Eco-Compensation in China: Mediating Water Demands on the Xin'an River

Environmental degradation is a global challenge recognised internationally in the 2000 Millennium Development Goals and again in the 2015 Sustainable Development Goals. Chinese President Xi Jinping also applied the phrase "New Normal" in 2014 to describe China's future in which economic gains may be slower as to balance other social and environmental needs.[1] Interrelated environmental challenges including climate change, deforestation, loss of biodiversity, and desertification all negatively impact not only the environment but also the health, lifestyles, livelihoods, incomes, and cultures of people and communities.[2]

Eco-compensation was designed as a balancing mechanism to find a fair and socially responsible way to improve environmental objectives without completely stifling development. The Xin'an River was selected as an inaugural pilot program in 2007 to test eco-compensation in reducing water pollution.[3]

This case study will provide background to the context of China and the Xin'an River, define common struggles in environmental policy as per economic principles, detail possible policy options for addressing these struggles, and finally providing closure on how eco-compensation was able to solve the challenges of pollution in the Xin'an River.

Background

China made impressive development gains over the last few decades in terms of both GDP and quality of life. However, this impressive accomplishment is belied by the increasingly severe impacts of environmental damage resulting from a "growth-at-all-costs" mindset. This damage was clearly present in Anhui and Zhejiang Provinces and the Xin'an River running between them.

Economic Growth

Since market liberalization in 1978 under Deng Xiaoping, China's economy grew on average nearly 10% every year and successfully brought some 800 million people out of poverty.[4] In 2014, China's

[1] World Bank Group, *China - Systematic Country Diagnostic: Towards a More Inclusive and Sustainable Development (English)*, 2018: https://openknowledge.worldbank.org/handle/10986/29422

[2] Walter V. Reid, *Millennium Ecosystem Assessment MEA, "Millennium Ecosystem Assessment: Ecosystems and Human Well-Being Synthesis*," *World Resources Institute,* 2005, https://www.researchgate.net/publication/40119375_Millenium_Ecosystem_Assessment_Synthesis_Report#fullTextFileContent

[3] Philip Aern, Bernardete Neve, and Stéphane Jost, "Case Study on Remuneration of Positive Externalities (Rpe)/ Payments for Environmental Services (Pes)," *Prepared for the Multi-stakeholder dialogue 12-13 September 2013,* http://www.fao.org/fileadmin/user_upload/pes-project/docs/FAO_RPE-PES_PSAH-Mexico.pdf

[4] Wayne M. Morrison, "China's Economic Rise: History, Trends, Challenges, Implications for the United States," *Congressional Research Service,* 2019, https://crsreports.congress.gov/product/pdf/RL/RL33534/98

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GDP surpassed the US in terms of purchasing power parity.[5] However, China's push for GDP growth was sustained by highly-polluting industrial, manufacturing, and agricultural practices which have had long-term impacts on China's population.[6] In rural China, where high poverty is still found, agricultural growth declined from 1990s.[7]

As shown in **Exhibit 1**, China drastically increased manufacturing capacity in the 2000s compared to other high GDP countries. Despite calls for more sustainable green growth, high-polluting industries including machinery, plastics, and apparel and others listed in **Exhibit 2** still made up a significant portion of China's exports in 2016, and thus were still very central to the economy. Still, while these developments have succeeded in reducing poverty overall, conditions have improved in the urban (largely coastal) areas much faster than in rural areas, as shown in **Exhibit 3**. While overall prevalence of rural poverty dropped by 92 percentage points, poverty was 6.6 times as prevalent in rural areas as opposed to urban in 2013, compared to 1.6 times in 1981.[8]

Anhui and Zhejiang provinces benefited unequally from these economic policies and gains. Although similar in area size, population size, ethnic make-up, and culture, Anhui is landlocked while Zhejiang is a coastal province which borders Shanghai. Anhui historically was largely agricultural and suffered from irregular flooding from the Yellow River,[9] while Zhejiang had a strong fishing sector and was able to benefit from its proximity to Shanghai and trading. Zhejiang became majority urban by the 1970s, and more recently was able to move its economy towards the technology sector.[10] As seen in **Exhibit 4**, in 2010 Zhejiang's GDP was more than double that of Anhui's. As shown in **Exhibit 5**, Zhejiang had a lower prevalence of poverty compared to Anhui.

