ADB Pilot and Demonstration Activity for PRC:

Assessing the Feasibility of Nutrient Trading Between Point Sources and Nonpoint Sources in the Chao Lake Basin

Final Report

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World Resources Institute

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List of Acronyms

ADB	Asian Development Bank
BMP	Best Management Practice
CAFO	Concentrated Animal Feeding Operation
CLMA	Chao Lake Management Authority
CNY	Chinese Yuan
COD	Chemical Oxygen Demand
EPB	Environmental Protection Bureau
FYP	Five Year Plan
GDP	Gross Domestic Product
MEP	Ministry of Environmental Protection
NPS	Nonpoint Source
PDA	Pilot and Demonstration Activity
PDRC	Anhui Provincial Development and Reform Commission
PRC	People's Republic of China
TN	Total Nitrogen
TEC	Total Emission Control
TP	Total Phosphorus
WRI	World Resources Institute
WWTP	Wastewater Treatment Plant

1. Background

China's freshwater lakes are at risk. Despite years of rehabilitation efforts, four-fifths of the nation's major lakes are deemed polluted and nearly 60 percent also suffer from eutrophication problems.[1] One of those lakes is Chao Lake in Anhui Province. Due to excessive nutrient (nitrogen and phosphorus) enrichment, harmful algae blooms frequently occur in the lake, rendering water quality unsuitable for human consumption and other uses.

The Asian Development Bank (ADB) is proposing one of its largest financing projects in the environmental sector to support the People's Republic of China (PRC) to rehabilitate Chao Lake.[2] Initial studies commissioned by the ADB, Non-Point Source Pollution in Chao Lake Basin (Ji, 2011), and Non-Point Source Pollution in Chao Lake Basin (AECOM, 2011), suggested the agriculture sector is a major contributor to the lake's water quality degradation. However, past remediation efforts are mostly focused on urban point source control, while little attention has been paid to the agriculture sector. Meanwhile, unlike industries or urban wastewater, agriculture nonpoint sources have largely escaped from direct regulation and can't be simply addressed by command-and-control schemes. Therefore, new strategies are needed.

Globally, agricultural discharges can generally be reduced at lower cost than discharges from municipal or industrial point sources. Water quality trading programs that allow point-to-nonpoint trades may leverage point-source regulatory requirements to generate reductions from unregulated nonpoint sources. Under ADB's Pilot and Demonstration Activities (PDA), the World Resources Institute (WRI) is appointed to assess the feasibility of water quality trading between point sources and nonpoint sources in the Chao Lake Basin.

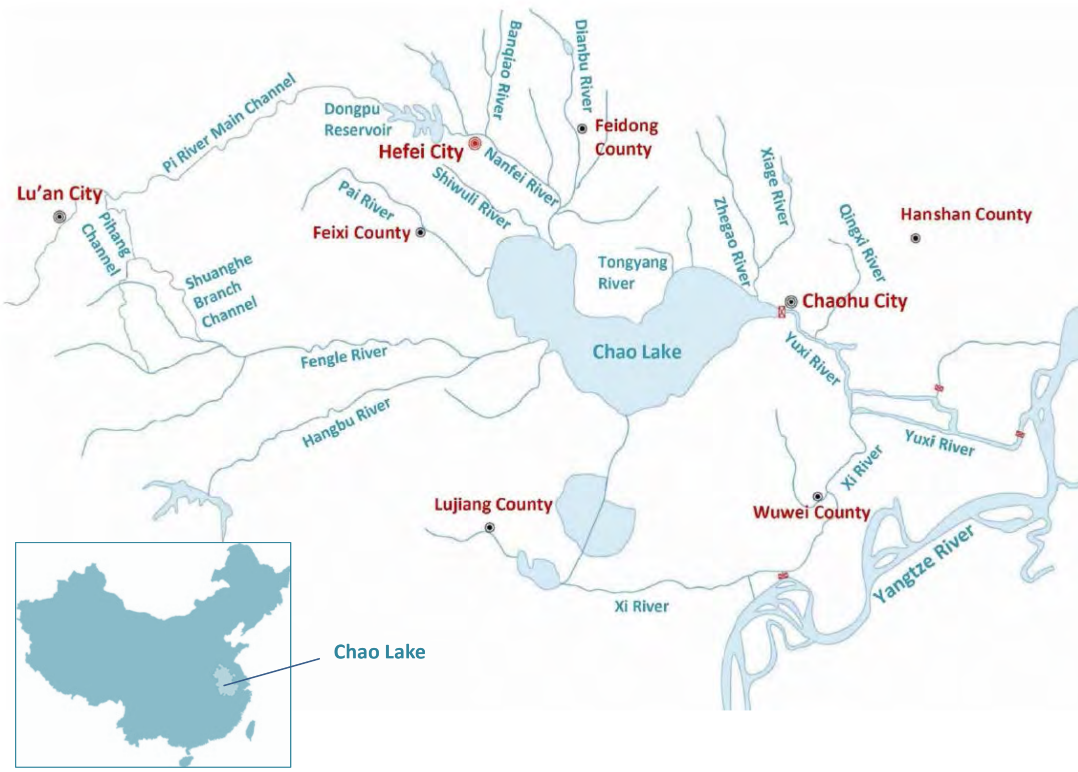
1.1 Chao Lake introduction

Located in the center of Anhui Province, Chao Lake is the PRC's 5th largest freshwater lake and a major source of water for public, domestic, agricultural, and industrial use. It has a surface area of approximately 760 km^2, with an average depth of approximately three meters. The lake is drained by the Yuxi River in the southeast, a tributary of the Yangtze River. When the Yangtze River floods, floodwaters back up in the Yuxi River and Chao Lake and cause flooding of lakeshore areas. To prevent this, two sluice gates were constructed on the

[1] China Ministry of Environmental Protection. *2010 China Environment Bulletin*, 2010 (http://jcs.mep.gov.cn/hjzl/zkgb/2010zkgb/201106/t20110602_211577.htm)

[2] ADB. 44036-013: Anhui Chao Lake Environmental Rehabilitation Project. http://www.adb.org/projects/44036-013/main

Yuxi River in the 1960s. This had the unintended effect of decreasing the natural flushing pattern of the lake, leading to increased eutrophication.[3]



Adapted from the Interim Report for Anhui Chao Lake Environmental Rehabilitation Project, ADB

Figure 1 Map of the Chao Lake Basin

The Chao Lake catchment area (Figure 1) comprises nine counties/districts from Hefei Municipality, and three prefectures (i.e. Liu'an, Wuhu and Ma'anshan).[4] It covers 13,486 km^2 of rugged mountain and flood plain. The total population of the catchment in 2010 was about 10 million, of which 56.26 percent were urban inhabitants, [5] higher than the national average of 49.95 percent.[6]

[3] Xie, P. (2009), Reading the History of Cyanobacteria, Eutrophication and Geological Evolution in Lake Chao, Beijing: The Science Press

[4] On September 10, 2011, the Municipality of Chaohu was dissolved and transferred its counties to neighboring Hefei, Wuhu and Ma'anshan. Currently, the Chao Lake Basin includes 9 counties /districts from Hefei (Hefei City, Feidong County, Feixi County, Chaohu City, and Lujiang County), Ma'anshan (He County, and Hanshan County), Wuwei County of Wuwei, and Shucheng County of Liuan. (Xinhua News Agency, 2011, Anhui Dissolved Chaohu Municipality: http://news.xinhuanet.com/politics/2011-08/22/c_121891458.htm)

[5] Anhui Statistical Yearbook 2011, 2011

[6] China Statistical Yearbook 2011, 2011

Chao Lake is a shallow natural lake surrounded by large area of productive farmland as well as nine municipalities and counties that are experiencing rapid urbanization. Total GDP of the catchment area was about CNY 326 billion (USD $51.34 billion, 2010 exchange rate of 6.35) in 2010. Per capita GDP was CNY 33,670 or 5,302 in USD (12 percent higher than the national average of CNY 29,992 and 43 percent higher than the provincial average CNY 20,887).[7] Like many other freshwater lakes in the PRC, population growth, agricultural intensification and rapid urbanization have led to environmental deterioration of the Chao Lake. The water quality of the lake has been rated as Grade V in 2010, with primary pollutants of nitrogen and phosphorus.[8]

1.2 Past efforts to restore Chao lake

Since the 9th Five-Year-Plan (FYP, 1995-2000), main efforts to restore Chao Lake have concentrated on reducing point source discharges and some efforts to clean river courses and dredge the lake bed. Assisted by loans from the ADB totaling CNY 2 billion (approx. USD $241 million, 1997 exchange rate of 8.3) since 1997, Anhui has successfully reduced emissions from untreated municipal wastewater and the industry sector via the construction of Wangxiaoying WWTP (Phase II), Chaohu WWTP (Phase I), and several industrial wastewater treatment plants.[9] While urban industrial discharges and atmospheric deposition still contribute to pollutant load to Chao Lake, the agriculture sector is now the biggest contributor of nutrient pollution in the basin. According to the first national pollution source census conducted in 2008, agricultural activities accounted for over 60 percent of nutrient discharges in Anhui province.[10] While several billion CNY have been invested to date to clean up Chao Lake, little of this money has been devoted to controlling agricultural nonpoint source (NPS) pollution.[11] The investments in point source controls alone will be insufficient to restore the water quality of Chao Lake, hence new strategies are needed.

1.3 Challenges

Despite the government's determination to remediate Chao Lake over the past two decades, direct and indirect drivers of eutrophication are expected to continue to increase. Specifically:

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[7] Anhui Statistical Yearbook 2011, 2011

[8] According to PRC's surface water quality standard, Class I, Class II and Class III means the water quality is suitable for drinking water supply purpose, Class IV water can be utilized for industrial purpose while Class V can only be used in the agricultural sector. (source: China Ministry of Environmental Protection, http://kjs.mep.gov.cn/hjbhbz/bzwb/shjbh/shjzlbz/200206/t20020601_66497.htm)

[9] Yin, F., Shan P. (2003), Environmental Benefits Analysis of Chao Lake Rehabilitation, Environment Science Trends, 4: 1-2

[10] Anhui Environmental Protection Bureau, 2010. Report on the First National Census on Pollution Sources

[11] Interview with officials at Anhui Agriculture Commission. 2012

- Urban populations will continue to grow in the surrounding municipalities, most likely at a very high rate. According to the provincial 12th FYP (2011-2015) for urban development, the urbanization rate of Anhui is expected to reach 50 percent by 2015, up from 43.2 percent in 2010,[12] which will increase pressures on natural resources, urban infrastructure, and the productive capacity of agriculture and industry;

- Intensive agriculture will continue to increase in the Chao Lake Basin as a result of greater demand for food, especially meat. Vegetable yields are expected to increase by 27 percent in the coming five years while total production of meat, egg and milk are projected to rise by 22 percent, in the same period.[13] Continuous rapid growth in the agricultural sector threatens to cause increased nutrient loads to the lake.

However, policies to address eutrophication are largely lacking or are inefficient in China today. Barriers to developing and implementing effective policies for nutrient pollution control mainly include:

- *Lack of knowledge and understanding of eutrophication*. China's policies to reduce water pollutants have centered on oxygen-demanding substances (measured in terms of chemical oxygen demand or COD). Though ammonia nitrogen has been incorporated into the national major pollutant reduction program, as the first step to tackle nutrient pollution, decision-makers still need more information about the sources of nutrient pollution and the available options for reducing nutrient discharges.

- *Incomplete strategies.* Current policies to reduce water pollutants largely focus on point sources such as industrial runoff and municipal wastewater, and fail to address agricultural nonpoint source pollution, which now accounts for the majority of nutrient pollution.

- *High costs*. The costs associated with reducing nutrient loading to impaired water bodies are often excessively large. For example, the cost of achieving Chesapeake Bay restoration goals in the United State is estimated to be $28 billion (2003 dollars)[14], the cost of achieving Lake Tai

[12] Anhui Development and Reform Commission. 2011. (http://www.ahpc.gov.cn/shownews.jsp?newsId=5293)
[13] Anhui Agriculture Commission. 2011,Anhui Provincial 12th Five-Year Plan for Agriculture Development
[14] Karl Blankenship. 2011. Studies aim to put a figure on cost of cleanup, benefits of better Bay. Chesapeake Bay Journal. http://www.bayjournal.com/article/studies_aim_to_put_a_figure_on_cost_of_cleanup_benefits_of_better_bay

restoration goals in the period of the 11th FYP (2006-2010) in China is estimated to be $14.4 billion (2007 exchange rate of 7.3)[15].

- *Low cost-effectiveness*. Restoration plans often do not or cannot maximize nutrient reductions per dollar spent. For example, the current policy to upgrade existing wastewater treatment plants (WWTPs) to meet Class I-A standards could only reduce limited amount of pollutants, particularly nitrogen, at relatively high cost.

1.4 Nutrient trading as a possible solution

The PRC government recognizes the need for controlling nutrient pollutants and eliminating eutrophication. Caps for total nitrogen (TN) and total phosphorus (TP) discharges have been implemented for all municipalities within the key lake basins in the 12th FYP period (2011-2015),[16] in addition to the mandatory national targets of reducing COD by 8 percent and reducing ammonia-nitrogen by 10 percent. To meet these targets, local government must find cost-effective ways to achieve nutrient discharge reductions, including ones from the agricultural sector.

The success of past clean-up efforts has been limited partly due to ineffective strategies for controlling agricultural NPS pollution. In many areas of the world the majority of nutrient pollution originates from agricultural nonpoint sources, which can generally be reduced at lower cost than discharges from municipal or industrial point sources. Accordingly, point-to-nonpoint source water quality trading can take advantage of differences in pollution reduction costs. Globally, over 70 percent of active water quality trading programs allow trades between point and nonpoint sources.[17]

Experiences from the United States indicate that point-to-nonpoint source water quality trading can improve environmental quality in a manner that:

- Reduces cost and creates revenue opportunities by incentivizing the lowest cost pollutant reductions, for instance, the pollutant reduction from agricultural nonpoint sources. With trading, entities that are able to reduce their pollution below required levels are able to sell their surplus reductions to entities facing higher costs.
- Accelerates pollution reductions by encouraging adoption of less expensive pollution reduction practices that are typically faster and easier to implement. Trading can tap the most efficient, available reductions.

[15] Lake Tai costs are taken from the Tai Lake Master Plan (NDRC, 2008)
[16] Key Lake Basins include the Chao Lake, Tai Lake and Dianchi Lake.
[17] Selman, et al. 2009.Water Quality Trading: An International Overview. Washington,DC: World Resources Institute.

- Provides flexibility by allowing nutrient dischargers to make their own decisions on how to reduce the discharge or runoff of water pollutants and thereby meet water quality targets;
- Stimulates innovation in technologies and land management practices that reduce nutrient pollution by offering new revenue streams for these innovations; and
- Generates ancillary benefits such as habitat for wildlife, erosion control, and aesthetic benefits by financing land management practices that reduce nutrient runoff such as expanded buffer strips on farms and wetland restoration or construction.

