination of Information

- Mobile technology adaptable
- Decision support system adaptable
- Check list of adaptable cover crops for a given area

“Hot-Spot” Example

“Hot-Spot” Project Example

Croatia Agricultural Pollution Control Project

Overview

This is a World Bank funded project (reference numbers 74 and 217 in 2013 spreadsheet). Creating a culture of growing early planted fall cereal grain cover crops to “trap” residual nitrogen from the summer crop provide substantial soil and water quality benefits with minimal adjustments to the next summer’s crops. Cereals dominate agriculture production, occupying about two-thirds of the entire arable land.

Project Objective

The overall development objective of the project is to significantly increase the use of environmentally friendly agricultural practices by farmers in Croatia to reduce nutrient discharge from agricultural sources to surface and ground water bodies. The global objective of the project is to reduce nutrient discharge into surface and groundwater in watersheds draining into the Danube River and Black Sea.

Cover Crop Component

Rationale: Various cover crops should be grown for soil cover and prevent nutrient losses, notably during winter. If the soil is bare there is a risk of losing nitrogen. Growing crops in the autumn and early winter reduces the amount of nitrate in the soil and consequently the amount that could be lost by leaching.

Cover crop types: Crops, which could be used as cover crops - alone or in mixtures - include legumes, mustard, grasses, buckwheat, lupines, etc.

Legumes grown in winter or summer add nitrogen through biological fixation.

Winter cover crops should be sown in late summer/autumn in fields that would otherwise be bare over autumn and winter. Crops used need to have sufficient cold tolerance to endure winter temperatures.

Non-winter cover crops can be sown to fill a niche in crop rotations, to improve the soil and to prepare it for a main crop. These crops also serve as green manures, or cover crops incorporated into the soil while still green to provide nutrients.

Under-sowing (living mulch) was very well known and widely practiced in traditional farming. Unlike cover crops that are incorporated into the soil before planting the main crop, under-sown crops co-exist with the main crop during the growing season and continue to grow after the crop is harvested. The most suitable crops for under-sowing are cereals, although it can be done with some other crops.

Results: About 40% of the farmers in the project area is adopting preventive and remedial measures to reduce nutrient discharges, including the use of cover crops.

Options for Implementation & Scale-Up in “Hot-Spot” Areas

Independent of farm size or farm location leaving the soil bare at any time is potentially detrimental and the land becomes prone to soil erosion. Cover crops whether fall or summer planted can keep the soil covered and provide numerous benefits as cited above.

For example, much of the arable land in Eastern Europe and Central Asia is plowed in the fall in preparation for spring planting. This practice causes high levels of soil and phosphorus loss. The practice may be done for a combination of weed control or earlier soil warming in the spring but its detrimental impacts to soil and water likely far outweigh the perceived advantages. Creating a culture of growing early planted fall cereal grain cover crops (e.g. rye or barley) to “trap” residual nitrogen from the summer crop could provide substantial soil and water quality benefits with minimal adjustments to the next summer’s production system.

In cases where corn (maize) or other crops are left in the field until cold weather, cover crops may not be applicable or could be inter-seeded at planting, but this would require substantial demonstration and evaluation before proposing widespread adoption.

Leguminous cover crops (e.g. clover, vetch) could be planted where summer crops are harvested early enough to allow reasonable fall growth. Although not as effective at “trapping” residual nitrogen from the summer crop, microbes associated with these winter legumes can fix about 100 kg/ha for the next summer’s crop and reduce erosion, sedimentation and phosphorus loss while not increasing nitrogen loss.

Toolbox BEP #7: Grazing Management

GLOBAL PARTNERSHIP ON NUTRIENT MANAGEMENT
TOOL BOX CASE STUDY #7
GRAZING MANAGEMENT

Grazing Management – Take Home Message

- * Implementation is very “Regionally Dependent”
- * Socio-Economic issues abound
- * Land degradation control should be top priority
- * Devise an incentive programs for fencing & alternate water sources
- * Can reduce/replace costs of synthetic fertilizers
- * Can be part of an organic production system

Overview

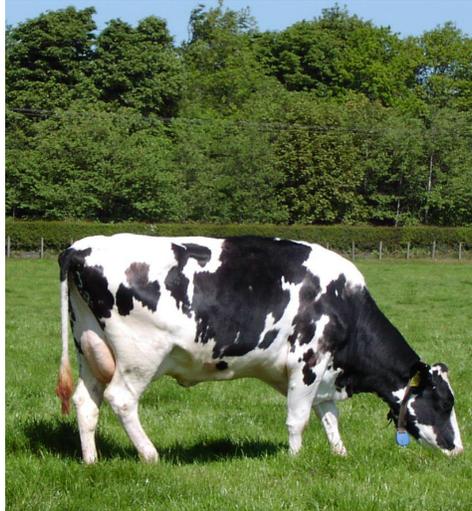
In the Chesapeake Bay watershed region Prescribed Grazing is defined as utilizing pasture management and grazing techniques to improve the quality and quantity of the forages grown on pastures and to reduce the impact of animal travel lanes or other degraded areas of the pastures.

Prescribed grazing should be applied on a continuing basis throughout the occupation period; the grazing plan should be reviewed or re-evaluated annually to determine if adjustments or modifications are needed; in-season evaluations of the current feed and forage supply are needed; the grazing infrastructure should be maintained in good working order.

In addition to grazing management two other BEPs are important considerations:

- Alternate Watering Facilities – located remotely from stream they allow livestock exclusion from streams thereby helping to protect the stream corridor.

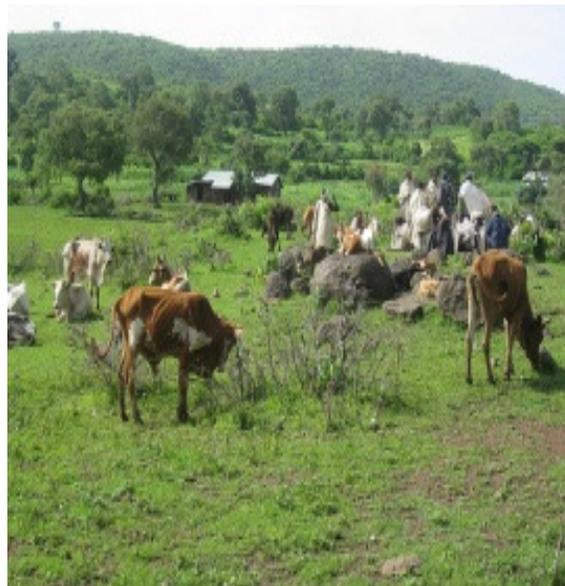
- Stream Access Control with Fencing – can allow access for stream crossing, area between fence and stream can be planted to trees or grass, width should ideally be at least 3m, reduced with will reduce efficiency



Prescribed pasture grazing

Prescribed grazing as described above could be depicted as shown in the above picture. Note the fence in the background. This type of system also eliminates the need for large manure storage lagoons and manure management then becomes pasture management.

In contract, there has been much work on grazing systems in the developing countries from pastoral to communal (as depicted below) to ranching systems.



Transferring prescribed grazing as BEP to these types of management systems is problematic. However, the underlining goal of either system should be the maintenance of the land and minimization of water quality impacts.