Environmental Degradation

Widespread air pollution at unhealthy levels was an early well-known side effect of China's development– in Beijing air pollution reached "unhealthy" levels approximately 240 days per year between 2008 and 2015,[11] contributing to an annual 6.5% loss in GDP due to lost productivity from negative health impacts.[12] In addition, contamination of soil and water was another major problem that negatively impacted ecosystems and human health. Unfortunately, a 2012 report identified seven out of the ten most polluted rivers in the world in China.[13] **Exhibit 6** shows that in 2002 only about 30% of China's surface water was categorized as fit for human use, and that ground water pollution was also a major challenge. Soil and water pollution also contributed to 3.2% total loss to GDP per year since 2000[14] and led to increased scarcity of potable water in already water-scarce regions.[15]

The Xin'an River was one such important water source which has had a long history with pollution. The River runs for 359 km from Anhui Province past the border to Zhejiang Province and into Qiandao Lake, as shown in **Exhibit 7**. Some 10 million people in Zhejiang – including more than 7 million in Hangzhou, the provincial capital – receive their drinking water from Qiandao Lake, a man-

[5] World Bank Group, 2018.
[6] Ibid.
[7] Ibid.
[8] Ibid.
[9] Chinafolio, "Anhui Province," https://chinafolio.com/provinces/anhui-province-2/
[10] Chinafolio, "Zhejiang Province," https://chinafolio.com/provinces/zhejiang-province/
[11] Morrison, 2019.
[12] Ibid.
[13] World Bank Group, 2018.
[14] Morrison, 2019.
[15] Ma Ting et al., "Pollution Exacerbates China's Water Scarcity and Its Regional Inequality," *Nature Communications* 11, no. 1, 2020, https://doi-org.libproxy1.nus.edu.sg/10.1038/s41467-020-14532-5

made lake near the Anhui border and fed mostly from the Xin'an River.[16] As Anhui began to increase the efficiency of its agrarian economy and built up its industry, run-off from factories, agriculture, livestock, and rural villages with no sewage systems increasingly became a problem for the Xin'an River and its outlet in the Qiandao Lake.

Conflict over pollution in the Xin'an River reached the national stage after the 1998 outbreak of blue algae on Qiandao Lake. Blue algae is a naturally occurring bacteria but can become pervasive due to large amounts of nitrogen and phosphorus, which often flow into rivers from agricultural runoff.[17] Contact with these bacteria, especially when consumed, can be lethal to animals like dogs and toxic to children and adults. After an algae bloom, water must be specially treated as boiling will not remove the toxicity, and the toxin may still be present in fish up to two weeks after the bloom ends.[18]

After this outbreak, Zhejiang made an official request to the central government asking for Anhui to take responsibility of its water pollution.[19] Anhui responded later asking for support from the central government. In 2001 the then-National Environmental Protection Bureau (NEPB), which became the Ministry of Environmental Protection in 2008, attempted to work together with both provinces, but there was little substantial progress.[20] The issue dragged on for years.

Problems

Globally, despite an increasingly large amount of scientific evidence, heighted awareness, and broad consensus on the dangers of environmental degradation, challenges remain. Some of these challenges are due to lack of research or limits to technology; research solutions for environments and ecosystem services can be very complicated. However often too the solutions for addressing environmental problems are limited due to necessary trade-offs between social, political, and economic needs. Here, the field of economics developed a number of concepts useful for understanding these trade-offs including terms such as the Environmental Kuznets Curve, standing, externalities, and discounting.

Environmental Kuznets Curve

The Environmental Kuznets Curve (EKC) is a neoclassical economic idea which stated that pollution levels and GDP per capita have an inverse U-shaped (∩) correlation. This was said to be because agrarian economies with low levels of development should have low levels of pollution, while industrialising economies will need to pollute more, and advanced economies will pollute less due to preferences of a wealthier society.[21] A sample EKC can been viewed in **Exhibit 8**.

However, later economists identified some serious flaws with the idea of EKC. First, the only empirical observations which most closely supported its claims was from industrial air pollution, not

[16] Asian Development Bank, "People's Republic of China: Anhui Huangshan Xin'an River Ecological Protection and Green Development Project," *Projects,* 2019, https://www.adb.org/projects/52026-001/main#project-overview
[17] Minnesota Pollution Control Agency, "Blue-Green Algae and Harmful Algal Blooms," *Water,* https://www.pca.state.mn.us/water/blue-green-algae-and-harmful-algal-blooms
[18] Ibid.
[19] Aern, Neve, and Jost, 2013.
[20] Ibid.
[21] Soumyananda Dinda, "Environmental Kuznets Curve Hypothesis: A Survey," *Ecological Economics* 49, no. 4, 2004: https://doi.org/10.1016/j.ecolecon.2004.02.011

water pollution.[22] Water and soil pollution fit the curve less well in part because pollution came from agricultural and livestock runoff and not just industry. Secondly, there were examples of nations bucking this polluting cycle in their development.[23] Furthermore, EKC implied that economic degradation is inevitably linked to development, and that the best way to improve environmental conditions is to become wealthy as quickly as possible or never develop at all. Even more worryingly, EKC in its most extreme interpretation could imply the environment would improve naturally with wealth without government action.

In the Xin'an River case, it could be said that Anhui was a pre-industrial economy while Zhejiang was post-industrialized and thus disagreement over pollution is inevitable. As both provinces were at very different development stages, the relative ability and inclination to limit pollution would also be quite different. However, it would be unlikely for either province to claim Anhui completely incapable of any environmental action as EKC would suggest.

Standing

The idea of standing is largely used in the practice of law, but the term can also be applied in tools such as cost-benefit analysis to clarify who is considered as beneficiaries of a project. If a town is considering a project, it is important to make sure the town's citizens will benefit enough to justify the cost of the project. However, the town may or may not care about the benefit or harm to resident non-citizens, visitors, neighbouring towns, etc. The town only cares about its own citizens, so only the citizens are given standing.