Hence, market-based instruments such as nutrient trading between (municipal and / or industrial) point sources and (agricultural) NPS could potentially help Chao Lake municipalities meet the targets for nutrient reductions. A market for nutrient discharge reductions could have other benefits as well, including creating financial incentives for farmers to decrease nutrient runoff, increasing farmer income, achieving the nutrient reduction targets at lower costs, and improving the water quality of Chao Lake and its upstream rivers and streams. It could become part of a new, more cost-effective and efficient strategy for improving the water quality of Chao Lake.

2. Objectives and tasks

2.1 Objectives

This PDA project seeks to evaluate the feasibility of a point-to-nonpoint source nutrient trading program in Chao Lake Basin. Specifically:

- Determines if an effective point source-nonpoint source nutrient trading program could be established in the Chao Lake basin;
- Determines the potential benefits of a Chao Lake nutrient trading program;
- Determines the framework and necessary elements of a Chao Lake nutrient trading program.
- Provides policy recommendations to develop a nutrient trading program.

2.2 Scope of work

The overall evaluation of the feasibility of a Chao Lake nutrient trading program, its potential benefits, framework, and elements will focus on the entire Chao Lake basin. The development of a recommended pilot program will be for a portion of the basin, such as a river basin or county, that will be selected during the overall evaluation.

2.3 Key tasks

This PDA project will be implemented in the Chao Lake catchment. It will evaluate the environmental, technical, economic, and institutional feasibility of establishing a point-to-nonpoint source nutrient trading program. Specific activities include:

- Reviews national, provincial and local legislations, policy documents, plans to identify legal and institutional foundations of nutrient trading.
- Selects pollutants to be traded—Total Nitrogen (TN), Total Phosphorus (TP) or both.
- Assesses emission sources and rates for the selected pollutant(s).
- Identify agricultural BMPs to reduce nutrient pollution in the pilot county.
- Assesses the potential supply of credits of the selected pollutant(s) by conducting a Pollutant Reduction Opportunity Analysis.
- Identifies potential credit buyers (sub-sector level identification) and assess potential credit demand.
- Assesses the economic impact of trading on credit sellers and buyers. And
- Identifies trading program elements and rules that are necessary to ensure the requirements for efficiency, equivalence, additionality, and accountability are met.

2.4 Overview of project implementation

This study was previously planned as a 6-month project starting on February 8, 2012 but the completion date was extended to November the 30th with ADB's approval. Two progress reports (Inception Report and Mid-term Report) were submitted on March 22 and August 1, respectively.

The project activities mainly include field visits, stakeholder meetings, literature review, and data collection and analysis:

- Field visits and stakeholder meetings: Four field trips with various stakeholder meetings were organized to obtain more accurate and quantitative information. A list of individuals who were interviewed by the Project Team is attached as ANNEX I.
    - The first trip was organized soon after the project kick-off, from February 8 to 10. Separate meetings were arranged to introduce research objectives and seek feedback from government officials. Government agencies that provided inputs were the Anhui Development and Reform Commission (PDRC), the Anhui

Environmental Protection Department (EPD), the Anhui Agriculture Commission, CLMA, and the Lujiang Development and Reform Commission. Experts from the AECOM TA team were also interviewed.

- The second trip was led by Prof. Jin Leshan, the Agriculture Specialist on the team, from February 26 to 29 to evaluate the nutrient load from the agricultural sector. Officials from the Anhui Agriculture Commission, the Lujiang Agriculture Bureau, as well as farmers and owners of concentrated animal feeding operation (CAFO) were interviewed.
- The third trip to Hefei was organized from April 25 to 27 to assess policy environment and government capacity regarding water quality trading. Led by Dr. Zhong Lijin, Team Leader of this project, the Project Team visited concerning government agencies, including PDRC, PEPB, CLMA, the Anhui Agriculture Commission, the Anhui Agricultural Environmental Protection Center, and the Soil and Fertilizer Station.
- The fourth trip was organized from September 17 to 19 to better understand the potential nutrient credit buyers and sellers within Chao Lake basin through a series of stakeholder meetings. The Project Team visited farmers, CAFO owners, and WWTP managers to further identify potential participants of the proposed trading program.

- Literature review and data analysis: The Project Team reviewed legislation, plans, policy documents related to Chao Lake rehabilitation, point source and nonpoint source (NPS) pollution control, as well as pollutant trading. Meanwhile, Lake Tai COD Trading Program was evaluated as a case study to identify barriers of a successful trading project. All data and information were processed in Beijing.

2.5 Outputs and outcomes

- **Output**

Report on the findings of the feasibility study, including policy recommendations and key elements for a trading demonstration project in a small portion of the Chao Lake catchment.

- **Outcome**

The feasibility of point-to-nonpoint source nutrient trading in the Chao Lake basin is demonstrated.

3. Research and theoretical framework

3.1 Research framework

The research framework of this study is described in Figure 2, focusing on determining if an effective point-to-nonpoint nutrient trading program could be established in the Chao Lake basin and identifying the obstacles.

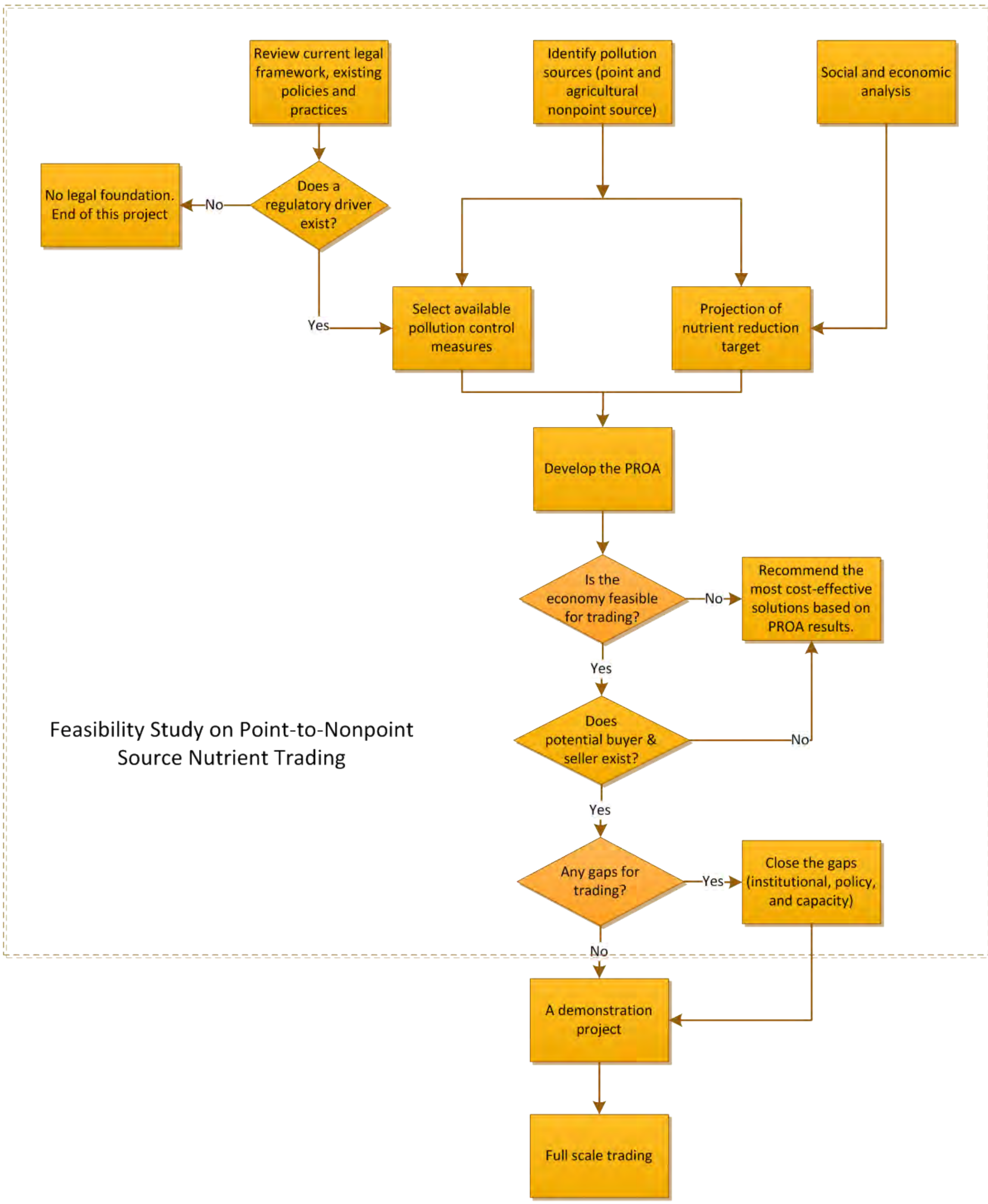


Figure 2 Research Framework

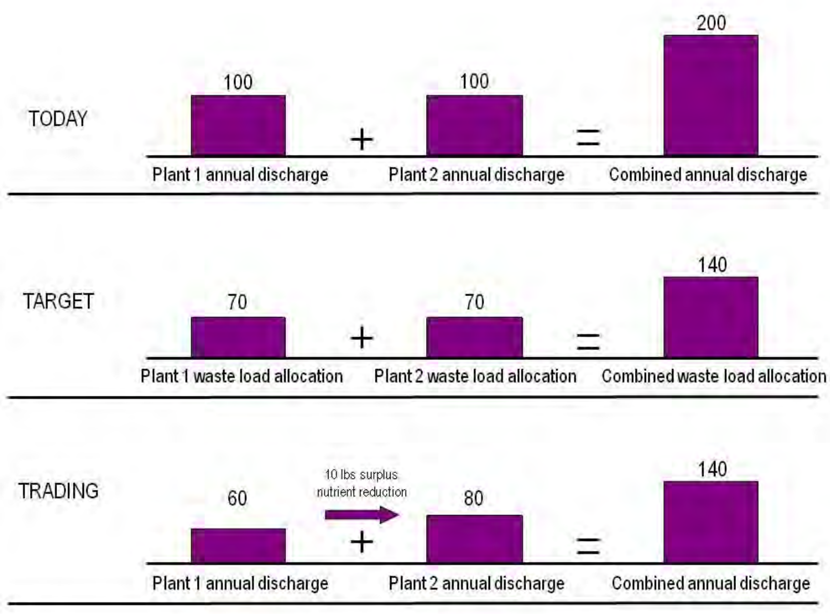
3.2 Pollution Reduction Opportunity Analysis (PROA)

The PROA tool was first developed by WRI and Tsinghua University to assist eutrophication control in the Tai Lake Basin. It is a decision-support tool designed to help identify the most cost-effective solutions for pollution reduction (e.g. ammonia-nitrogen). The PROA tool can be used to determine reduction potentials and estimated costs of each option, and show the cost difference among various reduction measures, which is a prerequisite for nutrient trading.

3.3 Point-to-nonpoint source nutrient trading

3.3.1 Rationale of point-to-nonpoint source nutrient trading

Water quality trading is a market-based approach to reducing water pollution and achieving water quality goals in a cost-effective manner. It is premised on the fact that the cost of reducing pollution discharges differs between pollution sources depending on their size, location, scale, management, and/or overall efficiency. Under a water quality trading program, dischargers that are able to economically reduce their annual pollutant discharges below regulated or permitted levels are allowed to sell their "surplus" reductions to dischargers facing higher pollution reduction costs. This is illustrated in Figure 3 for trading between point sources.

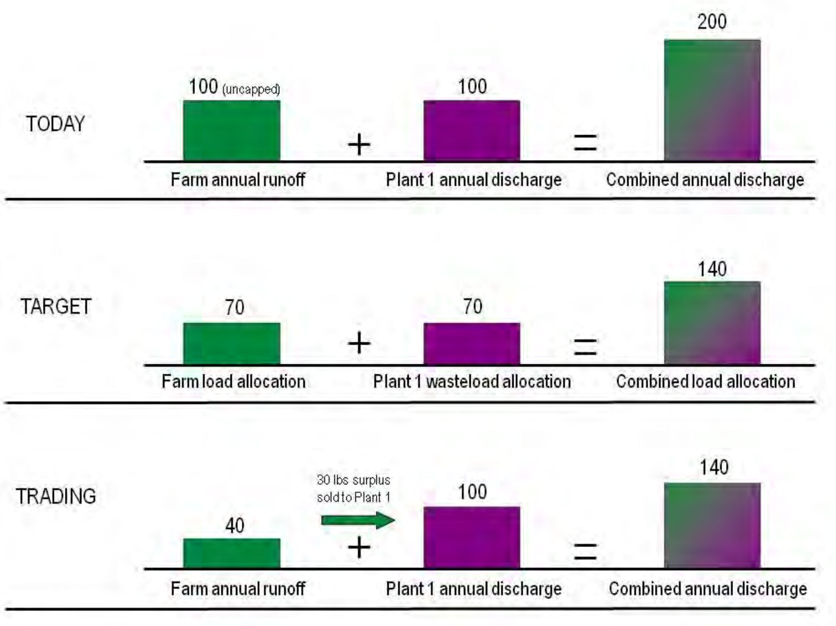


Source: FAQ on Water Quality Trading, WRI

Figure 3 Point Source-Point Source Trading (illustrative)

However, the majority of nutrient pollution in China, as well as in most other countries, originates from agricultural NPSs and is generally unregulated. Trading between point sources and NPSs provides an opportunity for point sources with high nutrient reduction costs to purchase nutrient reduction credits from nonpoint sources, which often have lower costs per unit of nutrient reduction. As illustrated in Figure 4, agricultural nonpoint sources (e.g. farmers) usually play the role as sellers of nutrient reduction credit in the point-to-nonpoint sources nutrient trading. It should be noted that in the United States, potential credit sellers (farmers) must first achieve load reductions that satisfy their baseline requirements before selling nutrient credits.[18] Trading gives both point sources and nonpoint sources the flexibility of achieving an environmental target using the most cost-effective option available to them.

In addition to helping achieving water quality goals in a cost-effective manner, water quality trading is also a mechanism for maintaining a watershed cap while accommodating for growth. For example, a water quality trading program would allow new or expanding industries to obtain discharge permits as long as they offset their loads through the purchase of nutrient credits.