Grazing Management Benefits

- Improves infiltration and runoff characteristics
- Results in healthier grass stands
- Reduces need for fertilizers or other inputs
- Reduces erosion thereby eliminating land degradation
 - An efficient grazing management system will restrict the transport of soil particles in surface runoff by maintaining good vegetative soil coverage with appropriate grass/legume species that promote physical entrapment of eroded soil particles and particulate-bound nutrients,
See http://www.sera17.ext.vt.edu/Documents/BMP_grazing_management.pdf
(Reference #171 in 2013 spreadsheet)
- Improves soil health, increases soil organic matter
- Enhances wildlife habitat
- Reduces production costs associated with machinery and fuel
- Improves livestock health
- Reduces costs for nutrients, pesticides, and labor
- Water Stewardship, Inc. produced a short handout on the benefits and how to for converting a dairy to a partial year grazing system
See http://www.waterstewardshipinc.org/downloads/WSI_Information_Sheet_2.pdf

Grazing Management Adaptability

Location/ Terrain: Avoid sensitive sites

Crop(s): Regionally adapted varieties

Nutrient(s): Effects both nitrogen and phosphorous as well as sediment

Practice Efficiency

- Prescribed grazing - an efficiency of 11 percent for total nitrogen and 24 percent for total phosphorous and sediment is applied to each hectare of improved pasture that demonstrates a predominance of surface versus subsurface storm water flow.
- Alternate Watering Facilities – an efficiency of 5percent for total nitrogen and 8 percent for total phosphorous applied to each pasture hectare

- Stream access control with fencing – Off Stream watering with fencing: This BEP is meant to exclude livestock from streams. It incorporates both alternative watering and installation of fencing that excludes narrow strips of land along streams from pastures and livestock with management of the alternative watering area so it does not become a source of sediment or phosphorus. Effectiveness estimates: 25 percent nitrogen, 30 percent phosphorus and 40 percent sediment.
(Note: Stream Access Control with Fencing is actually a stand-alone best management practice but is included under grazing management for the purposes of this report)

Input Costs

- Fencing costs – dependent upon type (permanent versus movable) and composition
- Watering facilities

Incentives for Implementation

- Incentive programs to help defray costs of fencing and watering facilities

Cost Effectiveness

- Rank: High

Complimentary Practices

- Nutrient management
- Manure/pasture management
- Erosion control
- Organic production systems

Dissemination of Information

- Mobile technology adaptable
- Decision support system adaptable

Examples of grazing systems issues and comments for developing countries

The following is a small sampling of articles dealing with the cause/effect of grazing on land degradation. It is important for this discussion in that it highlights the impact of socio-economic factors on land degradation which in turn can lead to diminished water quality.

Implementation of BEPs needs to take into account these varied factors, if not they are doomed to failure. The first four articles deal with grazing system in Africa and the last deals with Asia.

The report's authors are aware that these are dynamic issues and are probably in a constant state of flux, Again the purpose is to put the grazing management BEP in a context other than what is required in developed countries.

1. Community Management of Grazing Lands and Impact on Environmental degradation in the Ethiopian Highlands, Samuel Benin and John Pender, 2002

See:

<http://dlc.dlib.indiana.edu/dlc/bitstream/handle/10535/124/benins230502.pdf?sequence=1>

- Results suggest that community grazing land management can contribute to sustainable use of grazing lands and alleviation of feed shortage problems, as in the highlands of northern Ethiopia.
- Collective action for grazing land management may be more beneficial and more effective in communities with large areas that are far from markets where wealth is more equally distributed, and where population pressure is low.

2. Forage Development and Management in Communal Grazing System in Malaysia, F.Y. Chin, 1992. <http://www.fao.org/ag/AGP/AGPC/doc/Proceedings/manado/chap9.htm>

- Forage development and management in communal grazing systems is feasible.
- Requires more organized grazing schemes to be introduced in order to control the use of the land by farmers and their livestock.
- Pure grass sward is common and aggressive and hardy, persistent, N responsive and drought resistant grasses that can withstand heavy and close grazing pressure are usually cultivated.
- Cooperation and commitment of farmers towards forage management is vital for success.

3. Communal grazing and range management: The case of grazing associations in Lesotho, S. W. Larry, 1987, <http://cgspace.cgiar.org/handle/10568/4372>

- In recent years governments and donor agencies have devoted considerable resources to efforts to improve the management of communal grazing lands.
- Range and livestock projects have been designed to address such familiar pastoral problems as endemic overgrazing of rangelands, often leading to permanent degradation of vegetation, soils, and water resources, and reduced livestock productivity, adversely affecting the welfare of rural people.

- Whatever the complex of factors which have led to range degradation in Africa, policy-makers and project designers very often see at least part of the solution in land tenure reform.
 - Recent range policy in Lesotho has emphasized a dual strategy. On the one hand, the strategy is to invest greater control over local management decisions in grazing associations, and on the other, to develop the institutional capacity for better administrative regulation of grazing, principally by reinforcing the role of the chieftainship in range management matters.
- 4. Pastoralism and the Demise of Communal Property in Tanzania, Susan Charnly, 2010, Community Survival Quarterly 20.1 (Spring 1996)**
<http://www.culturalsurvival.org/ourpublications/csq/article/pastoralism-and-demise-communal-property-tanzania>
- The Usangu Plains are a microcosm of what is occurring in many parts of pastoral Africa, where the demise of communal property systems and the loss of pastoral land are causing rangeland degradation, pastoral impoverishment and dramatic changes in the pastoral way of life.
 - Historically, most African pastoral societies held rangelands under systems of communal property. These systems promoted the sustainable use of rangelands by controlling resources access, regulating resource use by community members and providing secure tenure rights, thus encouraging long-term conservation practices.
 - Over the last few decades, many African pastoral property systems have been transformed.
 - In some areas, communal grazing lands have undergone privatization.
 - Elsewhere, pastoral land has been alienated to become State property, from which pastoralists are excluded. Other communal property systems have been converted to open access situations, in which resource access is uncontrolled and resource use is unregulated. These changes have had negative ecological and social consequences in many pastoral areas.
 - The Usangu Plains provide one example of what happens when communal property systems break down.
 - Subsequent studies of African pastoralism have shown that communal property systems do not cause rangeland degradation in Africa; rather, they promote rangeland conservation.
 - Communal property systems are not inherently ecologically destructive.
 - It is not the presence, but the demise of communal property systems that is an important cause of rangeland degradation, as the Usangu case study demonstrates.

5. Grazing and Land Degradation in CIS Countries and Mongolia, Mauricio Rosales and Svetlana Livinets, FAO,

http://www.fao.org/fileadmin/templates/lead/pdf/e-conf_05-06_background.pdf

- Covering 260 million ha, the Central Asian rangelands are the world's largest continuous area of grazed land.
- The problem is characterized by overgrazing in nearby village pastures and under-grazing in remote areas.
- In the past, livestock grazing was carried out in a semi-nomadic manner with frequent changes in pasture allowing regeneration to occur. Today permanent grazing is often practiced in the vicinity of villages with artificial wells has caused local overgrazing.
- Other pastures have been under-utilized for many years, resulting in a build-up of a soil crust and reduced water absorption.
 - The underlying causes driving this “Hot-Spot” are:
 - Disruption of transhumance herding
 - Overstocking -...figures show a dramatic reduction of the total number of animals in the region, herds are concentrated in pastures near villages and exceed the safe carrying capacity. This has been exacerbated by an increase in private livestock holdings and the reduction of pastures areas due to desertification, soil erosion, pasture allocation for cultivation, construction and development of mineral resources.
 - Change in the livestock composition: The number of goats in the region is increasing and the number of sheep is decreasing. This has violated the principle of mixed farming in the region in which different domestic animals are grazed on the same pasture from different layers of plant formation: horses eat the upper layer, cows eat the lower layers and sheep eat whatever is left. An increased goat population creates a heavy load for pasture.
 - A number of other factors are listed by the author
- Technologies that can help to reduce or eliminate the problem included:
 - increase livestock nutritional status during winter by supplementation
 - alternative management schemes
 - range improvements
 - seasonal-suitability and rest-rotation grazing methods
 - fencing of land to attain exclusive and rational range use
- The challenge here is to address the negative social and environmental consequences of grazing and land degradation.
- Establishing an appropriate land-livestock balance is fundamental for the restoration of degraded pasture lands in the region

Options for Implementation & Scale-Up in “Hot-Spot” Areas

In areas with limited per farm area:

Grazing management and stream protection from livestock and fowl are very important to local and downstream water quality where animals have access to streams and should be emphasized as part of the overall conservation management system where applicable.