Source: FAQ on Water Quality Trading, WRI

Figure 4 Point-Nonpoint Source Nutrient Trading (illustrative)

3.3.2 Fundamental criteria in designing a point-to-nonpoint trading program

The fundamental purpose of a water quality trading program is to help achieve water quality goals. Because of this, trading programs must be carefully designed in order to achieve this. If not properly designed, they could actually make things worse. Trading programs must not pose risks to society's ability to achieve water

[18] The baseline is defined as their nutrient reduction requirements or load allocations under a TMDL or watershed strategy. While this is not a direct regulatory requirement for farmers, state and local governments are required by regulations to ensure that the agricultural loads are reduced to the cap set by the TMDL. (Source: FAQ on Water Quality Trading. WRI)

quality goals. Water quality trading programs can be evaluated in terms of three fundamental criteria for sound design that have been identified and applied in most trading programs around the world.[19,20]They are environmental equivalence, additionality, and accountability and are defined as follows:

- **Environmental Equivalence** –requires that the pollutant load being trading would produce environmental results equivalent to the no-trading situation. A kilogram mass load reduction produced by the credit seller must have equivalent environmental benefit to a kilogram of reduction produced by the credit buyer.
- **Additionality** –requires that pollutant load reductions produced in order to sell credits must be in addition to those reductions that would occur in the absence of trading, if any. A credit seller that has a requirement under the a watershed loading cap to reduce his or her load must first achieve reductions that meet this requirement and then produce additional reductions to sell as credits. Trading programs must ensure that this is the case when trades are approved, and remains the case throughout the life of the trades (i.e. "leakage" is prevented). If a seller has no requirements under the cap, it still might be a good idea to establish some sort of baseline requirement for the seller to meet before selling credits, in order to require the seller to make some contribution to meeting water quality goals and make it easier to achieve the overall watershed cap.
- **Accountability** –provides the means to ensure that the equivalence and additionality criteria are met. It covers many aspects of a trading program, including establishing trading eligibility, tracking of trades, verification of credit generation, compliance and enforcement, monitoring of results, and program assessment.

3.3.3 Necessary Elements in a point-to-nonpoint trading program

WRI has identified six elements that would be necessary components of a Chao Lake trading program and would help ensure that the equivalence, additionality and accountability criteria are met. They are briefly introduced below.

- **Credit Definition** – the commodity being sold in a water quality trading market is a public good – a pollutant load reduction – and hence must be carefully defined. This is particularly important for meeting the equivalence

[19] Fang, F. Easter, K.W. (2003) Pollution Trading to Offset New Pollutant Loadings—A Case Study in the Minnesota River Basin. Presented at the American Agricultural Economics Association Annual Meeting, Montreal, Canada, July, 2003; http://www.envtn.org/docs/MMN_case_Fang.pdf
[20] CPLS (1999) Effluent Trading: A Policy Review for Texas. Report prepared for the Texas Natural Resources Conservation Commission by the Center for Public Leadership Studies: Texas A&M University, College Station, Texas.

criterion. A standard definition of a credit has evolved in trading programs around the world: A unit of pollutant discharge expressed in the mass-per-unit time created when a discharger reduces its discharge of the pollutant below its baseline requirement.[21] This is usually taken to mean the mass load delivered to the portion of the water body that is impaired, and not the edge-of-field or end-of-pipe loads.

- **Eligibility Requirements for Credit Producers and Users** – in order to help ensure that the trading market functions properly and contributes to meeting water quality goals, eligibility rules for parties wishing to participate must be defined. For example, a trading program in which point sources purchase credits from nonpoint sources could limit eligible nonpoint sources to agricultural producers and exclude other land uses or pollutant sources. Credit purchase eligibility could be given to municipal point sources, industrial point sources, or both. Once the general classes of credit suppliers and users are determined, the potential need for eligibility criteria for individual suppliers and users should be evaluated. For example, are there conditions that a farming operation should have to meet before being eligible to participate in the program? For a wastewater treatment plant to meet before being eligible to buy and use credits?
- **Credit Certification and Verification Procedures** – trading programs must have mechanisms to ensure that credits sold on the market are real and verifiable. Credit certification and credit verification are two critical elements that help ensure this. Credit certification is a process in which a party wanting to sell credits must submit an application to the trading program managers in which the proposed method of generating credits and the quantities that will be produced are described in sufficient detail so that the managers can determine if the credits will be real and verifiable. Approval of the application certifies that the credits are valid and may be sold. Following their sale, an annual inspection of the credit generating practices is required in order to verify that the credits are being produced in accordance with the initial certification. In sum, this is a process of initial certification followed by ongoing verification.
- **Monitoring and Reporting Requirements** – some level of monitoring may be required as part of the verification process. This will depend on the method for producing credits. Trading programs must also be transparent to help ensure their integrity. Credit producers and buyers

[21] Jones, C., L. Bacon, M.S. Keiser, and D. Sheridan. 2006. Water-Quality Trading: A Guide for the Wastewater Community. Water Environment Federation and Water Environment Research Foundation. New York: McGraw-Hill.

must be required to report their trading activity. Credit sellers should report their credit production and information on each credit sale, notable the identity of the buyer and the quantity sold. Credit purchasers should report their credit purchases and uses.

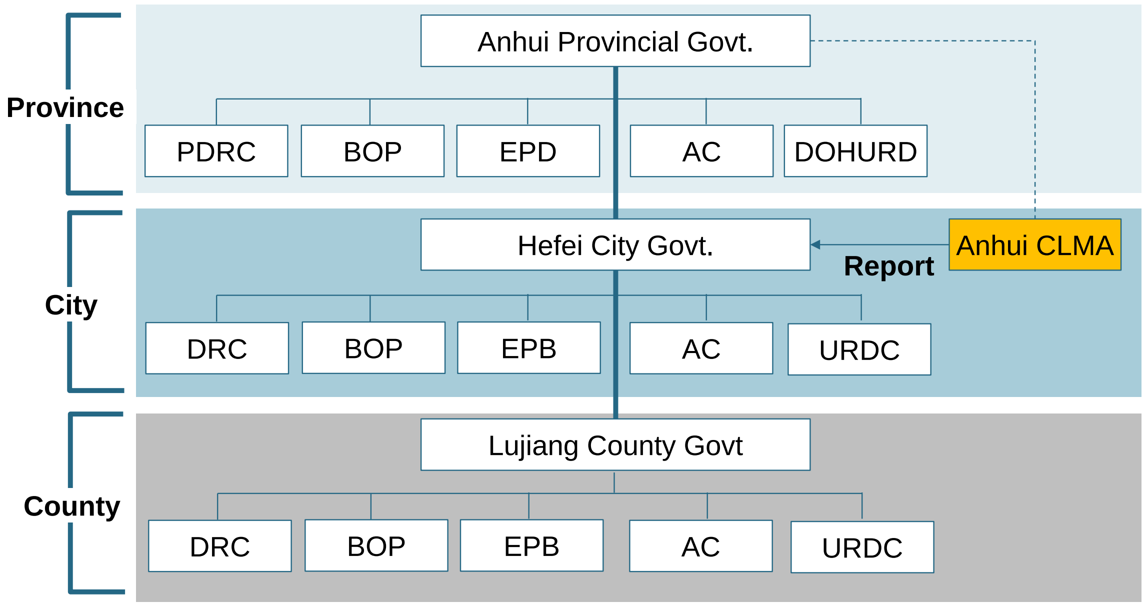
- **Trading Mechanisms** – credit trading mechanisms define how buyers and sellers find each other and execute trades; in other words, how the market actually functions. There are a number of mechanisms that could be used in a trading program. They range from bilateral trading in which buyers and sellers find each other and negotiate trades to much more structured mechanisms such as central credit banks or exchanges. Local conditions and requirements must be carefully evaluated in order to select the most appropriate mechanism for a given watershed and trading program.
- **Compliance and Enforcement Mechanisms**– the compliance and enforcement mechanisms of a trading program are the means by which the program ensures that the accountability criterion is met. Program managers must have the ability to determine if credit buyers and sellers are complying with all of the rules and requirements of the program. The credit certification and verification procedures described above, as well as the monitoring and reporting requirements are examples of compliance mechanisms. In the event a buyer or seller fails to meet a trading program requirement or breaks a program rule, the managers must have adequate and effective enforcement tools available to them so that they can require corrective actions or impose penalties. A variety of enforcement mechanisms ranging from mild to severe is needed.

4. China's water quality management policies and implications on nutrient trading

China's water quality management is rather young and started almost from scratch in the late 1970s when the National People's Congress passed the first ever Environmental Protection Law. In the subsequent era of reform and open-up policy, the institutional and legal regime began to develop, coinciding with growing awareness of environmental issues. In a relatively short period, China has developed an extensive framework of water pollution prevention and control, building an instructional and legal foundation for nutrient trading.

4.1 Institutional structure of water quality management in China

The institutional structure of water management is quite fragmented in China, making it necessary to forge partnerships with key institutions and in some cases create bridging institutions to coordinate information and activities among the various agencies, jurisdictions, and stakeholders. Figure 5 presents the matrix of institutional structure of water quality management in the Chao Lake basin.



(Developed by WRI)

Abbreviations: CLMA - Chao Lake Management Authority; PDRC - Provincial Development and Reform Committee; DRC - Development and Reform Committee; BOP - Bureau of Pricing; EPD - Environmental Protection Department; EPB - Environmental Protection Bureau; AC - Agricultural Committee; DOHURD - Department of Housing and Urban-Rural Development; URDC: Urban-Rural Development Committee.

Note: Lujiang is a pilot county under this project.

Figure 5 Institutional Structure of Water Quality Management in the Chao Lake Basin

At the national level, the Ministry of Environment Protection (MEP) oversees water quality management with a prevailing focus on point source discharges (including industrial and domestic pollution). A number of other ministries are empowered to manage water quality related affairs within their jurisdiction, for instance, the National Development and Reform Committee (NDRC) steers planning and pricing (such as wastewater treatment charge and pollution fee), the Ministry of Agriculture (MOA) leads agricultural pollution and the Ministry of Housing and Urban-Rural Development (MOHURD) manages the construction and operation of urban wastewater infrastructure.

At provincial and local levels, government organization is similar to the central government. A notable difference in Anhui is the Chao Lake Management Authority (CLMA), a river basin management authority structured under the provincial government but which directly reports to the Hefei City government. The CLMA was created in 2011 to address the weak coordination in watershed management, which incorporates different functions across traditional departments, including designing basin-wide regulations, developing strategy plans, overseeing water resource, environmental protection, fishery, tourism, and navigation in Chao Lake Basin. However, some of the CLMA's responsibilities overlap with environmental and agricultural authorities at both provincial and municipal levels. Because of this, CLMA's potential role in water quality management need to be further identified.

The multi sectoral nature of trading between point and nonpoint sources needs stronger and more engaged institutions than would be true of point-to-point source trading programs. Active cooperation between the environmental authorizes and the agricultural authorities will be required, in particular regarding agricultural nonpoint sources monitoring, BMPs verification, as well as agricultural credit measurement and certification. Collaborative efforts among the DRC, BOP, DOHURD, and CLMA in the case of Chao Lake, will also be required for an effective trading scheme.

4.2 Legal and policy foundations for water quality management

Globally, mandatory regulations, also referred to as "command-and-control" approaches, represent one of the most straightforward approaches to controlling pollution. Market-based approaches, on the other hand, have gained increasing attention for their cost-effectiveness. This section identifies the legal and policy foundation of water quality management through the evaluation of historical development of China's water pollution control policies. A list of key regulations and policies can be found in ANNEX II.

4.2.1 Point source pollution control

Over the past three decades, the Chinese government's efforts to control water pollution have been expanding from industrial point source, to residential and commercial point source, and then to NPS pollution.

The legal foundation of water pollution control has been established with the promulgation of China's first ever Environmental Protection Law since 1979. A more dedicated legislation for water, the Law on Prevention and Control of Water Pollution was issued in 1984 and was amended twice in 1996 and 2008, separately, further clarifying the responsibilities of various governmental departments and introducing stricter non-compliance provisions.

Regulatory tools such as environmental impact assessment and the three simultaneities system, as well as the pollution levy system have been introduced to tackle industrial pollution since the 1980s.[22] The wastewater treatment charge for water users found its legal foundation in the Administrative Method on Urban Water Price issued by the National Development and Planning Commission in

[22] Three Simultaneities stand for the policy that pollution control facilities must be designed, constructed and used at the same time with the construction project.

1998 (today's NDRC), [23] which will be further discussed in section 4.2.5. Meanwhile, national water quality and pollutant discharge standards were issued over time. Today the priority of point sources regulation is given to pollutant reduction and environmental compliance.

4.2.2 Nonpoint source pollution control

Agriculture pollution has been largely neglected until recently. Although the Agriculture Law, the Cleaner Production Promotion Law, and the Agricultural Product Safety Law all have articles on pollution control, they are very general and difficult to implement.

In response to increasingly severe pollution from livestock farming, a portion of animal farming that meets the definition of concentrated animal feeding operation (CAFO) started to be regulated as point source under the Measures for Pollution Prevention and Control in Animal Feeding Industry in 2001.[24]

For two consecutive years in 2006 and 2007, the No. 1 Central Policy Documents[25] called for modernizing Chinese agriculture and improving the rural environment, and for speeding up the implementation of rural environmental protection and the control of agricultural NPS pollution. A significant investment project that accompanied it – The New Rural Construction – has been implemented nationwide to provide subsidies and cost-share for the management of manure, waste straw, and rural wastewater.

The 2008 Amendment of Water Pollution Prevention and Control Law was regarded as a major progress to explicitly connect environmental protection with NPS pollution. A whole section on agriculture and rural pollution was parallel with point source pollution control. However, the amendment still lacks detailed measures and institutional building, especially on regulating pollution caused by crop farming.

4.2.3 Water pollutant reduction targets and caps

Water pollutant reduction targets and caps include limits on the amount of allowable pollution discharge that can be emitted to the air or water. In China, the ongoing Total Emission Control (TEC) program set COD and ammonia nitrogen load reductions as water quality targets on a five-year basis, while total nitrogen

[23] The formerly National Development and Planning Commission. Administrative Method on Urban Water Price. 1998

[24] Measures for Pollution Prevention and Control in Animal Feeding Industry (No. 9, Policy paper of SEPA, 2001)

[25] In China, the central government's first policy document of the year sets the top priorities and has significant political influence.

(TN) and total phosphorus (TP), indicators of eutrophic levels, are not compulsory.

However, the 12th FYP for Water Pollution Control in Key River Basins integrated TN and TP to the TEC program for all key basins (including Chao Lake municipalities), and the agriculture sector is expected to reduce nutrient loads as well as point sources. Echoing the plan, the Anhui Agriculture Commission allocated the reduction goal and mapped out solutions to different categories, e.g. improving fertilizer efficiency by 5 percent, increasing straw recycling to 85 percent, and expanding CAFO by 60 percent.[26]

4.2.4 Environmental monitoring system

Water quality monitoring is overseen by MEP, consisting of water quality monitoring and pollutant source monitoring. Pollutant source monitoring is relatively incomplete, with its focus in industrial and urban areas while rural villages are largely ignored before 2008.