Although most producers may be land-limited grazing management could be implemented on a community scale.

Stream fencing: While fully fencing cattle out of streams may not be widely feasible in many regions, remote watering, shade and hardened stream crossing could provide major reductions in sediment, phosphorus and, to a lesser extent, nitrogen loss.

Toolbox BEP #8

GLOBAL PARTNERSHIP ON NUTRIENT MANAGEMENT
TOOL BOX CASE STUDY #8
ECOLOGICAL / ORGANIC PRODUCTION SYSTEMS

Ecological / Organic Production Systems

Take Home Message

- * A systems approach
- * Nutrient and Manure Management may be more challenging
- * Eco-efficient agriculture borrows technologies from intensive agriculture and couples them with practices that reduce environmental impacts, the resultant system may enhance water quality
- * Ecological-based adaptation (EBA) is a new approach that could easily incorporate water quality BEPs into viable systems

Overview

Ecological/organic production systems are not really BEPs but rather a systems approach that relies on organic inputs. Ecological agriculture requirements and expectations can drive implementation of many BEPs. Documented Nutrient Management and Manure Management should be standard requirements for ecological agriculture and many other practices such as buffers, should be expectations. It should also be noted that growing crops ecologically (organically) can actually make long term nutrient management and erosion control more challenging than in conventional production systems.

Ecological-Based Adaptation (EBA) is a new strategy being initiated by the World Bank to allow communities to avoid detrimental impacts from climate change⁸. It is based on healthy

⁸ Adapting to climate change – one ecosystem at a time, Richard Munang and Jessica Andrews, Guardian Professional, Wednesday 7 August 2013. <http://www.theguardian.com/global-development-professionals-network/2013/aug/07/ecosystem-based-adaptation-climate-change->

ecosystems and the multiple services they provide. According to the author for EBA to work the inter-connectivity between ecological, social-cultural, economic and institutional structures has to be recognized. EBA often requires for large patches of previously productive land to be set aside for restoration purposes. At this early stage of implementation, EBA may or may not impact water quality. However, if future applications can take into account impacts on water quality within the ecosystems, it could be a viable tool for the Nutrient Management Toolbox.

Benefits

Ecological, organic or sustainable agricultural practices do not necessarily equate to reduced nutrient pollution. The procedures and approaches used to implement these types of systems will determine the ultimate benefit to reducing nutrient pollution. This is why nutrient and manure management must be an important part of ecological agriculture.

Options include:

- Ecological agriculture could provide a platform for farmers or private farmer cooperatives to produce products for export markets at premium prices. This could both require that they implement and document water quality protection efforts and provide sufficient revenue, compared to current systems, to allow this to occur. Thus, although not actually a BEP, ecological agriculture could promote implementation of other BEPs.
- For small land holders it is likely that groups of farmers with adjacent or nearby land will need to form private cooperatives to get to a scale where they can afford the equipment and harvesting and storage cost and generate enough product to enter export markets.

Practice Efficiency

- The same efficiencies that apply to Nutrient and Manure Management would apply

Input Costs

- See Nutrient and Manure Management case studies

Incentives for Implementation

- Incentive programs to help defray costs

Cost Effectiveness

- Rank: unknown

unep?CMP=&et_cid=44897&et_rid=7093727&Linkid=Adapting+to+climate+change+-+one+ecosystem+at+a+time

Complimentary Practices

- All 7 other BEP case studies

“Hot-Spot” Examples

The following two examples show the move towards ecological systems. Note that in both cases they are using a suite of BEPs and that the fundamental nutrient management “tools” are still needed to produce a system that reduce water quality impacts.



Multi-story rice–fish–farm animals– agroforestry IFS model for deep-water ecology

Eco-Efficiency: From Vision to Reality

C. H. Hershey and P. Neate, eds., 2013. CIAT

http://ciat.cgiar.org/wp-content/uploads/2013/04/eco-efficiency_book.pdf

Enhancing Eco-Efficiency in the Intensive Cereal-based Systems of the Indo-Gangetic Plains (Chapter 7), V. Balasubramanian, T.K. Adhya, and J. K. Ladha

- The northwest and central parts of the Indo-Gangetic Plain (IGP) of South Asia are among the most productive agricultural regions of the world.
- But production is becoming unsustainable due to depletion or degradation of soil and water resources, rising production costs, decreasing input use efficiency, and increasing environmental pollution.
- In contrast, cereal production systems in the eastern IGP are largely traditional, with low yields and farm income.
- Eco-efficient farming can be used to enhance productivity throughout the IGP.
- Eco-efficient agriculture borrows technologies from intensive agriculture and couples them with practices that reduce environmental impacts
 - laser-aided land leveling
 - reduced or zero tillage and direct/drill seeding
 - precise water management
 - crop diversification
 - improved plant nutrient management
- These eco-efficient practices are expected to raise land and water productivity, improve resource use efficiency, reduce risks and vulnerability of cropping systems to climate change, diversify farm income, and improve family nutrition and livelihood. A comprehensive understanding of scientific, technical, environmental, economical, and societal issues, including farmers' re-education, are required to effectively promote eco-efficient farming practices.

Development and Implementation of the Lake Peipsi/Chudskoe Basin Management Programme

The Living Water Exchange, a GEF/UNDP project, 2003-2006

<http://projects.inweh.unu.edu/inweh/report.php?ListType=ProjectDocumentAjax&ID=93>

Objective: to develop and start implementation of the Lake Peipsi/Chudskoe Basin Management Programme including practical recommendations for nutrient load reduction and prevention and the sustainable conservation of habitats and ecosystems in the cross-border region.

Background: Lake Peipsi is the fourth largest and biggest transboundary lake in Europe.

Results: measures to reduce nutrient loading included:

- short-term measures related to the reduction of emissions from municipal wastewater discharges through the construction, upgrade and maintenance of wastewater treatment and sewerage facilities
- creation of "buffer" zones where industrial activities cannot be conducted by the shore.
- long-term measures are targeted at the development of eco-farming in the region to reduce nutrient loads from animal husbandry and crop production

The program strategy focuses on the prevention of nutrient pollution by encouraging BEPs and management of on-farm nutrient losses, including:

- prohibiting application of mineral fertilizers to snow cover and frozen soil
- prohibiting the use of herbicides for ditch maintenance
- controlling the application, transport and storage of mineral fertilizers and pesticides
- promoting reductions in fertilizer and pesticide application
- supporting BEPs in agriculture and eco-farming
- establishing buffer vegetation strips between water bodies agricultural areas
- devising strategies for and carrying out assessments of designing new drainage systems or storing old drainage systems in order to maintain the apparent high nutrient retention capacity in the drainage basin

Appendix A - Global Summary of Hotspot References Examined

(The parenthetical Ref. numbers below refer to the original global inventory spreadsheet)

Chilika Lake

(19 references)

Chilika Lake is Asia's largest brackish lagoon on the east coast of India.

Overview of references: Only four of the 19 references contained significant information, two had some information while 13 references were of limited value (5) or of no value (8) to the task.

Chilika Development Authority at Magarmukh (Ref. 102)

<http://moef.nic.in/modules/recent-initiatives/nlcp/Indian%20Case%20Studies/Q-33.pdf>

The result was a large exchange of free breeding migration of fish, prawn, and juvenile crab into the Chilika Lake from the Bay leading to a significant improvement of the fishery resources.

Analysis: This "opening" was essentially a salinity/wetland restoration project.