In 2008, the State Council launched the First National Pollution Sources Census on the 1st January, firstly covering both (industrial and municipal) point sources and agricultural nonpoint sources. This pollution sources census was led by the Ministry of Environmental Protection, with the support of the Department of Science, Technology and Education of the Ministry of Agriculture and local agricultural authorities to collecting the information of agricultural pollution sources. During the two years period of census, a variety of agriculture related information was collected, including the basic information (e.g. types, scale, patterns, location conditions, and etc.) of three agricultural activities (i.e. crop farming, livestock farming, and aquiculture), consumption of chemicals (such as fertilizer, pesticide, plastic film), and waste (including wastewater, crop residues, and animal waste) collection and treatment.

The year 2009 saw a regulatory milestone of the water quality monitoring system. The General Office of MEP issued the Guiding Opinion of Monitoring China Rural Environment (No.150 Environmental Policy Paper, 24 December 2009), calling for establishment of rural environmental monitoring system and integrating agricultural NPSs to the national monitoring system. The scope of monitoring is defined as two components, both the ecological water system (drinking water source, surface water and soil environment) and also the point/nonpoint source pollutants (rural industrial and mining pollutants, agricultural planting and husbandry).

[26] Anhui Provincial Agriculture Committee. Anhui Agricultural Environment Protection Five-Year Plan. 2011

In October 2012, the General Office of the Ministry of Agriculture promulgated a piece of policy paper (No.69 Science & Education Policy Paper) to request a routine Ag NPS survey every two years since 2012.

4.2.5 Economic instruments and trading

Chinese environmental policies are evolving from an administrative approach to a more market-driven approach. Pollution levy system, China's first economic measure for pollution control, was established as legal provision in the Water Pollution Prevention and Control Law in 1984. Since the new millennium, the levy system went through a major change as the original pollutant concentration based charge was replaced by more scientific load based charge.

Meanwhile, wastewater treatment charge has been applied since 1998 with the No. 1810 NDPC policy paper.[27] Since then a series of policies were issued to promote the full recovery of municipal wastewater treatment, and the level of wastewater treatment charge increased sharply across China. Compare to 2000, the average level of wastewater treatment charge has increased 2.8 times in 2008.[28]

According to the 12th Five-Year Plan for Social and Economic Development of Anhui Province and the Anhui Ordinance for Environmental Protection (2010 Amendment), the government will integrate water environment management in the Chao Lake across regions and departments, and promote a pollutant trading system in the area where meets the needed conditions.

4.3 Lesson learned from Tai Lake Water Quality Trading Program

Water quality trading was introduced to the Tai Lake Basin in 2008, marking China's first effort in market-based mechanisms at river basin level. Compared with the proposed nutrient trading in Chao Lake, two fundamental differences in program design should be noted. Firstly, the traded item proposed in this Chao Lake study is nutrient indicators (namely TN and/or TP) which mainly originate from agricultural nonpoint sources, whereas that in Tai Lake is Chemical Oxygen Demand (COD). Secondly, the scope of market players is also different, as Chao Lake involves both nonpoint sources and point sources, while Tai Lake is constrained to point sources only. While many lessons can be drawn from the Tai Lake Program, the following findings are particularly important:

- ***Set a science based loading capacity for water quality trading.*** Loading capacity means the maximum amount of pollutants that a

[27] The formerly National Development and Planning Commission. Administrative Method on Urban Water Price. 1998

[28] Zhong, L., Mol A. (2009), Water Price Reforms in China: Policy-Making and Implementation, Water Resources Management, 24:377-396

recipient water body can receive without violating water quality standards. A trading program should be designed under a strong, accurate environmental capacity to avoid water quality degradation. However, basin-wide water quality models and watershed models that are commonly used in developed countries to quantify carrying capacity have not been applied in China, due to data availability. The de facto practices often avoids carrying capacity while only considering exiting pollutant loads and mandatory targets such as reducing COD by 8 percent. Without a science-based loading capacity, it's difficult to benchmark initial allocation and set reduction quotas for concerning pollution sources.

- ***Build a standardized allocation framework for basin-wide trading.*** The initial allocation of discharge quota is essential to the implementation of a trading program. The Tai Lake Program was developed by Jiangsu as a provincial trading scheme, in which dischargers were required to purchase their quota. On the other hand, Zhejiang in the same watershed also designed its own trading pilot, adopting the grandfathering allocation principles. Due to the preliminary stage of trading, the allocation and trading principles have not been standardized in Tai Lake. Difference between Zhejiang and Jiangsu make basin-wide trading difficult.
- ***Develop a market driven approach.*** Tai Lake trading has received strong government support, but instead of an interventionist approach, more economic incentives should be created to allow market forces to function. Current trading demand from enterprises is weak, only 5% of 1357 enterprises registered in the online transaction system have traded in the secondary market, far below the anticipated scale. Two key factors were identified:
    - First, credit price was set by government, not the market. For the sake of easier implementation, the average cost of COD removal by major industries in the Tai Lake Basin was adopted as the official credit price in Jiangsu Province.[29] This government –dominated pricing mechanism suppressed the transactions as it underestimated credit price and posed the risk of long-term policy uncertainty. Consequently, enterprises tend to retain discharge allowance surpluses as an asset because its either trading value will rise under the expectation of stricter environmental policies, or more discharge space is preserved for future production growth opportunity.

[29] Bi Jun, Zhang Bin. Preliminary Design of the Policy Framework for Emission Trading. Nanjing University

  - Second, credit aggregators should be encouraged. Although the Tai Lake program has established an online exchange platform to enhance information transparency, credit provisions and demands are hardly equal from single sources. Barriers of volume mismatch and duration mismatch require multiple credit buyers and sellers for an agreed transaction. According to international experience, credit aggregators will function as a bank to solve this double mismatch and to evaluate the risk more professionally.

- ***Enhance monitoring capacity.*** The lack of real-time monitoring capacity significantly impacts the verification of pollutant load from enterprises. Constrained by resources, the Jiangsu Environment Protection Agency has revealed many weaknesses in both the coverage of point source monitoring and the accuracy of information. Apart from the key point sources that have installed online monitoring equipment, monitoring in most enterprises is irregular. Some enterprises are sampled only once or twice annually. Obtaining sufficient and accurate information of pollutant discharge is the prerequisite to verify and implement pollutant discharge trading. Drawbacks in monitoring capacity became a major barrier to an effective trading program.

5. Feasibility assessment for a trading program in Chao Lake basin

Based on WRI's experiences from the Chesapeake Bay Water Quality Trading Program as well as an in-depth analysis of 57 water quality trading programs worldwide[30], the following six criteria serve as the pre-conditions for a trading program:

- Legal authority
- Identified pollution sources
- Reduction potentials
- Potential credit sellers
- Presence of credit buyers
- Cost-effectiveness of trading

While many other factors, e.g. methodology to estimate/verify reduction from NPS and liability risks to the regulated community from meeting regulations through trades, are also critical to a successful trading program and will be discussed later, trading becomes feasible only if all above six key pre-conditions

[30] Mindy Selman. Water Quality Trading Programs: An International Overview. 2009

are fulfilled. This chapter assesses and answers each question in the context of the Chao Lake basin.

5.1 Does a regulatory "driver" exist for water quality trading?

The primary policy driver for all water quality trading programs has been the implementation or forthcoming implementation of pollutant discharge caps (i.e. total emission control, TEC).

China's TEC policy currently provides a significant regulatory basis to develop and administrate water quality trading programs. The TEC policy was firstly introduced in 1996 in the 9th Five-Year-Plan for the National Economic and Social Development and became a nationwide mandatory policy in the 11th Five-Year period (2006-2010).[31] Only one water pollutant, COD, was initially regulated under the TEC however, ammonia nitrogen, another key indicator of water quality, has been added to the system since 2011. For impaired key watersheds such as Chao Lake, Tai Lake, and Dianchi Lake, total nitrogen and total phosphorus have been regulated under regional TEC as well.

According to the 12th FYP for Water Pollution Control in the Key River Basins, a nitrogen cap of 29,000 tons has been set for Chao Lake and a 10.4 percent reduction in nitrogen load from the 2010 level is expected from all sectors. Detailed information on how these targets were set is not available; however, based on observations of target-setting in previous FYPs, the reduction targets are most likely to be an administrative will rather than science-based decisions. The government has realized the necessity to incorporate rural pollution into the big picture, and CAFOs are prioritized as the nutrient reduction contributor in addition to traditional industrial point sources.

5.2 Are pollutant sources and loads known?

High quality environmental monitoring data is essential to identify pollution sources and loads. Like other cities in China, primary focuses of water quality monitoring are given to point source effluent and urban environment, while monitoring capacity in rural area is largely non-existent in Chao Lake basin. Pollutant generation and discharge coefficients developed from China's First National Pollution Sources Census are generally used to estimate rural pollutant load instead.

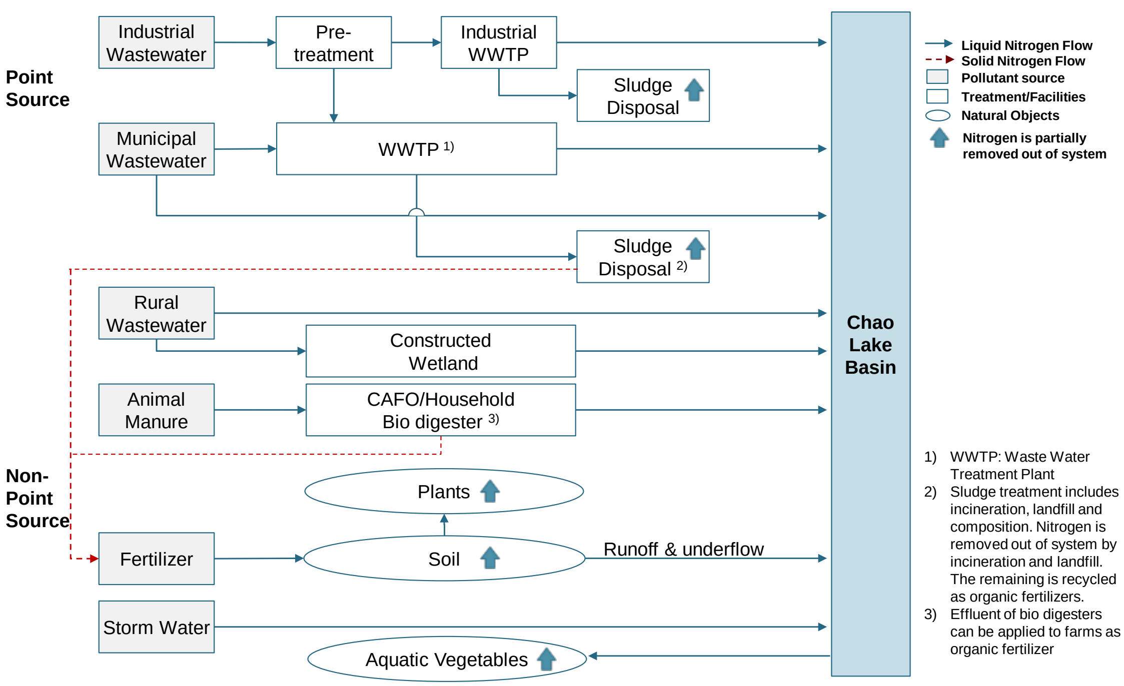
Given the lack of monitoring capacity especially at the county level, obtaining reliable data from point sources is also difficult. Another challenge is that nitrogen is not a mandatory controlling pollutant for most industries. Therefore, few plant-

[31] Ge Chazhong. China's Total Emission Control Policy: a Critical Review. http://www.cpre.sdnu.edu.cn/Res/EnMagazine//200910221650357259.pdf

level data were available to accurately quantify nitrogen load from the industrial sector.

Available water quality data of Chao Lake indicate that both nitrogen and phosphorus exceed Class III of China's Surface Water Quality Standard and cause the lake's eutrophication.[32] Due to limited time and resources, nitrogen was selected as the item to be traded in this feasibility study.

For a lake system, the primary sources of nitrogen pollution depend on land use activities in the catchment area and might include urban and rural municipal wastewater, industrial wastewater, animal farming, crop farming, air deposition, and sediment release. Figure 6 illustrates nitrogen flow from major sources to Chao Lake.[33] Point sources such as industrial wastewater and municipal wastewater, together with discharge from crop farming and livestock feeding are major contributors to Chao Lake's nitrogen pollution.



Developed by WRI

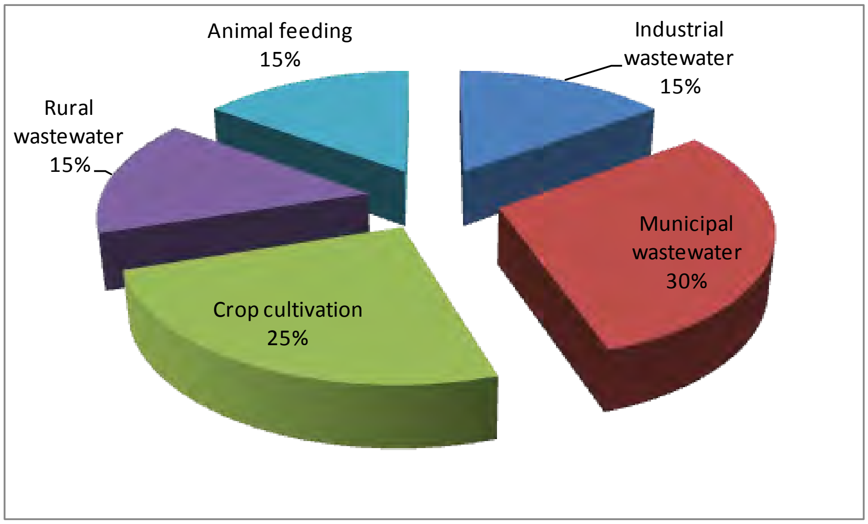
Figure 6 Nitrogen Flow Map in the Chao Lake Basin (illustrative)

5.2.1 Current nitrogen load in Chao Lake Basin

[32] Anhui Environmental Protection Department. Anhui Environmental Quality Bulletin 2005 - 2010

[33] Urban stormwater is a substantial source of nutrient pollution but has not been regulated or evaluated in China.

In 2010, 32,366 tons of nitrogen was discharged to Chao Lake, [34] among which agriculture related emissions (including crop farming, animal feeding and rural wastewater) played a role as the largest contributor, accounting for 55 percent of the region's nitrogen pollution. Second to the agricultural sector was municipal wastewater, including untreated runoff and effluent from treatment systems, contributing 30 percent of total loads (Figure 7).