Integrated Sustainable Environmental Management Programme (Ref. 103)

http://wldb.ilec.or.jp/data/ilec/WLC13_Papers/S2/s2-2.pdf

The above site is an article by C. R. Das titled "Effect of climate change on integrated sustainable Environmental Management Strategies of the biggest fresh water Lake Ansupa of Orissa, India".

Reviewers could not identify other reports that expand upon the spreadsheet information which stated:

"Treatments include Soil Conservation Measures with heavy plantations to arrest siltation and eutrophication, engineering intervention to augment floor circulation of water by opening inlet channel from river Mahanadi and developing outlet channel, de-silting and de-weeding activities"

Analysis: A wetland restoration project with significant impact on fisheries. (non- Chilika Lake)

Water quality monitoring (Ref. 104)

23 water sampling stations were set-up throughout the entire Chilika Lake. Surface water was collected from undisturbed waters

There was a lack of information on project name, project manager etc. therefore no additional information identified.

Analysis: Monitoring is an important component of water quality, it is a way to set a baseline and then look at implementation impacts over time.

LTRA-11: CAPS among tribal societies in India and Nepal (Ref. 110-112)

<http://www.oired.vt.edu/sanremcrsp/professionals/research-activities/phase4/ltras/ltra11/>

SANREM CRSP stands for Sustainable Agriculture and Natural Resource Management – Collaborative Research Support Program organized by Virginia Tech. The specific project was LTRA-11: CAPS among tribal societies in India and Nepal. (LTRA -11 is one of 11 Long Term Research Awards under SANREM)

CAPS (conservation agriculture production systems) is an approach that aims at increasing small farmers agricultural productivity and food security through improved cropping systems, including maintaining a year-round soil cover, minimizing soil disturbance by tillage, and use of crop rotation systems.

The project website provides the following project overview:

“Traditional agriculture in tribal and ethnic agricultural societies in India and Nepal is increasingly relegated to less productive land, often on steep slopes, resulting in lower productivity, degradation of soil and water resources, impairment of health, and loss of livelihood options... Environmental degradation has driven these tribal and ethnic communities engaged in subsistence agriculture into severe malnutrition and loss of livelihood options.

The research is organized by an innovative approach that is referred to as a "**nested landscape systems approach.**" We begin with systems that are being used in the field, and from there we build through farm, enterprise, and watershed systems. Finally, our approach considers the broader ecological, governance, and policy systems that these other systems are nested in.”

Analysis: Further explore the “nested landscape systems approach” and how the 8 BEPs would fit. This might be facilitated by using the SANREM Knowledgebase (SKB) which can be accessed at: <http://www.oired.vt.edu/sanremcrsp/professionals/knowledgebase/>

**Ecosystem Modeling for Chilika Lake (Ref. 113)
(Carbon in Chilika Lake)**

http://drs.nio.org/drs/bitstream/2264/1055/3/Biogeochemistry_87_265p.pdf

The above article by G. V. M. Gupta concludes: “Chilika Lake is another coastal ecosystem that can be concluded as net source of CO₂, a net heterotrophic during the periods of observation.”

Analysis: None.

Initiative: Operation Kolleru (Ref. 114)

Kolleru Lake is not near Chilika Lake – Operation Kolleru was a government shutdown of all aquaculture operations in the Lake.

(Note: There is a four part You Tube video with an interesting title: “Operation 'Kolleru' success but patient died Part 1” <http://www.youtube.com/watch?v=iWZpe4WII3g>, unfortunately the video is not in English.)

Analysis: None.

Water quality monitoring (Ref. 115-117)

<http://www.indjst.org/>

(Provided link for 115 was incorrect)

8 water sampling stations were set-up throughout the entire Chilika Lake. Two stations were established in each of four sectors of the lake. Surface water was collected from undisturbed waters. (Ref. 115)

16 water sampling stations were set-up covering three sectors of Chilika Lake. Surface water was collected from undisturbed waters. (Ref. 116)

3 water sampling stations were set-up covering three sectors of the western mangroves of Kachchh-Gujarat. Surface water was collected from undisturbed waters every month for two years. (Ref. 117)

Analysis: None. See Ref. 104

Seaweed flora and prawn farming interactions (Ref. 118)

http://www.bioinfo.in/uploadfiles/13257457181_1_1_JBR.pdf

“Utilization of nitrate and ammonium by algal biomass available in prawn cultivation sites in Chilika Lake, Orissa” by S. B. Padhi (project manager)

Studied four seaweed species however this was only a proof on concept project and it is unclear whether or not this could be implemented in real world.

Analysis: This could be a novel tool to decrease soluble N levels in waters.

Restoration of the Chilika Lake after the opening the new mouth (Ref. 119)

The opening of the new mouth has greatly improved the exchange of water between the sea and the lagoon. This has facilitated auto-recruitment and free breeding migration of the fish, prawn, and crab juvenile into the lagoon, thus an improvement of fishery resources.

There was no additional source of information on this project identified.

Analysis: None

Niche Area of Excellence on Acid Soil Management (Ref. 120)

There was no source of information on this project identified.

Analysis: None

Bio-fertilizers and Bio-inoculants (Ref. 121)

<http://www.iiss.nic.in/SBBF.pdf>

Impact of bio-fertilizers and bio-inoculants on crop yields and nutrient use efficiencies

Analysis: This project would be part of the larger 4R's initiative.

Slow release and specialty fertilizers (Ref. 122)

Fertilizers which are programmed to release nutrients at intervals synchronized with crop physiological stages, improve NUE, and cut down on nutrient loss to the environment

There was no source of information on this project identified.

Analysis: None

Model of marine ecosystem structure (Ref. 123)

There was no source of information on this project identified.

Mathematical model based on four compartments: nutrient, phytoplankton, zooplankton, and detritus. A tool to better understand what effects plankton population. The model is simulated for two cases: 1) detritus link with the system through remineralization, 2) detritus link with the system through remineralization and palatability of detritus to zooplankton

The amount of nutrient entering into the system and growth rate of phytoplankton play an important in controlling phytoplankton growth. The model tested for the Chilika lagoon simulated results for phytoplankton are very well validated with observations when the feedback of detritus into the system is through both the processes of re-mineralization and palatability of detritus to zooplankton.

Analysis: None

Issues for property rights and collective action (Ref. 124)

There was no source of information on this project identified.

Integrate insights from ecological and socio-economic theory which focuses on the ecological underpinnings of watershed management, developing the concepts of scales, lateral flows, and externalities; also discussing the role of government, non-governmental, and research organizations in watershed management.

Presumptions involved with policy making are fallacies of watershed and catchment management; plot level soil erosion rates being used to calculate gross erosion for the watershed, role of soil erosion from minor uses, time frame for soil to move from upper areas of the watershed to streams, seasonal water shortages caused by trees, and catchments boundaries used for planning purposes. Property rights and conservations practices are discussed. Land-care groups have been effective in implementing watershed project bringing together local policy makers, farmers, and technical agencies as information and knowledge are often the most limiting factors in catchment management. Roles of external organizations can assist in the solutions: non-government organizations, the state, information brokers, and public investment.

Analysis: The comments above, lifted from the spreadsheet, identify some major issues with watershed data (scaling up plot level studies) and the need to bring together all interested parties together for a common goal to be recognized and implemented. Would like to see additional documentation from this study

Coastal Pollution Management (Ref. 127)

There was no source of information on this project identified.

Identify conditions fostering deterioration of the environment in Coastal areas of the Gulf of Thailand. Initiate management tools for tackling coastal environmental problems.

Total P and N into the Tha Chin River Basin have been traced back to cultivation, 90 and 88% respectively. Thailand is in the process of delegating responsibility for environmental management from the major land-based pollutants.

Analysis: None

Lake Victoria

(31 references)

Lake Victoria, the largest fresh water body in Africa

Overview of references: Ten of the 31 references provided useable information, one was of limited value and another one contained no information. The remaining 19 references were all carbon sequestration projects.

Transboundary Agro-ecosystem Management Programme for the Lower Kagera River Basin (ref. 94-99)

http://www.fao.org/fileadmin/templates/nr/kagera/Documents/Com_material/KAGERA_Brochure_eng_light.pdf

Transboundary Agro-Ecosystem Management Programme (TAMP) for the Kagera River Basin

Project Brief – December 2006

The Kagera river basin covers an area of 59,700 km², distributed between Burundi, Rwanda, Uganda and Tanzania. It flows into Lake Victoria, the largest fresh water body in Africa. Expected outcomes include the reversal of land degradation trends, through improved land use and management practices, including:

- reducing erosion and sedimentation;
- restoring soil productivity through nutrient cycling, moisture and cover management and other conservation measures;
- restoring water quality and recharge;
- protecting wetlands from agricultural encroachment.

One of the key indicators of success was a 10% reduction in sediment load in 4 representative micro-catchments.

Analysis: There was no readily available final report at the FAO website for this project. Of interest was the last landscape photograph in the FAO document at the above website. There appears to be a need to reduce farming activities at the river edge. A continuous buffer zone along the river edge would greatly impact water quality. Ideally this would be a forest buffer since they are already being established for carbon sequestration efforts. The existence of small landowners would compound implementation of these buffers.

The list of practices to be implemented by the project cover 3 of the 8 recommended BEPs (nutrient management, cover crops, erosion control).

Scaling-up of agroforestry innovation adoption (ref. 100)

The database contained no information or names that could be searched. Ironically this was the only listed “Hot-Spot” project that estimated N and P reductions.

Improving human welfare and environmental conservation by empowering farms to combat soil fertility degradation through use of agroforestry green manures, farmyard manures, and rock phosphates (ref. 101)

<http://www.vicres.net/>

This is a VicRes (Lake Victoria Research Initiative) project. Reports or other information on the specific project could not be located at the website.

Analysis: From the information provided in the spreadsheet database the study included agroforestry, composting, green manures, farmyard manures, and phosphate rock to increase agricultural productivity. Furthermore, it was noted that top soils in this area had adequate P content due to the deposition of shells from the lake. However, N and organic matter were very low. With an adequate P content, crop responses to treatments with rock phosphate were minimal. Farmyard manures improved the N content of the compost. Agroforestry green manures had high N concentrations and thus, were good fertilizers. The high rate of nutrient release from the green manures suggested that they did not need to be composted to be effective. Therefore, N fertility can be improved through the use of green manures and farmyard waste.

Analysis: The reported information highlights the need for adequate soil testing as part of a nutrient management program. This would avoid situations where a valuable commodity, rock phosphate, can be used where most needed.

Development and transfer of conservation agriculture production systems (CAPS) for small-holder farms in eastern Uganda and western Kenya (ref. 106)

<http://uwyosanrem.wordpress.com/>

This is a part of the SANREM CRSP project @ Wyoming but run through Virginia Tech - deals with intensive maize production, plowing and soil depletion. Project is ongoing (2010-2015).

Analysis: Status reports on project activities were not readily apparent at the listed website

Issues for property rights and collective action (ref. 124 – no project title provided)

Outcomes provided in database: Presumptions involved with policy making are fallacies of watershed and catchment management; plot level soil erosion rates being used to calculate gross erosion for the watershed, role of soil erosion from minor uses, time frame for soil to move from upper areas of the watershed to streams, seasonal water shortages caused by trees, and catchments boundaries used for planning purposes. Property rights and conservations practices are discussed. Land care groups have been effective in implementing watershed project bringing together local policy makers, farmers, and technical agencies as information and knowledge are often the most limiting factors in catchment management. Roles of external organizations can assist in the solutions: non-government organizations, the state, information brokers, and public investment.

Analysis: The comments above, lifted from the spreadsheet, identify some major issues with watershed data (scaling up plot level studies) and the need to bring together all interested parties together for a common goal to be recognized and implemented. Would like to see additional documentation from this study (This reference was also cited under Chilika Lake.)

Managing ecosystem services, managing nutrient cycles, managing below-ground biodiversity, and empowering farmers through long term management experiments (Tropical Soil Biology and Fertility Institute of CIAT) (ref. 126)

<http://www.oasisglobal.net/achieve.htm>

Applying normal doses of fertilizer is too expensive for most farmers in the Sahel. The use of organic matter, in the form of livestock manure and crop residues, is effective, but supplies of these materials are limited. A more economical alternative is to apply small



quantities of inorganic fertilizers in the hole where seed is sown, a practice called “micro-dosing.” Practiced by thousands of farmers in Burkina Faso, Mali, Niger and Zimbabwe, micro-dosing helps crops mature more rapidly, yield 50-100% more grain, and escape the worst effects of drought. This and other soil fertility enhancement options are the focus of collaborative research among CIAT, ICRISAT and IFPRI.

Analysis: From the information in the spreadsheet for this project shows the value of nutrient management, crop rotations, and conservation tillage on increasing yields - in other words need a systems approach.

The “micro-dosing” approach is a tool that should be used in nutrient management planning to help optimize nutrient use efficiency as well as nutrient-source efficiency. This should be part of a 4R’s approach for specific Lake Victoria conditions.

Integrated nutrient management in tropical cropping systems: improved capabilities in modeling and recommendations
(Project no. LWR2/1999/003) funded by: The Australian Centre for International Agricultural Research (ACIAR) (ref. 135)

<http://aciar.gov.au/files/node/542/pr114.pdf>

The purpose of the project was to test and enhance a modeling capability that can be applied to farming systems where both organic and inorganic sources of nutrients are used. In tropical regions, organic materials are often more important for maintenance of soil fertility than fertilizers, yet current fertilizer recommendations and most crop models cannot credit the organic inputs and the different qualities of these organic inputs used by farmers.

Many of the soils in Africa and Latin America are P-fixing and/or P deficient, and these projects are now contributing further modeling capability for P dynamics in these farming systems. The Soil P module developed and evaluated within this project has provided the opportunity for the other projects to proceed. This is a major outcome and one measure of the project’s success.

Analysis: The development of a model for organic and inorganic nutrient sources as a tool to make recommendations. The current model will have a higher impact on P utilization on P-limited soils. Additional work is needed to refine the N utilization between the different sources. This work also impacts the 4R’s and nutrient management in general.

Carbon Sequestration (ref. 136-154)

http://earthtrends.wri.org/features/view_feature.php?fid=68&theme=3 (from ref. 141)

(Note: project document URLs listed in the spreadsheet require a login to access the information)

Carbon sequestration through afforestation and reforestation can often generate other locally-valued ecosystem services such as improved water quality and reduced soil erosion and sedimentation. For example, the Western Kenya Integrated Ecosystem Management Project aims to improve the ecology of Lake Victoria Basin by taking responsibility for erosion control and watershed management activities over an area of 900 square kilometers. A key project component is to encourage adoption of agroforestry and other land management techniques that sequester carbon and pay local communities for carbon credits. Carbon sequestration projects may not always benefit local ecosystems. A global study on the hydrological effects of forestry projects found that annual runoff reduced by as much as 75 percent when grasslands were converted into eucalyptus plantations for carbon sequestration purposes. Considering that many parts of Africa are rain deficient, there is a need to locate carbon sequestration projects carefully and to encourage native plant species, which require less water, over exotics.