Source: WRI estimates, 2012

Figure 7 Nitrogen Discharge by Sectors in the Chao Lake Basin (2010)

5.2.2 Projected load in 2015

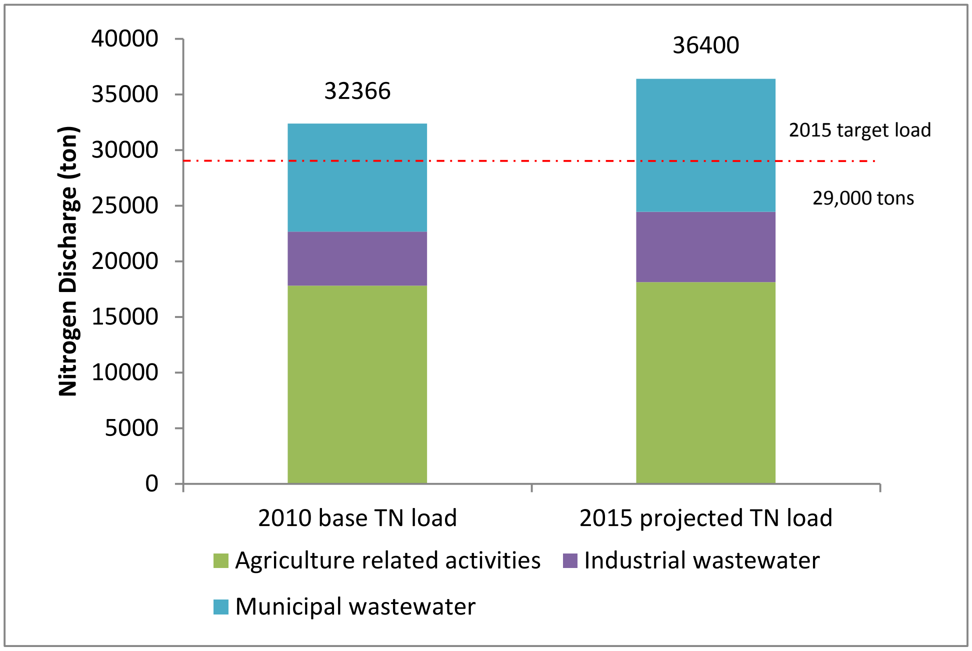
Key factors influencing pollutant load, including population growth, urbanization rate, economic development, industrial structure, crop yield, and meat production, were carefully evaluated to forecast the incremental increase of nitrogen discharge in the coming five years. Leveraging the Pollutant Generation and Discharge Coefficients Handbook and Outline for Formulating the 12th FYP for Water Pollution Control in Chao Lake Basin, a rough estimate is presented in Figure 8.[35]

By 2015, nitrogen loads from all sectors are expected to reach 36,400 tons, a 12 percent increase compared to that of 2010. Most of the increases will come from municipal wastewater systems and industrial discharge, as consequences of exploding urbanization and industrialization. The share of agricultural related

[34] According to the Master Plan for the Integrated Water Environment Management in Chao Lake Basin (Anhui Provincial Government, 2008) and the 12th Five-Year-Plan for Water Pollution Control in Key River Basins (Ministry of Environmental Protection, 2010).

[35] Due to lack of reliable data, load projection for the industrial sector was taken from MEP's document, Outline for Formulating the 12th Five-Year-Plan for Water Pollution Control in Chao Lake Basin. 2010. http://www.zhb.gov.cn/gkml/hbb/bgt/201012/W020101206595119451462.pdf

activities is expected to decrease by 5 percent, but will still contribute half of the region's total nitrogen loads.



Source: WRI estimates, 2012

Figure 8 Projected Nitrogen Loads by 2015

5.3 Do pollutant sources have the ability to reduce loads? – A PROA approach

According to the 12th Five-Year-Plan for Water Pollution Control in Key River Basins, a nitrogen cap of 29,000 tons has been set for Chao Lake. Based on our estimation of nitrogen generation, this would require 7,400 tons of reduction by the year 2015, including 4,000 tons of incremental increase.

WRI's water quality decision-support tool, Pollutant Reduction opportunity Analysis (PROA), was applied to estimate nitrogen reduction potential and unit cost from each pollutant reduction opportunity (including technologies and policies) by sources.

5.3.1 Mythology and assumptions

Due to insufficient data and information, not all available pollution control measures were quantified and presented in this report. For example, the Chao Lake Basin is currently reshaping its industrial structure and some industrial categories will be phased out in the catchment area. However, quantitative data and information is not available for a cost-benefit analysis. On the agriculture side, cover crops, grass/forest buffers and conservation tillage are practices commonly used in North American farms but haven't been systematically experimented with in China. Therefore, their actual implementation costs and reduction potentials are uncertain for the time being.

The Project Team grouped the TN removal measures into three categories: industrial practices, WWTP practices, and agricultural practices. The methodology of estimating reduction potential and unit TN removal cost is listed below:

- **Industrial practices**
  - New industrial wastewater treatment facilities: reduction potential and associated costs are from the Master Plan for the Integrated Water Environment Management in Chao Lake Basin,[36] assuming all new facilities could be complete and in operation by the end of 2014.
- **WWTP practices**
  - New WWTPs: reduction potential is calculated based on the projected new wastewater treatment capacity required to accommodate the population growth by 2015, which is lower than the approved capacity in the 12th Five-Year Plan. All costs information is estimated from interviews with WWTP managers.
  - Upgrade existing WWTPs: reduction potential is based on the difference of TN discharge limits in Class IA and Class IB (15 and 20 mg/L) and treatment capacity of existing WWTPs facing upgrading; Upgrading and O&M costs are estimated values based on interviews with WWTP managers and also the Technical Guideline for Upgrading WWTPs.[37]
  - Sludge disposal: reduction potential is calculated from the average nitrogen concentration in the sludge as well as projected treatment capacity as of 2015.[38] Unit reduction cost is obtained through expert consultation and literature review.
- **Agricultural practices**
  - Aquatic vegetable: TN reduction can be achieved through converting rice paddies to aquatic vegetables.[39] The potential is based on the

[36] Anhui Provincial Government Master Plan for the Integrated Water Environment Management in Chao Lake Basin. 2008

[37] Jiangsu Housing and Urban Rural Development Commission. Technical Guideline for Upgrading WWTPs. 2010

[38] Hefei is building an incineration plant capable of disposing 300 tons of sludge on a daily basis. 2012 http://news.mediaxinan.com/hefei/2012/0322/1130457.shtml

[39] According to Li (2009), aquatic vegetables can effectively reduce nitrogen, phosphorus and chemical oxygen demand in a watershed through their often large roots systems. These plants are able to derive their entire nutrient supply directly from the water as dissolved compounds. An experiment showed that 30.6% of total nitrogen (TN) and 18.2% of total phosphorus (TP) were removed from the total input nutrients by an aquatic vegetable Ipomoea aquatic in 120 days.

proposed acreage of aquatic vegetables and nitrogen reduction efficiency given by the 12th Five-Year Plan for Eco-Agriculture Development in Chao Lake Basin.[22] Unit cost/profit is based on interviews with lotus farmers in Lujiang County.

- Biodigester: reduction potential is calculated from TN removal efficiency of biodigester and projected capacity in the 12th Five-Year Plan period; unit cost is based on interview and published literature.
- Soil testing: reduction potential and unit cost are based on interview information obtained from Anhui Soil and Fertilizer Station.
- Constructed wetland: reduction potential is an estimation based on the government goal of treating 65 percent of rural wastewater in the Chao Lake Basin by 2015;[40] Unit cost is adapted from Jiangsu's Technical Guideline on Rural Wastewater Treatment.

5.3.2 TN PROA of the Chao Lake Basin

A TN PROA for the Chao Lake basin as shown in Figure 9 was developed based on the above assumptions.

In Figure 9, each bar represents an option to reduce nitrogen discharge, with the vertical axis indicating the average cost to reduce a ton of nitrogen based on available information while the bar width showing reduction potential (assumptions for reduction potentials and costs of selected pollution control measure as listed in Annex III) . It does not show credit prices in a water quality trading market but, rather, current average costs to reduce a ton of nitrogen based on available information. Meanwhile, the costs do not take into account the baseline or minimum practices that agriculture will have to implement prior to selling credits.

[40] Conventional treatment technologies have been proved not infeasible in China's rural area. Pilot research by Jiangsu Housing and Urban Rural Development Commission demonstrated constructed wetlands could remove nitrogen by 76 percent, with minimal capital investment and operational costs. Constructed wetland, along with land treatment, is now often used in treating rural wastewater.

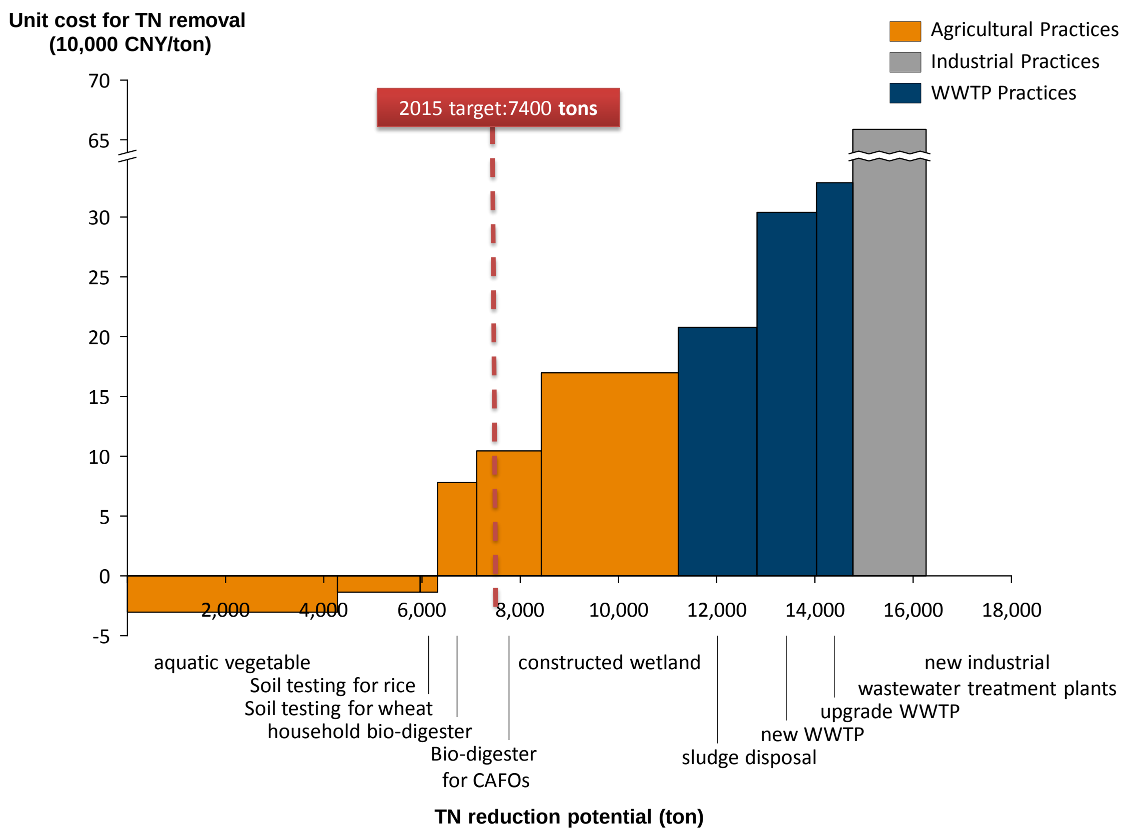


Figure 9 Nitrogen PROA for the Chao Lake Basin

a. Industrial sources

It's estimated that 1,500 tons of nitrogen could be reduced from the new industrial wastewater treatment facilities at the cost of CNY 660,000 per ton, which is the most expensive practice among all options evaluated.

b. Municipal wastewater and treatment system

As the biggest single source of nitrogen pollution in Chao Lake Basin (as estimated in Figure 7), untreated municipal wastewater together with discharge from WWTP system contributed to 30 percent of total loads and is an important area to look for reductions.

Around 3,550 tons of nitrogen could be potentially cut in the following options:

- **Increase wastewater treatment capacity.** Based on the projected wastewater amount of 2015, around 150,000 m^3/day of treatment capacity need to be added to accommodate the development, which could offer 1,200 tons of nitrogen reduction in 2015, at a cost of CNY 300,000 per ton.
- **Upgrade WWTPs to meet more stringent discharge standards.** Three major WWTPs, with 455,000 tons of daily treatment capacity, need retrofit and reducing effluent nitrogen concentration limit from 20 to 15 mg/L.

Upgrading these WWTPs could offer 730 tons of nitrogen reduction by 2015 at a cost of 330,000 CNY/ton, ranking the second highest of all.

- **Improve sludge management.** Sludge management appears to be the least-cost approach to reduce nitrogen loading from the residential source. Assuming all sludge generated in Hefei was incinerated by 2015, around 1,600 tons of TN could be cut at an average cost of CNY 200,000 per ton.

c. Agricultural source

Chao Lake Basin is one of the most productive agricultural bases in China. In 2010, the agriculture sector contributed to 55 percent of the region's nitrogen loads, with mid-to-large scale animal feeding being regulated under the CAFO rules whereas runoff from crop farming was largely uncontrolled.

However, the agriculture sector can offer effective pollution control measures and often at a relatively low cost. Approximately 11,200 tons of nitrogen could be avoided from entering the lake, if the following practices were implemented:

- **Reduce nitrogen fertilizer application rate through soil testing.** Experiences from Anhui demonstrated that soil testing could reduce nitrogen fertilizer application by 10 percent while increase yield by 13 percent for major crops.[41] Figure 9 shows that cutting fertilizer usage ranked number 2 among the most cost-effective nitrogen reduction options. Over 2,000 tons of TN could be reduced from the region's rice and wheat field if the soil testing program was well implemented. Furthermore, the associated cost is shown as negative because this practice could reduce farmers' expenditures on fertilizer.
- **Replace rice with aquatic vegetables to reduce nitrogen fertilizer application and nutrient loss.** Aquatic vegetable does not need the draining process required by the rice paddies and generally does not need chemical fertilizer. Field studies revealed that organic fertilizer such as manure will be required before seeding for most aquatic plants however, application rate is much lower than that of rice. 260,000 Mu (17,333 hectares) of lotus and Chinese celery (or watercress) will be cultivated around the lake shore and potentially cut 4,200 tons of nitrogen discharge annually.[42] The reduction in fertilizer expenditures, together with increase in revenue from selling aquatic vegetable, enable farmers to achieve the highest cost-effectiveness in nitrogen reduction, which reflects as negative CNY 30,000 per ton as shown on Figure 9.

[41] Interview with Mr. Zhao, Director of Anhui Soil and Fertilizer Station. April 26, 2012

[42] Hefei Agricultural Commission. 12th Five-Year Plan for Eco-Agriculture Development in Chao Lake Basin. 2012

- **Build biodigesters for CAFOs and rural households. A** biodigester itself cannot remove nutrients. However, effluent from the treatment process can be applied to farmland as organic fertilizer, which potentially cut chemical fertilizer input in the first place. An estimated TN reduction of 1,300 tons could be achieved through using biodigesters on CAFOs, with a unit cost of CNY 105,000 per ton. Household biodigesters could potentially reduce 810 tons of TN at a cost of CNY 78,000 per ton.
- **Use constructed wetland to treat rural wastewater.** Assuming 65 percent of rural wastewater in the Chao Lake region was treated by constructed wetland at the year of 2015, around 2,800 tons of TN could be cut at a cost of CNY 170,000 per ton.

5.4 Are potential sellers present and are they willing to consider participating in the program?

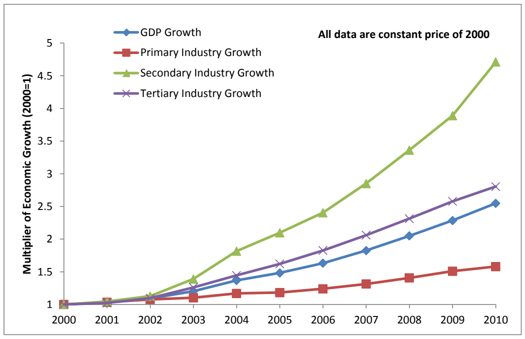
Due to time and resource constraints, Lujiang County (Box 1), rather than the whole lake basin, was selected as the project area to assess the credit supply side of the proposed trading program.

Nitrogen reduction, or nitrogen credits in water quality trading programs, can be generated by a variety of technologies and practices. For instance, point sources can generate credits by reducing pollutant discharges below regulated or permitted levels. Farmers may be able to generate credits through a wide range of practices, such as fertilizer reduction and manure management. Generally, the cost of agricultural measures is lower than that of point source practices (see Figure 9), therefore, the nitrogen credit supplier in a point-to-nonpoint trading program primarily focused on the agricultural sector.

Through site visit and expert consultation, agricultural best management practices (BMPs) for reducing nitrogen pollution currently used in Lujiang (as well as the whole Chao Lake Basin) were identified and evaluated for their reduction potentials. A summary of available opportunities for nonpoint source reduction credits was shown in Table 1.

Box 1. Lujiang Profile

Lujiang County is located on the south shore of Chao Lake, covering 2,348 km^2 of land between the lake and the Yangtze River, of which 31 percent, or 728 km^2, are arable land. The total population as of 2010 was 1.18 million, of whom about 1.02 million were registered as rural residents, representing an urbanization rate of 14 percent, significantly lower than the basin average.

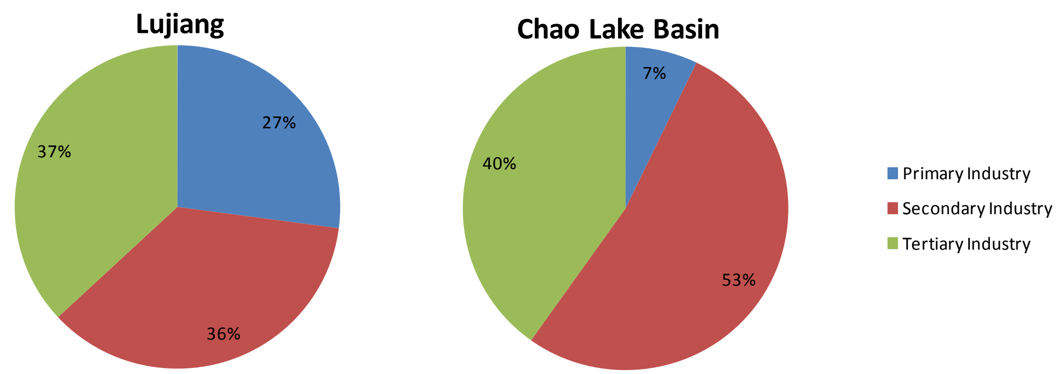


(Source: Anhui Statistical Yearbook 2000-2011)

Figure 10 Economic Growth in Lujiang

Lujiang has witnessed a remarkable economic growth in recent years (Figure 10). The city's GDP increased by 255 percent and the output of the secondary sector [43] increased by about 470 percent between 2000 and 2010.[44]

Lujiang is a national key agricultural production base. Though the agricultural sector grew substantially less than the other two sectors (by about 158 percent over the same period), it remains an important component of local economy. In 2010, agricultural output contributed over 27 percent of the city's total GDP, (compared to the Chao Lake basin average of 7 percent), with the primary agricultural activities being rice cultivation and poultry growing (Figure 11).[45]



Source: Anhui Statistical Yearbook 2011

Figure 11 GDP Breakdown by Sector in Lujiang and the Chao Lake Catchment

[43] Primary industry refers to the agricultural sector, while secondary industry includes processing and manufacturing industries, transportation and construction. The tertiary industry is the service industry.
[44] Lujiang's key industries are mining, chemicals, machinery and auto parts, construction materials, textiles, and food processing. (http://www.lj.gov.cn/ljgk/?kindid=1002&parentid=1000&classid=1001)
[45] Lujiang's key agricultural products include grains, tea, fish, poultry, flowers and vegetables.

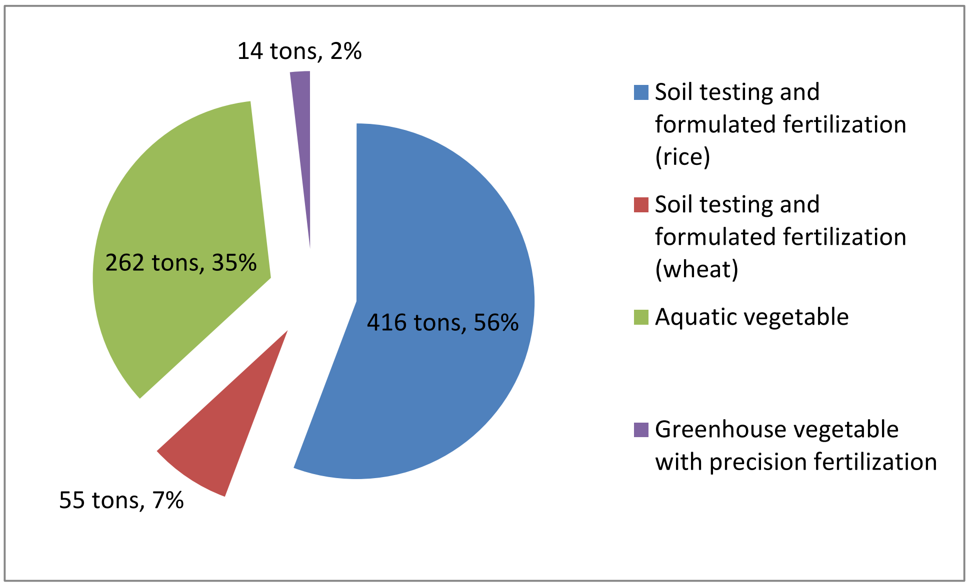
Table 1 Nitrogen Credit Supply in Lujiang County

Measures	Description	Benefit	Cost	Funding Sources	Current Coverage	Barriers
Demonstration farm	A holistic approach for green crop farming includes water-saving irrigation, soil testing, and nutrient management	Reduce up to 30% of nitrogen input per unit of crop produced	NA	MOA	10% of Lujiang's farmland	Relatively high capital investment and labor input
Soil testing and formulated fertilization	Use of formulated fertilizer based on soil testing	Reduce up to 1.4 Kg of nitrogen input per mu (0.067 hectare)	Soil testing is covered by the government. The unit cost of formulated fertilizer increases by 5-10% but the application rate reduces by 10%	MOA provides CNY 300,000 of fund annually for soil testing and technical support in Lujiang	An estimation of 80,000-100,000 mu (around 10% of all) as core participation area	Low capacity in terms of technical support: 146 agricultural extension staff to support over 400,000 farmers; Farmers' reluctance
Aquatic vegetable	Replace rice with aquatic vegetable (e.g. lotus, watercress) in paddy field	Reduce up to 60% nitrogen input per unit of production	Increase CNY 500 per mu in annual profit	NA	50,000 mu	Reduction in rice production
Low-impact animal farming	Use of green technologies (e.g. fermentation bed to digest manure) to treat manure	Zero-emission to the environment (manure will be processed into organic fertilizer)	Decrease CNY 2 in profit per Kg of meat produced	MOA provides cost-share for CAFO construction	60% of pigs are now raised in CAFOs	Same price for high-quality/environmentally friendly product
Greenhouse vegetable with precision fertilization	Use of precision fertilizer technology to avoid nutrient loss	Reduce up to 50% nitrogen input per unit of production	Initial investment on greenhouse is high	NA	Demonstration project	Relatively high capital investment and management requirements
Crop farming with water-saving irrigation	Use of sprinkler or drip system to minimize nutrient loss through runoff	Reduce up to 20% nitrogen input per unit of production	Initial investment on irrigation system is high	NA	Demonstration project	Relatively high capital investment and management requirements

Preliminary analysis revealed that large scale crop producers, aquatic vegetable growers, as well as greenhouse vegetable growers were potential credit sellers. Though significant nitrogen reduction could be achieved from animal farming, it was not viewed as a credit seller as CAFOs are regulated as point sources and will soon face more rigid reduction quota under the TEC program.[46]

The amount of nitrogen credits is estimated based on the following assumptions: 1) all rice and wheat are produced with the Soil Testing Program; 2) aquatic vegetable acreage increases to 80,000 mu; 3) acreage of greenhouse vegetable with precision fertilizer increases by 10 folds from current 500 mu demonstration project. General information on Lujiang's crop farming and fertilizer usage can be found in ANNEX IV.

Based on our estimation, Lujiang's farmers could ideally generate 747 tons of nitrogen credit by 2015, or 10 percent of Chao Lake's total reduction quota (Figure 12).



Source: WRI estimates, 2012

Figure 12 TN Credit Generated by Lujiang Farmers by 2015

According to an interview with officials from the Lujiang Agriculture Commission, farmers participating in the Soil Testing program can reduce up to 20.9 kg of nitrogen input per hectare without any negative impacts on crop yields. Though the unit cost of formulated fertilizer is 5 to10 percent higher than conventional nitrogen fertilizer, there's very little effect on total fertilizer expenditure as the application rate reduces by 10 percent. On the other hand, vegetable growers

[46] Renmin News. Agricultural Pollution to Be Included in the TEC Programin the 12th Five-Year Plan Period. 2010
http://news.163.com/10/0310/15/61E3OL5H0001124J.html

converting rice paddy into lotus field can reduce up to 60 percent nitrogen input per unit of production, and see a CNY 7,000 financial gain per hectare. In a trading program, farmers could earn additional revenue if they sell nutrient credits generated by implementing practices that reduce fertilizer beyond required levels.

The Project Team visited two lotus growers and a crop/vegetable farming company (Chunsheng Farming Company), all expressed willingness to participate in the proposed trading program. Generally large-scale farmers are more likely to adopt agricultural BMPs and serve as credit sellers. Currently there are around 400 large-scale farmers cultivating 200,000 mu (13,333 hectares) of rice/wheat plantation, accounting for 20% of Lujiang's total.[47] The Government will continue to encourage large-scale farming through land right transfer, which will help secure more credit sellers in the future.

5.5 Are potential buyers present and are they willing to consider participating in the program?

In a point-to-nonpoint trading scheme, credit buyers are generally those that face higher reduction costs, and often are highly regulated point sources. In the Chao Lake Basin, major point sources can be divided into the following category:

- WWTPs
- Industrial dischargers
- CAFOs

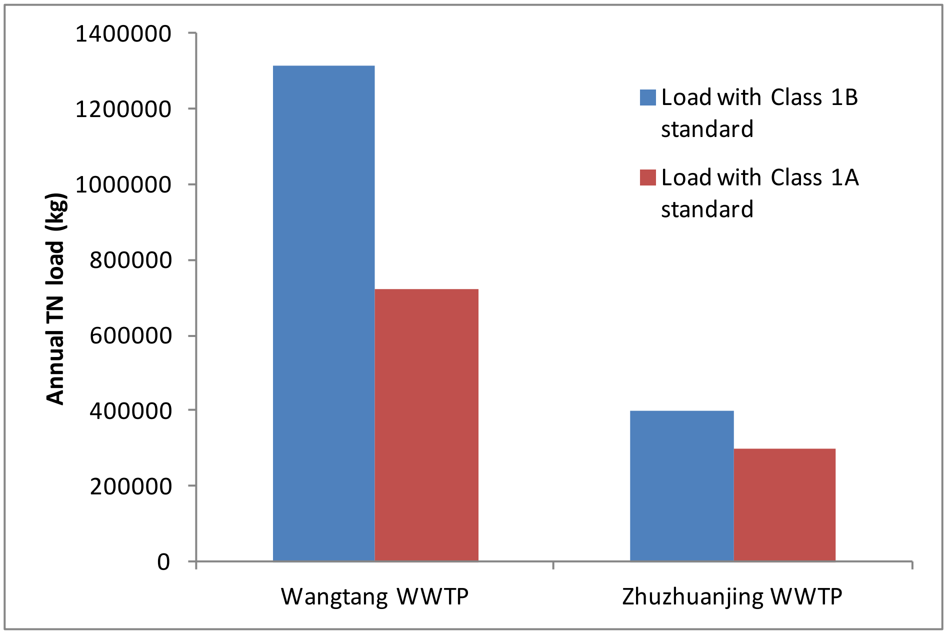
China is at an initial stage to regulate CAFOs and based on the team's observation in the Chao Lake region, there's still a long way to go before effective enforcement and compliance. For instance, pollutant discharge permit[48] and TEC reduction target have not been issued to the two CAFOs the team visited.

Meanwhile, total nitrogen was not monitored and regulated in most industrial subsectors until the 12th Five-Year Plan for Water Pollution Control in Key River Basins imposed a nitrogen CAP for the Chao Lake Basin. Lack of empirical data increased the difficulty in quantifying nitrogen reduction demand in the industrial sector.

Therefore, the wastewater treatment sector was identified as the potential short-term credit buyer. MEP has requested all existing WWTPs in the Chao Lake Basin to meet Class 1A of the National Discharge Standard for WWTP effluent,

[47] Interview with Mr. Qiang, Chief Agricultural Engineer at Lujiang Agricultural Commission. 2012
[48] According to Chinese Environmental Protection Law, point sources may not discharge pollutants to surface waters without a permit issued by the environmental authorities.

tightening the TN limit from 20 mg/L to 15 mg/L. Two municipal wastewater treatment facilities, the Wangtang WWTP and Zhuzhuanjing WWTP were interviewed and selected as examples to evaluate feasibility as credit buyers.