Degraded tract of land have average crop yields of 1.5 tons per hectare for maize, 0.8 tons per hectare for sorghum, and 0.7 tons per hectare for millet (as compared to about 2.5 tons of maize per hectare in many other parts of the world). This is due to poor soil quality, which occurs when soil organic carbon is lost to the atmosphere, leading to desertification: estimates of the affected area range from 3.47 to 3.97 billion hectares. The process can be reversed through improved agricultural practices such as conservation tillage, soil erosion control, establishment of appropriate shrubs and woody perennials, soil fertility enhancement, and crop residue management. These not only restore soil quality by increasing its organic content but also aid in mitigating climate change by returning more carbon to the soil.

Analysis: Global demand for carbon credits will increase. The overall impacts on water quality will be site-specific and require that most of the 8 BEPs be implemented simultaneously.

Philippines / Manila Bay

(8 references)

Overview of references: Five references provided good information, two were very general and one was of limited value.

GEF/UNDP project; Regional Programme on Building Partnerships in Environmental Management for the Seas of East Asia (PEMSEA) (Ref. 93) (Integrated Coastal Management)

<http://beta.pemsea.org/>

PEMSEA (Partnerships in Environmental Management for the Seas of East Asia)

ICM addresses a variety of threats challenging the sustainability of the coastal area, such as fishery resources depletion, habitat loss and degradation, sea-level rise, natural hazards, multiple-use conflicts, pollution, and poverty of coastal communities.

ICM has contributed to the reduction of multiple resource-use conflicts, and risks from pollution and red tide occurrence. Sustained growth in of shipping, fisheries, tourism, and property the present value of ICM net benefits amounts to \$3.3 billion.

The information examined at the PEMSEA website was general in nature. An example was “Sustainable Development and Management of Manila Bay: A Focus on Water Quality” (<http://beta.pemsea.org/sites/default/files/pb-2004-manila-bay.pdf>) which was a general overview of prevailing issues (in 2006) of phosphate in water and coliform contamination.

Analysis: General information on Manila Bay readily available, specifics not identified at the PEMSEA website.

The Organic Fertilizer Production Project (Ref. 94)

The project covered: 1) The establishment of community-based composting facilities (rice straw composting), 2) the upgrade of existing compost fungus activator production laboratories, 3) the upgrade and rehabilitation of biological nitrogen fertilizer mixing plants.

All three stages of the project are have commenced and rice and corn production is beginning the use of the organic fertilizers. However, more time is needed to know the economic impacts along with the overall reduction in chemical fertilizers. 1,380 composting facilities established in 2009 and 1,342 scheduled for 2010 (85% completed as of November 2010). These have

produced 26,713 bags (50kg/bag) but would need to produce 21 million bags to provide needed N for corn and rice crops. There has been no economic analysis.

www.afaci.org/.../downfile.asp?...Rodelio%20B%20Carating.pdf

For the Organic Fertilizer Production Program, BSWM has long abandoned traditional or conventional extension concepts of linear transfer of technology and researcher-lead on-farm experiments. We implement participatory approach, even as early as community appraisal stage. Our working premises are that we do not come to the community with a solution to the problem when farmers do not know that they have a problem in the first place, and that farmers are part of the solution. Our minimum techno-demo farms are 25 hectares, with farmer average farm holding of 2 hectares.

Analysis: Project covers nutrient management with emphasis on production of organic fertilizers. Information would be germane to 4R's.

**Cambodia, China, Indonesia, Malaysia, Philippines, Thailand, & Viet Nam: Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand; GF/2730-01-4340 (Ref. 105)
(International Waters - GEF Operational Program #8)**

<http://iwlearn.net/publications/gefpolicies/operational-policies-in-international-waters>

Objectives of the project: 1) Improved regional co-ordination of the management of the South China Sea marine and coastal environment, 2) Improved national management of the marine and coastal habitats, 3) improved integration of fisheries and biodiversity management in the Gulf of Thailand.

The habitats of concern in the South China Sea were identified as being mangroves, coral reefs, seagrass beds, and estuaries/wetlands. Environmental concerns and issues of the habitat concerns include: habitat loss and degradation, over exploitation, pollution, and freshwater concerns. Targets for all of the habitats: maintain 90% of the present mangrove area, maintain the area of coral reef with more than 50% live cover, maintain at least 80% of the present area of seagrass in good condition, and adopt management plans for all wetlands, excluding mangroves, with emphasis on wetlands in the coastal zone of the region.

Analysis: General information.

LTRA-12: Conservation agriculture for food security in Cambodia and the Philippines (Ref. 107-109)

An ongoing SANREM CRSP project (2009-2014) – continual mulching & crop rotations

<http://www.oired.vt.edu/sanremcrsp/professionals/research-activities/phase4/ltras/ltra12/>
Conservation Agriculture Production Systems (CAPS)

The research theme of SANREM CRSP's current phase (Phase IV) is to develop conservation agriculture production systems (CAPS). Our research is aimed at increasing smallholder's agricultural productivity and food security through improved cropping systems. In addition to increasing food security, CAPS will contribute to and take advantage of improved soil quality and fertility.

Farming systems with CAPS will:

- Maintain a year-round soil cover
- Minimize soil disturbance by tillage
- Utilize crop rotation systems

Promote conservation agriculture as a technologically-feasible, economically-viable, environmentally-sustainable, and gender-responsive production system that will contribute to food security of small farm communities in the Philippines.

Expected Outcomes: Decreased labor burdens for women, men, and children; Improved soil quality ; Reduced production inputs (e.g. machinery wear and tear and fuel costs for tillage); Increased agricultural profitability; Enhanced resilience to climate change (since CAPS can reduce runoff); Increased residual moisture, minimizing drought during extreme weather events; and Reduced soil erosion to natural levels.

Analysis: The project plan fits well with the eight BEP list and incorporates a systems approach.

Coastal Pollution Management (Ref. 127)

http://www.ucd.ie/dipcon/docs/theme14/theme14_21.PDF

Identify conditions fostering deterioration of the environment in Coastal areas of the Gulf of Thailand. Initiate management tools for tackling coastal environmental problems.

Total P and N into the Tha Chin River Basin has been traced back to cultivation, 90 and 88% respectively. Thailand is in the process of delegating responsibility for environmental management from the major land-based pollutants.

Analysis: None.

Integrated nutrient management in tropical cropping systems: improved capabilities in modeling and recommendations (Project no. LWR2/1999/003) funded by: The Australian Centre for International Agricultural Research (ACIAR) (Ref. 135)

<http://aciar.gov.au/files/node/542/pr114.pdf> (Note: warning message that some files at this site may contain viruses!)

http://webapp.ciat.cgiar.org/tsbf_institute/pdf/nut_mgt_full_text.pdf

Develop a model that can be applied to farming systems where both organic and inorganic sources of nutrients are used.

The model now includes a capability to simulate the N and P dynamics from different quality manures and their effects on crop growth. The improved management of soil fertility needs to be evaluated from economic, social, and environmental perspectives. From the economic sense, combinations of organic and inorganic nutrient sources need to be identified that increase and maintain crop production. This evaluation should include differences in both the short and longer-term benefits.

From the social and economic sense, organic resources identified can substitute for mineral fertilizers in areas where fertilizers are not available or affordable. From an environmental aspect, management practices could be identified that would result in smaller losses of nutrients and would rebuild or maintain the soil resource base.

Analysis: The project plan fits well with the eight BEP list and incorporates a systems approach.

Appendix B - Additions and Remarks on New Database Entries

(The original literature 2011 spreadsheet consisted of 291 citations. The new literature 2013 spreadsheet associated with this new analysis contains 356 citations. The original citations are the same in the 2013 spreadsheet.)

The comments that follow are for 'new' citations starting with #292 (see Column A in spreadsheet). Column D is the name and type of practice and policy and Column AA is the URL or other information about the project details.

Only those listing in bold face type under Column AA or contain text boxes are potential useful sources of information for the current analysis.