Source: WRI estimates, 2012

Figure 13 TN Loads of Wangtang and Zhuzhuanjing WWTP by Class 1A and 1B

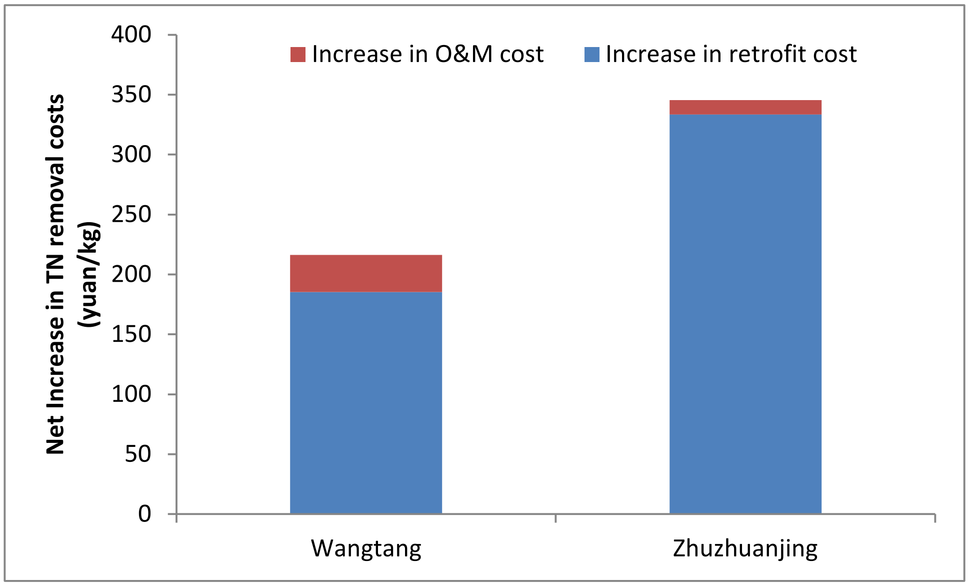
Wangtang WWTP has a designed capacity of 180,000 m^3 per day and recently retrofitted to meet the Class 1A standard. The upgrade enables Wangtang to further reduce 591,300 kg of TN per year, or 45 percent of the original load. Zhuzhuangjing WWTP (daily treatment capacity @55,000 m^3), on the other hand, is now in the middle of a major upgrade. TN load is expected to drop by 25 percent (Figure 13).[49]

Capital costs to upgrade WWTPs to meet the Class 1A standard are fairly high. Wangtang spent over CNY 100 million for its advanced treatment facility, while the total investment including a pumping station and associated sewage collection system exceeded CNY 230 million. Zhuzhuanjing's retrofit cost is estimated to be more than CNY 30 million. Moreover, the operation and maintenance (O&M) costs will increase with the upgrade, due to higher energy consumption and chemical input. Wangtang, for example, experienced a 55 percent increase in O&M costs, while Zhuzhuanjing is estimated to face at least 20 percent increase.

After the system upgrade, Wangtang's unit TN removal cost increased by 216 CNY per kilogram, while that of Zhuzhuanjing might face a more drastic raise of 345 CNY (Figure 14). In terms of nitrogen removal, WWTP upgrading is capital

[49] Interviews with WWTP managers.

intensive and not cost-effective. Trading therefore could significantly reduce WWTP cost, which will be discussed in the following section.



Source: WRI estimates, 2012

Figure 14 Net Increase in TN removal costs for WWTP Upgrade

Like large-scale farmers, WWTP managers also showed genuine interest in nitrogen trading between nonpoint sources and point sources for the potential cut in O&M cost. However, retrofit cost is not a major concern as the government currently subsidizes all WWTP upgrade. Accordingly, much more in-depth outreach and education would be necessary with these key stakeholder groups to move the trading program forward in the Chao Lake Basin.

5.6 Is water quality trading cost-effective?

The opportunity for water quality trading arises because large differences in the unit cost to reduce nitrogen exist among various sectors and practices.

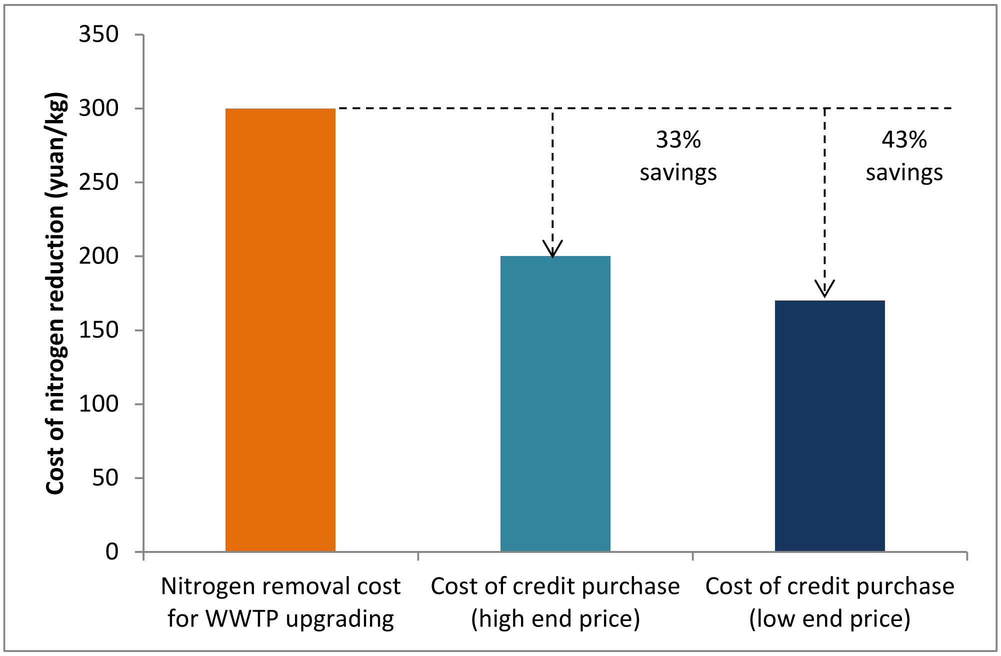
5.6.1 Possible price range of nutrient credit

To generate economic incentive for buyers and sellers, the low end of the credit price in a point-to-nonpoint source trading scheme is decided by the equalized maximum costs for implementing agricultural BMPs, which represents an estimated minimum price at which farmers may be willing to sell credits. As indicated in Figure 9, the unit cost of nutrient removal via wetland construction (CNY 170 per kilogram) is the lowest available price of nutrient credit. The high end price, on the other hand, is decided by the least expensive point sources measure, representing an estimated maximum price at which point sources would be willing to buy credit. The unit cost of improving sludge management defined the high end credit price of CNY 200 per kilogram. Therefore, the TN credit price should be in the range between CNY 170 and 300 per kilogram.

5.6.2 Economic benefit of nutrient trading

As discussed in the Section 5.3, WWTPs facing high upgrade costs are most likely to be the credit buyer. The Project Team analyzed major WWTPs in the Chao Lake Basin and found that the average upgrade cost is 329 CNY/kg of nitrogen removal on an annual basis, which is higher compared to the proposed credit price ranging from CNY 170 to CNY 200 per kilogram nutrient. Thus, purchasing credits would save WWTPs 33-43 percent relative to implementing treatment process upgrades (Figure 15).

On the credit seller side, CAFO owners, for example, could earn CNY 65-95 for each kilogram of credit generated in the farm.



Source: WRI estimates, 2012

Figure 15 WWTPs Facing Upgrading Requirement Meet Reduction Target by Trading

Therefore, trading allows those WWTPs and industries that face higher nitrogen reduction costs to save money by purchasing credits to meet a portion of their nitrogen reduction obligations. As a result, trading could help achieve overall nitrogen reductions in the Chao Lake Basin in a more cost-effective manner.

5.6.3 Transaction costs within a trading program

As discussed in previous sections, the purpose of introducing a water quality trading scheme is to minimize the cost of achieving the environmental goal of pollutant reduction. In addition to the direct cost of reducing nutrient run-off through the application of specific technologies or measurement, the cost of achieving the goal of nutrient reduction also include administration costs (such as the cost of establishing and running the trading scheme) and transaction costs.[50]

The transaction costs within a point-to-nonpoint nutrient trading program are not commonly defined and may vary between different trading schemes. It may include any one of these costs for gathering information, bargaining, decision-making, any cost borne by trading participants, and, costs for modeling trades, certifying that agricultural practices are in the ground and performing properly, verifying that agricultural practices generate necessary pollutant loads reductions, maintaining agricultural practices, and etc.

Ribaudo and McCann (2012) focused on the costs that affect incentives of buyers and sellers while examining the transaction costs in Pennsylvania's point-to-nonpoint nutrient credit trading program, including the costs for finding trading partners, verifying plans, estimating farmers' credit and verifying the costs, and purchaser reporting. It is estimated that the transaction costs amount to about 7 percent of the average price for a nutrient credit in completed trades and 80 percent of public owned WWTPs (point sources) would benefit from trading.

To implement a successful trading scheme and improving the efficiency of a trading scheme, it is significant to minimize the transaction costs. There are many ways to reduce transaction costs within a trading program. For instance, a third party such as aggregator or broker can partly reduce the transaction costs related to identifying and locating buyers and sellers, tools such as online marketplaces and registry databases to track credits and trades can help reduce transaction costs as well. In addition, developing standardized language in regulatory compliance documents, drafting model contracts for sale transactions, and standardize processes to eliminate unnecessary delays are all important for improving the efficiency of a trading scheme (Selman and et al, 2009).

5.7 Is a trading program feasible in Chao Lake basin?

Based on the above discussion regarding the six preconditions for a trading scheme, the study team's key observations and conclusions are as follow:

- The Law on Water Pollution Prevention and Control (2008 Amendment), the Anhui Provincial Regulations for Environmental Protection and the 12th FYP for Water Pollution Control in Key River Basins (which set a nitrogen cap of 29,000 tons for the Chao Lake Basin) currently provide a legal authority for water quality trading programs.

[50] McDonald and Kerr (2011), Trading Efficiency in Water Quality Trading Markets: An Assessment of Trade-Offs, Motu Working Paper 11-15, Motu Economic and Public Policy Research.

- FYPMajor nitrogen sources, including industrial wastewater, municipal wastewater and agricultural activities, have 16,300 tons of reduction potential as of 2015, among which the point sources can only generate 30 percent of reduction potentials.
- Potential nitrogen credit sellers and buyers are all present in the Chao Lake Basin and show interest in participating in the trading program.
- Overall, agricultural best management practices (BMPs) offer the largest reduction potential at lower costs compared to point source measures. This serves as an economic foundation for a water quality trading program.

Accordingly, the study team would preliminarily conclude that the Chao Lake basin could achieve the basin-wide pollutant reduction target at a lower cost via nitrogen trading program between point sources and nonpoint sources, however, much room for improvement remains in the institutional, policy, and capacity aspects.

5.8 Obstacles and areas that need to be improved for a trading program

From the assessment of the trading pre-conditions, we identified 6 key obstacles that stakeholders need to overcome and areas where improvement is needed for the successful implementation of a trading program in the Chao Lake Basin.

- The trading between point sources and nonpoint sources and its implication for water quality management has not been well recognized and understood by stakeholders.
- NPS pollution is excluded from the national TEC system. China's national management framework for controlling agricultural NPS pollution is still under development and currently reduction from the agricultural sector is not addressed in the TEC system. Changes need to be made at the national level – point-to-nonpoint source trading would never work unless MEP incorporates the pollutant reduction from NPS into the big picture. However, it should be noted that China is not likely to achieve its water quality goals without controlling nonpoint source pollution.
- The environment and agriculture authorities in the Chao Lake Basin lack the institutional capacity for an effective trading scheme. For instance, rural environmental monitoring is basically non-existent and empirical data required to quantify nonpoint source loading is not available. The agricultural authority lacks funding and personnel to promote agricultural BMPs. In Lujiang County, 146 agricultural extension officers are supposed

to support over 400,000 farmers.[51] Without adequate funding, properly trained staff and a comprehensive monitoring system, the success of any market-base mechanism is limited.

- Small scale farms and aging farmers, who tend to stick on old practices and are generally not interested in new technologies regardless of their cost-effectiveness and environmental benefit, pose major obstacles to promoting BMPs and will hinder the implementation of innovative schemes such as water quality trading in the Chao Lake basin. In order to general sufficient and steady nutrient reduction, the large scaled farmers should be prioritized as the target groups for implementing the agricultural BMPs, and participating in the nutrient trading program as well. It is expected that the small scale farmers could follow the big ones to implement BMPs gradually, but they will be excluded out of the trading program in its embryonic stage.
- It remains a challenge to quantify and verify nutrient reductions from agricultural NPS, due to lack of a reliable models and standardized tools to estimate nutrient losses. Because nutrient loss and thus reduction from nonpoint sources are often difficult and expensive to measure, developing a calculation tool to estimate reduction magnitude is essential to minimize management and transaction costs.
- TN discharge limits are not designated for most industrial dischargers in China. The National Integrated Wastewater Discharge Standard (GB8979-1996), which is applicable for the majority of industrial categories, has not been revised since 1996 and does not include a nitrogen limit (see ANNEX V for a summary on nitrogen limits in Chinese discharge standards). Without a national/regional standard to regulate TN discharge from the industrial sector, the TN CAP as well as a water quality trading mechanism would not find a solid regulatory ground.

6. Conclusions and recommendations

To address the serious water pollution in China, the agricultural nonpoint sources can’t be omitted any more. Chinese Government has incorporated agricultural nonpoint sources control into its water quality management, hence regulatory and capacity conditions are likely to improve in the 12th Five-Year Plan period. It could improve the capacity of agricultural nonpoint sources control and enhance the feasibility of a water quality trading program as well.

[51] Personal communication with Lujiang Agricultural Commission in September 2012.

Given the results of this evaluation, the Chao Lake Basin has a high potential for point-to-nonpoint source water quality trading to provide substantial economic and environmental benefits in the future. Trading can mobilize the unregulated farming sector, currently the region's biggest pollution source, to generate nutrient reductions and contribute to achieving the water quality goals. Meanwhile, point sources such as WWTPs can also benefit from the opportunity to address nutrient effluent limit requirements with more economical options.

However, the opportunity for a water quality trading program in the Chao Lake basin is somewhat limited by present regulatory and capacity conditions, which are also the important requirements for the general agricultural NPS control. Accordingly, the Project Team would strongly provide recommendation below which can fill in the significant gaps in institution, policy, and capacity to incubate the water quality trading market while enhancing the agricultural NPS control in the Chao Lake basin.

- **Deliver a policy note regarding water quality trading to provincial and national government**

The project analyzed the feasibility of establishing a point-to-nonpoint nutrient trading program in the Chao Lake basin via a bottom-up approach. It discovered that a top-down approach was significant to introduce and implement any innovative scheme such as trading program in China. Accordingly, it is strongly recommended to summarize the findings of the Chao Lake trading feasibility assessment and deliver a specific policy note to Anhui Provincial Government and higher government via the ADB.

- **Enhance the stakeholders' awareness on water quality trading**

As an innovative approach to control water pollution, trading is currently not well understood by key stakeholders, whose attitudes and perceptions are critical to determining the potential success of a nutrient trading program. Accordingly, a series training program on water quality trading is necessary. Specifically, we would suggest:

  - Invite Anhui DRC, CLMA, and other relevant agencies to attend trading related workshop and seminar, such as the Asian Water Week organized by the ADB
  - Organize series trading courses for relevant agencies (such as Anhui DRC, CLMA, EPBs, Agricultural Commissions, and etc.) and potential trading participants (such as WWTP manager, industrial polluter, big farmer, and etc.)

- Organize a study tour for relevant agencies to the US and/or other countries where have active trading programs to better understand how a water quality program is run

- **Improve environmental monitoring system and data sharing mechanism**

A comprehensive environmental monitoring system covering both point sources and nonpoint sources is essential for characterizing pollution sources and loads in a watershed, providing data and information required in a water quality trading program, as well as in the broader context of water quality management. Areas need improvements are:

- Improve the monitoring system of WWTPs and industrial pollutions sources, expanding the indicators for COD, ammonia-nitrogen, TN and TP
- Establish the monitoring system for agricultural nonpoint sources, collecting data for the land use patterns, and type, scale, amount of various agricultural sources (such as crops, livestock, aquiculture)
- Build up a comprehensive pollution data centre covering both monitored point sources loads and investigated nonpoint sources profiles, which can be shared among various relevant governmental agencies, and, be used for calibrating the watershed models, verifying and tracking the reduction potential of various sources, and providing time-series data to evaluate and project long-term trends

- **Develop a standardized estimation tool for nonpoint source emission and reduction**

Pollutant loads from agricultural nonpoint source as well as reductions achieved by implementing BMPs are not practical to measure directly. Therefore, science-based estimation methodologies are often used to calculate the reductions from the agriculture sector. In the United States, several tools have been developed and accepted by the government to estimate nutrient reduction from farms for use in water quality trading programs (see ANNEX VI).China's Ministry of Agriculture issued the *Pollutant Generation and Discharge Coefficients for Crop Farming, CAFOs, and Fishery* in 2008, which includes algorithms and provincial level variables such as soil type, slope, and fertilizer application rate. This can be used in the development of an estimation tool for the Chao Lake Basin.

- **Develop provincial/local policies to incorporate agricultural nonpoint sources into the TEC program and to regulate TN discharge from industrial dischargers**

As mentioned previously, one of the key barriers for point-to-nonpoint source trading is that the national TEC program doesn't include nitrogen reduction from agricultural nonpoint sources. In addition, TN is not effectively regulated for most industrial categories under the current discharge standards, resulting in lack of motivation in participating in trading program for industrial point sources. Anhui Province and Hefei Municipality can leverage the demonstration project to pioneer innovation in environmental protection policies and contribute to shaping a national management framework for agricultural nonpoint source pollution control.

- **Conduct an in-depth survey to identify credit suppliers and buyers and their willingness to participate in trading**

A large scale willingness survey for potential buyers and sellers in a trading scheme is necessary and crucial for the successful implementation of any pollutant trading program. Limited by the time and resources, this project was not able to carry on an in-depth survey to locate potential participates of a trading program and to better understand their attitudes towards the trading scheme.

- **Select an appropriate site for nitrogen trading demonstration project**

The development of a full scale water quality trading program can take a couple of years to complete. For instance, the Chesapeake Bay Trading Initiative in the Unite State has taken over 20 years of efforts to get trading to the point where it is now, and small scale trading demonstration projects across the U.S. were an essential step to today's success.

A small scale trading demonstration project is critical to help identify the specific issues hindering the trading program, and choose the appropriate trading mode in local context. Taking into account the needs for policy development and capacity building within the Chao Lake basin, the provincial capital Hefei offers the best environment to build up a trading platform and also to lead the basin-wide trading program at a later stage. From the perspective of market development, Hefei has the greatest demand from point source dischargers, while highly productive agricultural bases surrounding the city, such as those in Lujiang County, offer plenty of reduction potentials. In addition, Anhui DRC is recommended as the leading authority to start up the trading demonstration project.

- **Establish an active cooperation mechanism among government agencies**

The multi-sectoral and trans-boundary nature of point-to-nonpoint source water quality trading requires a joint effort from various government agencies. Therefore, cross-agency cooperation is essential for an effective and successful trading program. In the United States for instance, USDA and EPA signed a partnership agreement in 2006 to coordinate efforts related to water quality trading markets.[52] In Maryland's State Nutrient Trading program, both Maryland Department of Agriculture (MDA) and Maryland Department of the Environment (MDE) are responsible for nutrient credit verification and certification.[53]

[52] USEPA. USDA and EPA Sign Water Quality Credit Trading Agreement. 2006 http://yosemite.epa.gov/opa/admpress.nsf/27166bca9a9490ee852570180055e350/d2abc3146a2167bb85257206004fcc85%21OpenDocument

[53] Evan Branosky, Cy Jones, and Mindy Selman. Comparison Tables of State Nutrient Trading Programs in the Chesapeake Bay Watershed. 2011

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ANNEX I: List of stakeholders interviewed

Name	Organization	Position
Ms. Chen Lei	Anhui Development and Reform Commission	Director, International Cooperation Division
Mr. Geng Dongmu	Anhui Development and Reform Commission	Director, Recourses and Environment Division
Mr. Wang Zhengyang	Anhui Development and Reform Commission	Deputy Director, International Cooperation Division
Mr. Shen	Anhui Environmental Protection Department	Director, Laws and Regulations Division
Ms. Guan	Anhui Environmental Protection Department	Officer, International Cooperation Division
Ms. Cao	Anhui Environmental Protection Department	Officer, Total Emission Control Division
Mr. Tian	Anhui Environmental Protection Department	Officer, Environmental Enforcement Division
Mr. Shi Rungui	Anhui Agricultural Environmental Protection Station	Director
Mr. Zhao	Anhui Soil and Fertilizer Management Station	Director
Mr. Zhang	Chao Lake Management Authority	Director in General
Mr. Fei Qinsong	Chao Lake Management Authority	Director, General Affair Division
Mr. Xu	Chao Lake Management Authority	Director, Environmental Protection Division
Mr. Chen	Chao Lake Management Authority	Director, Agriculture Division
Mr. Tang	Chao Lake Management Authority	Director, Fishery Division
Mr. Yu Shuting	Lujiang County Development and Reform Commission	Deputy Director in General
Mr. Qiang	Lujiang County Agriculture Commission	Chief Agricultural Engineer
Mr. Chen	Lujiang County Soil and Fertilizer Management Station	Director
Mr. Lin	Lujiang County Agriculture Commission	Officer
Mr. Xie Changhuan	Hefei Municipal Wastewater management Office	Section Chief
Mr. Wang	Hongxin Pig Feeding Operation	Manager
Mr. Song	Lotus Farm, Baishan Township	Lotus Farmer
Mr. Tang	Lotus Farm, Tongda Township	Lotus Farmer
Mr. Li	Chunsheng Farming Company	Manger
Mr. Chen	Wangtang Wastewater Treatment Plant	Manger
Mr. Xu Yanjing	Zhuzhuanjing Wastewater Treatment Plant	Manger

ANNEX II: Key regulations and policies on water environment protection

Law/policy	Code	Enacting Authority	Year
Environmental Protection Law	Order of the PRC President, No.22	National People's Congress	1989
Law on Prevention and Control of Water Pollution	Order of the PRC President, No.87	National People's Congress	1984, last amended in 2008
National 12th Five-Year Plan for Environmental Protection	Guofa 2011, No.42	State Council	2011
State Council Notice on Improve Urban Water Supply, Water Conservation, and Wastewater Treatment	Guofa 2000, No.36	State Council	2000
National 12th Five-Year Plan for Wastewater Treatment and Recycling	Guobanfa 2012, No.24	Ministry of Housing and Urban Rural Development	2012
National 12th Five-Year Plan for Water Pollution Control in the Key Water Basins	Huanfa 2012, No.58	Ministry of Environmental Protection	2012
Plan for Monitoring, Evaluation, and Promulgation of Urban Source Water Quality	Huanfa 2002, No.144	Ministry of Environmental Protection	2002
Guidelines for Rural Environmental Monitoring	Huanban 2009, No.150	Ministry of Environmental Protection	2009
Anhui Provincial Regulations for Environmental Protection	Announcement of Anhui Provincial People's Congress, No.24	Anhui Provincial People's Congress	2010
Regulations for Water Pollution Control in the Chao Lake Basin	Announcement of Anhui Provincial People's Congress, No.76	Anhui Provincial People's Congress	1998
Anhui Provincial Regulations for Agricultural Eco-Environment Protection	Announcement of Anhui Provincial People's Congress, No.81	Anhui Provincial People's Congress	1999
Anhui Provincial Regulations for Source Water Protection	Announcement of Anhui Provincial People's Congress, No.104	Anhui Provincial People's Congress	2001
Anhui Provincial 12th Five-Year Plan for Social and Economic Development	Wanzheng 2011, No.17	Anhui Provincial Government	2011
Anhui Provincial 12th Five-Year Plan for Eco-Agriculture and Rural Environmental Protection	Wannonghuan 2011, No.368	Anhui Agriculture Commission	2011

ANNEX III: Assumptions for reduction potentials and costs of selected pollution control measures

Options	**Reduction potentials (ton/yr)**	**Unit cost (1000 yuan/ton)**
Aquatic vegetable	4277	-3.04
Soil testing for rice	1682	-1.37
Soil testing for wheat	358	-1.37
Household bio-digester	797	7.81
Bio-digester for CAFOs	1314	10.44
Constructed wetland	2791	16.96
Sludge disposal	1600	20.78
New WWTP	1215	30.40
Upgrade WWTP	737	32.86
New industrial wastewater treatment plants	1493	65.87

ANNEX IV: Crops production and fertilizer consumption in Lujiang County

Crops Acreage and Yield in Lujiang (2006-2010)

Crop category		2006	2007	2008	2009	2010
Rice	Acreage (mu)	1658415	1661100	1738215	1739130	1699260
	Total yield (ton)	632020	647156	722272	746044	747523
	Unit yield (kg/mu)	381	390	416	429	440
Wheat	Acreage (mu)	184500	207285	274980	276000	286995
	Total yield (ton)	42028	51601	83984	84813	87820
	Unit yield (kg/mu)	228	249	305	307	306
Rapeseed	Acreage (mu)	240045	203325	259485	267135	230475
	Total yield (ton)	32385	28722	36363	40157	31457
	Unit yield (kg/mu)	135	141	140	150	136
Cotton	Acreage (mu)	49830	81975	84345	61005	58005
	Total yield (ton)	3576	6419	6494	5307	4698
	Unit yield (kg/mu)	72	78	77	87	81
Vegetable	Acreage (mu)					210795
	Total yield (ton)					291109
	Unit yield (kg/mu)					1381
Fruit	Acreage (mu)					15075
	Total yield (ton)					24542
	Unit yield (kg/mu)					1628

1 mu=0.067 hectare
Source: Lujiang Statistical Yearbook 2011.

Fertilizer Expenditure and Application Rate in Lujiang

Crop category		Application rate (kg)				Fertilizer expenditure per mu (CNY)
		N (as CON_2H_4)	P	K (as KCl)	Compound fertilizer	
Rice	Early	15	0	12	30	156.6
	Late	30	0	20	40	244
	Two harvests variety	25	0	15	35	202.5
Wheat		16	0	5	40	163.7
Rapeseed		25	0	25	45	263.5
Cotton		10	0	20	80	312
Vegetable		40	0	0	40	200
Fruit		20	0	5	30	144.5

Note: Fertilizer expenditure is calculated at the cost as June 2011.
Source: Lujiang Agriculture Commission, 2012.

ANNEX V: Nitrogen limits in Chinese discharge standards

Standard	Code	Effective date	TN discharge limit (mg/L)		
				National limit	Special limit for sensitive area[1]
Integrated wastewater discharge standard	GB8979-1996	1/1/1998		N/A	
Discharge standard of pollutants for municipal wastewater treatment plant	GB18918-2002	7/1/2003	Class IA	15	
			Class IB	20	
			Class II	N/A	
			Class III	N/A	
Discharge standard of Main Water Pollutants for Municipal Wastewater Treatment Plant & Key industries of Tai Lake Area	DB1072-2007	1/1/2008	Municipal WWTPs		15
			Industrial WWTPs[2]		15
Discharge standard of Pollutants for beer industry	GB19821-2005	1/1/2006		N/A	
Discharge standard of Water Pollutants for Sugar Industry	GB21909-2008	8/1/2008		15	8
Discharge standard of Water Pollutants for Pharmaceutical Industry Chemical Synthesis products category	GB21904-2008	8/1/2008		35	15
Discharge standard of water pollutants for pharmaceutical industry bio-pharmaceutical category	GB21907-2008	8/1/2008		30	15
Discharge standard of water pollutants for pulp and paper industry	GB3544-2008	8/1/2008		15	10
Discharge standard of water pollutants for down industry	GB21901-2008	1/1/2008		16	10
Emission standard of pollutants for synthetic leather and artificial leather industry	GB21902-2008	1/1/2008		15	15
Discharge standard of water pollutants for starch industry	GB25461-2010	10/1/2010		30	10
Emission standard of pollutants for nitric acid industry	GB26131-2010	3/1/2011		30	20
Discharge standard of water pollutants for fermentation alcohol and distilled spirits industry	GB27631-2011	1/1/2012		20	15

1. Currently only Tai Lake municipalities apply the special limits.
2. Industrial categories include textile, petrochemical, ammonia synthesis, pulp and paper, iron and steel, beer, and MSG manufacturing.

ANNEX VI: Nutrient reduction estimation tools in the US

- **Nitrogen Trading Tool**

The USDA has begun development of the Nitrogen Trading Tool (NTT). The NTT is an online tool that allows users to calculate changes in nitrogen loss potential based on changes in crop management practices. Users can assess how various BMPs may affect the nutrient losses from their farm, and calculate the total nitrogen reductions they can generate through changes in management practices. The NTT is still undergoing improvements but is currently being used in Maryland's Chesapeake Bay nutrient trading program.

- **Region 5 Load Estimation Spreadsheet Model**

The U.S. EPA Region 5 spreadsheet model estimates pollutant reductions for (a) sediment; (b) sediment-borne phosphorus and nitrogen; (c) feedlot runoff; and (d) commercial fertilizer, pesticides, and manure utilization. The Region 5 model is the standard used in the Michigan trading rules for estimating nonpoint source reductions and is also used in the Great Miami Watershed Trading Pilot. The spreadsheet model can be found at http://it.tetratech-ffx.com/stepl/.

- **NutrientNet**

NutrientNet is an online application developed by the World Resources Institute that can be used to estimate nitrogen, phosphorus, and sediment losses from farms using farm-level data inputs. NutrientNet calculation tools have been developed for the Pennsylvania, Maryland, West Virginia, and Kalamazoo trading programs. NutrientNet can be found at www.nutrientnet.org.