Additionally, two other lists were obtained they were:

10 Case Studies – they were all previously included in the 2013 spreadsheet

12 listed CCA practices – dated 19 July 2013 – they are characterized at the end of the this Appendix

WSI was tasked to “Develop a complete synthesis report of the best agricultural practices, case studies and experiences including wastewater/constructed wetlands, aquaculture and livestock executed from the global inventory of provided...”

For wastewater/constructed wetlands and aquaculture the inventory was of little or no use. In the case of wastewater/wetlands any useful citations were from projects in the DRB. The current report concentrates on Southeast Asia (Chilika Lake) and East Central Africa (Kagera River Catchment, Lake Victoria Basin). Specifically:

Aquaculture

Searches of topics in Column D of the inventory for Aquaculture indicated that there were only three citations:

Line #2 – use of a seaweed type for N removal in finfish systems, from NH, USA, the only reference was to the Elsevier general website

Line #6 – use of seaweed to control N in prawn farming, no URL provided

Line #11 – fish tank construction, no mention of nutrient management – reference goes to a USDA, NRCS website that lists conservation practices

Wastewater/wetlands

Searches of topics in Column D of the inventory for Wastewater/Constructed wetlands indicated that there were eight citations:

Line #12 – not wastewater but digestion/biogas from manures, this is the Anatolia Rehabilitation project

Line #67 – not wastewater - anaerobic digestion of manures, no URL

Line #271 – Developing Wastewater Improvement Plans (Bosnia & Herzegovina) – no URL

Line #278 – Treating village wastewater, no URL

Line #309 – Restoring wetlands – this is the Hungary –GEF project, URL okay but no final report is listed (project end date 2011)

Line #323 – Establishing wetlands, no URL

Line #324 – Restoring wetlands, probably the Bulgaria DRB project but no URL

Line #327 – Establishment of wetlands – an article by B. Arheimer, et al., 2004, Modeling diffuse nutrient flow in eutrophication control scenarios, Water Science & Technology Volume 49 No 3 pages 37–45 © IWA Publishing 2004 (abstract only, there is a charge for full article)

For both topics (aquaculture and wastewater/wetlands) there was a lack of useful information, especially aimed at Southeast Asia.

In regards to LMEs there was one inventory item on the Gulf of Thailand (Line #62) which notes monitoring of N and P in the Chin River Basin and that 90 and 80% of the N and P was due to cultivation. However, there was no URL associated with this listing. There were no other Thailand / LME citations in the inventory.

Line #	A#	Column D	Column AA (URL)
263	292	N index in Mexico	none
76	293	Intercropping	Crusciol, C.A.C., et al. 2010. Better Crops with Plant Food. 94:2, pp. 14-16 (Brazil)

Dry winter seasons prevent farmers from successful adoption of sustainable no-till systems. The consortium (intercropping) of cereals with tropical forages has been successfully adopted in several regions of Brazil as a means to protect the soil and obtain higher yields and higher economic return. This article discusses the main conditions of this consortium and its advantages, including improvement of nutrient use efficiency. May need higher N recommendation due to plant competition

151	294	N potato/irrigation	Li, S., et al. 2011, Better Crops with Plant Food, Vol. 95, No. 3, 20-23.
205	296	Nutrient balance – dairy	Fields, L 2011 Cornell University nutrient Management Spear Program, Whole Farm Evaluation Series Stallings, C.C. 2005 Virginia Cooperative Extension Tylutki T.P. et al. 2004. The Professional Animal Scientist 20:58-65.

The vision of the Cornell University's Nutrient Management Spear Program is to assess current knowledge, identify research and educational needs, conduct applied, field and laboratory-based research, facilitate technology and knowledge transfer, and aid in the on-farm implementation of beneficial strategies for field crop nutrient management, including timely application of organic and inorganic nutrient sources to improve profitability and competitiveness of New York State farms while protecting the environment

264

~~Malaysia (need a password for site)~~

The reference can be downloaded at:

<http://seap.ipni.net/article/seap-3057>

~~Witt, C. et al. 2009. IPNI, Penang, Malaysia~~

~~(need a password for site) Nutrient Expert Users Manual~~

[http://seap.ipni.net/ipniweb/region/seap.nsf/0/0A175E9C262EFBB848257B6B0026B326/\\$FILE/Nutrient%20Expert%20for%20Maize%20Manual%2002Mar10.pdf](http://seap.ipni.net/ipniweb/region/seap.nsf/0/0A175E9C262EFBB848257B6B0026B326/$FILE/Nutrient%20Expert%20for%20Maize%20Manual%2002Mar10.pdf)

Development approach and evaluation of the Nutrient Expert software for nutrient management in cereal crops, 2012, Mirasol F. Pampolino, Christian Witt, Julie Mae Pasuquin, Adrian Johnston, Myles J. Fisher
(I have a copy)

142	298	Crop history/soil sampling	Cash, D. et al. 2007 Nitrate Toxicity of Montana Forages, Montana State University (Think they put wrong citation?)
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65	299	Sugarcane/Australia	http://www.reefwise farming.qld.gov.au/pdf/smart-sugar-practices.pdf
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6 Easy Steps for the wet tropics: Sugarcane producers in environmentally sensitive areas were given a nutrient management tool that enables adoption of best management practices based on six steps: 1) knowing and understanding your soils; 2) understanding and managing nutrient processes and losses; 3) regular soil testing; 4) adopting soil-specific nutrient management guidelines; 5) checking on the adequacy of nutrient inputs; 6) keeping good records to modify nutrient inputs when and where necessary

Sugarcane farmers improved nutrient management practices and nutrient loading in the coastal plains of eastern Australia (along the Great Barrier Reef) was reduced.

- | | | | |
|-----|-----|---|---|
| 143 | 300 | Water management & Exner, M.E., H. Perea-Estrada, and R.F. Spalding
Reduced NO3. 2010 The Scientific World Journal 10:286-297. | |
| 206 | 301 | Manure injection | German Federal Ministry of Environment (2006)
Evaluation of policy measures and methods to
reduce diffuse water pollution - Forschungsbericht
201 24 222/01 - /04 UBA-FB 000727. p.70) |

Includes a number of BEPs to address NPSP - Specifically for animal Ag. Manure storage & application to reduce ammonia loss, animal nutrition optimization

- | | | | |
|-----|-----|--------------------------------|---|
| 207 | 302 | Avoid risky manure application | Cuttle et al, 2007 (book title) Mitigation
methods for avoiding the nitrogen and P
pollution risk under agricultural practices) |
| 208 | 303 | Avoid risky manure application | (Helsinki Commission, 2007) |
| 54 | 304 | Buffer strips | no URL |
| 55 | 305 | Catch crops | no URL |
| 161 | 302 | Retire Ag land to grass | no URL |
| 152 | 307 | Store more water | (Dworak et al 2007) |
| 230 | 308 | Charging for water | (Dworak et al 2007) |
| 303 | 309 | Subsurface drainage | Evans et al. 1996 Economics of Controlled
Drainage and Sub-irrigation systems |

<http://www.soil.ncsu.edu/publications/BMPs/drainage.html>

223	310	Convert to organic	no URL
162	311	Conversion to grassland	(Helcom 2007) need specific reference – this is a general Helsinki Commission site
241	312	No-till & erosion control	<p>http://www.hgca.com/publications/documents/cropresearch/Soils.pdf http://www.gardenorganic.org.uk/organicweeds/downloads/mincult.pdf</p> <p>These are a 2 page fact sheet and a 2 page note from an organic producer</p>
327	313	Establish wetlands	Arheimer et al (2004) (Abstract only)

Water Science & Technology Vol 49 No 3 pp 37–45 © IWA Publishing 2004
Modeling diffuse nutrient flow in eutrophication control scenarios, B. Arheimer, et. al.
 Interdisciplinary. The scenarios modeled in VASTRA phase I, show that (i) changed agricultural practices can be the most effective and least expensive way to reduce nitrogen transport from land to the sea; (ii) constructed agricultural wetlands may only have small impact on riverine nitrogen transport in some regions, due to natural hydro meteorological dynamics

334	314	Put gravel in river bed	no URL
114	315	Manure nutrients	(Cuttle et al) – see #207 above
56	316	Riparian strips	no URL
231	317	N-tax	no URL
266	318	Nutrient balances	no URL
83	319	Nutrient trading	(Helsinki Commission, 2007) site too general
335	320	Grass on erode areas	no URL
57	321	Plant cover in winter	no URL

144	322	Reduce N & P fertilizer	no URL
182	323	Reduce livestock density	no URL
93	324	Reduce fall tillage	no URL
304	325	Re-meandering streams	Hoffmann, et al. 1998 – could not find
305	326	Subsurface drainage	no URL
232	327	Pricing water use	no URL this was cited in column H but useless - Rodríguez Díaz JA (2004)
58	328	Slopes	Meaningless citation
94	329	Retain/create terraces Measures	APIB - Agronomic Soil Conservation http://megapib.nic.in/soil_conservation_control.htm fact sheet with conservation measure definitions
59	330	Riparian buffer strips	(Wenger, 1999) could not find
233	331	Soil erosion plans	no URL
153	332	Irrigation methods	no URL
209	333	Export farm manure	no URL
306	334	Subsurface drainage issues	The Macaulay Institute: http://www.macaulay.ac.uk/aweg/hydroirrigate.pdf
60	335	Vegetation/river banks	no URL
336			nothing
337			nothing
338			nothing
339			nothing
340			nothing
341			nothing
342		Improving N management & irrigation practices	IPNI 4R Fact Sheet – Case Study 7-2-2

- | | | |
|-----|--|--|
| 343 | Source/rate K for tomatoes
In China | IPNI 4R Fact Sheet – Case Study 7-2-3
Shows need for K in soil testing |
| 344 | Nutrient Expert maize | IPNI 4R Fact Sheet – Case Study 7-4-2 |

A dynamic and robust nutrient management approach is essential to increase yields and optimize profits for smallholder farmers practicing within intensified cropping systems. A new fertilizer recommendation method based on yield response and agronomic efficiency for hybrid maize, Nutrient Expert (NE), was tested in North China from 2010 to 2011.

- | | | |
|-----|---|--------------------------------|
| 345 | Bosch Algae
Management of agricultural
practices results in declines
of filamentous algae in the lake Littoral | URL no good - Conesus Lake, NY |
|-----|---|--------------------------------|

- Filamentous algal cover was quantified from 2001 to 2007 in six littoral macrophyte beds. Three of the six sites were next to streams that flowed from regions where extensive agricultural BEPs designed to reduce runoff were implemented in 2003. In those 3 sites the algal cover (compared to pre BEP) was statistically lower 8 of the 11 years (72%). While the 3 non BEP sites had lowered algal cover 3 or the 12 years (25%).
- BEP site 1: row crops and dairy farming--full spectrum management practices: fertilizer reduction, cover crops, contour strips, reduction in fall and winter manure spreading, various grass filters for runoff from bunker storage of silage and milk house wastes, livestock fenced from the creek and pond.
- BEP site 2: row crops—two major efforts: construction of 3 water and sediment control basins and strip cropping designed to retain soils on the watershed.
- BEP site 3: grazing pens and water troughs were installed, cattle were fenced and starting in May 2004; and cultural management practices were implemented (i.e. changes in crop rotations, tillage practices) were implemented as fallow land, wheat, and an alfalfa grass mix were converted to soybean production acreage starting in 2003.

- | | | |
|-----|---|---------------------------------|
| 346 | Bosch Macrophytes
Extension of above | URL no good - Conesus Lake, NY |
| 347 | Winter Manure
Avoid winter manure | URL no good – Conesus Lake, NY |
| 348 | Same watershed as above | URL: no good – Conesus Lake, NY |

6 small agricultural watersheds in the Conesus Lake catchment were selected to test the impact of BMP on mitigation of nonpoint nutrient sources and soil loss from farms to downstream

- Dairy and row crops were the focus of the BMPS. Structural BMPS (construction of manure lagoons, terraces, buffer strips, and sediment control basins) and cultural BMPS (crop sequencing, soil testing, fertilization rates, and tillage practices) were used.
- Significant reductions in total phosphorus, soluble reactive phosphorus, nitrate, total Kjeldahl nitrogen, and total suspended solids concentration and flux occurred by the second year and third year of implementation
- One site where structural and cultural BMPS were introduced observed the greatest percent reduction and largest # of significant reduction in analytes

- | | | |
|-----|---|---------------------------------------|
| 349 | Manure E. coli | URL no good - Conesus Lake, NY |
| 350 | ditto | URL no good - Conesus Lake, NY |
| 351 | Methodology to show NPSP Reductions from BEPs | URL no good - Conesus Lake, NY |
| 352 | S fertilization | IPNI 4R Fact Sheet – Case Study 3-2-2 |
| 353 | Sugar cane lime & phosphogypsum | IPNI 4R Fact Sheet – Case Study 3-2-3 |
| 354 | Split N applications | IPNI 4R Fact Sheet – Case Study 5-1-4 |
| 355 | P placement, soybeans, tropics | IPNI 4R Fact Sheet – Case Study 6-3-1 |
| 356 | SAIN update March 2013 (Sustainable Agriculture Innovation Network – UK/China)
http://www.sainonline.org/SAIN-ebsite(English)/download/SAIN_update_March_2013_EN.pdf | |

New additions from Chuck Chaitovitz – e-mail dated 19 July 2103

All 10 Case Studies were included above from the spreadsheet

New additions from Chuck Chaitovitz – e-mail dated 19 July 2103
12 listed CCA practices spreadsheet

Respondent ID	Where	Practice/result
<u>From Spreadsheet</u> 2663979798	Pampas, Argentina	Site specific management w/ NM, CT, EC, CC
2647900628	India	all 8 BEPs – climate resilient interventions at village level
2647359303	Ecuador	Sugarcane NM, no reports yet
2586171183	China	CT/EC on sloping lands, alley cropping, says part of IPNI work but none cited
2582154466	Canada	Lake Erie Watershed 4R Nutrient Stewardship Certification Program –URL no good
2559283044	Pampas, Argentina	Value of continuous covers, beef grazing management , Site specific
2536252294	India	Eco-Efficiency. The Rice-based IFS are dynamic Models and can be extended to rain fed lowlands and irrigated rice-growing areas in Africa and other Asian countries
2534716368	Brazil	Sewage sludge in San Paulo – no reports/URL
2533517266	India	NM of K on turmeric – nice response
2513885562	Brazil	Development of an algorithm for site-specific nitrogen management using active canopy sensors – 20/ha - NM

Based on these strong correlations, we developed an N recommendation algorithm based on ultrasonic plant height measurements to be used for on-the-go variable rate N application. Lastly, we evaluated the crop water status using infrared thermometry integrated with optical and ultrasonic sensors, we concluded that the integration of sensors was beneficial to detect water-stressed zones in the field, affecting yield and possibly promising to delineate zones for N and water management.

Luciano Shozo Shiratsuchi, "Integration of plant-based canopy sensors for site-specific nitrogen management" (January 1, 2011). *ETD collection for University of Nebraska - Lincoln*. Paper AAI3486927.

2509812547	Mexico	E/OPS – anaerobic effluents as substitute for fertilizers – no reports/URL
2508189020	Argentina	Cropping system effects on soil properties Includes crop rotation – no reports/URL