Standing is a particularly prevalent issue in environmental challenges, as often those polluting are not the most impacted by the effects of pollution; negative environmental impacts can spread through water, air, or even through the food chain or ecosystems. Since many of these negative costs are not being paid by those given standing, those selecting the projects are not incentivised to halt them. Ecosystems are holistic and transboundary in nature, but efforts to protecting the environment are often limited and restricted by jurisdiction.

In the case of the Xin'an River, the issue of standing played an important role due to the transboundary nature of this body of water. Anhui province had a much lower GDP than its coastal neighbors, and so prioritised economic development for its citizens even at steep environmental costs. Anhui gave little to no standing to residents of Zhejiang Province, as they are outside their jurisdiction. Similarly, Zhejiang Province gave little standing to residents of Anhui; Zhejiang saw its own polluted rivers, saw Anhui as the culprit, and so saw Anhui giving up polluting activities as the best solution. The drop in development and livelihoods in Anhui this would cost was of little concern to Zhejiang, as Anhui was given no standing.

Externalities

Adam Smith was one of the first to theorise that markets – and even society – maximize efficiency when individuals or firms make transactions solely for their own benefit. This is often referred to as "the invisible hand" in economics and is still a main tenant in the idea of free markets and capitalism. Externalities occur when such efficiency is not reached, and outside third parties are either positively or negatively impacted by others' transactions. Externalities are directly linked to

[22] Ibid.

[23] Samuel Asumadu Sarkodie and Vladimir Strezov, "Empirical Study of the Environmental Kuznets Curve and Environmental Sustainability Curve Hypothesis for Australia, China, Ghana and USA," *Journal of Cleaner Production* 201, 10 November 2018: https://doi.org/10.1016/j.jclepro.2018.08.039

the concept of standing; if a town chooses to implement a project but does not grant its neighbours standing, then it is those neighbours who are potentially subject to positive or negative externalities.

In the case of the Xin'an River, private factories and farms in Anhui Province had negative externalities in the form of pollution. The Xin'an River's waters became dirty with chemicals and garbage as an unfortunately common by-product of development and industry in Anhui Province. This pollution negatively impacted the river ecosystem as well as the biodiversity depending on the river. Furthermore, this pollution was carried downstream to Zhejiang Province, where the now-dirty water uglied the river's scenic value and tourism potential. More directly, the Xin'an River is an important source of drinking water for the people of Zhejiang Province, and so the polluted water could decrease overall health and increase water utility costs.

Discounting

Another major challenge to solving environmental crises is the perceived discount rate. Discounting refers to the perception that goods are worth less in the future than they are now. Even if the good is exactly the same, individuals have a time preference for the immediate rather than the far-off. For example, most people would prefer their Amazon delivery to arrive the same day instead of a week later even if they do not plan to use their purchase immediately. Some people are also willing to pay more for this to happen, even though the goods will be exactly the same upon arrival.

This principle applies to costs as well. It seems intuitive that bills due today are a higher priority than bills due tomorrow. Unfortunately, environmental challenges are too often considered to only have long-term costs and impacts, thus can be addressed after more pressing (usually economic) concerns. In developing countries, where poverty and limited physical and social infrastructure are of great concern, policies are more often aimed at addressing immediate needs: food, water, shelter. It is difficult for government to invest in long-term plans when there are many other immediate needs to fulfil. The discount rate reflects this, as many developing nations have a standardised discount rate of 10% or higher.[24] This means that when looking at two projects of similar costs and potential benefits, the calculated benefit of a project that takes an additional year before receiving a return is automatically 10% less valuable than the other. In contrast, many developed nations with fewer immediate challenges may have discount rates at around 3%, which means long-term projects like those which benefit the environment look more appealing. The global differences in national discount rates can be seen in **Exhibit 9**.

In the Xin'an River case, Anhui has a much higher poverty incidence rate than its wealthy downstream neighbour Zhejiang. Thus, while aware of the environmental risks, Anhui's calculations prioritise the immediate economic gains from industrial activities. Comparatively, Zhejiang is more developed with higher GDP, which means they can better afford to think of the long-term consequences of a polluted river on the health of residents and ecosystems.

Policy Options

There were many reasons for why environmental policies were so slow-moving. However, lack of political awareness at the national level in China was not one of them. Environmental protection had been a policy goal in China since the 1970s. Protection of environmental resources was directly written into the national Constitution as well as the Constitution of the Chinese Communist Party. Environmental targets had been set in every Five-Year Plan since 1975. While meeting and enforcing

[24] Macro Economy Meter,"Central Bank Discount Rate - by Country," http://mecometer.com/topic/central-bank-discount-rate/

these lofty targets is a work in progress, the central government has fine-tuned its articulation of environmental goals and implementing policies over the decades from their own experiences as well as from international best-practices. From these experiences, there are multiple potential policy options the central government could select to approach the Xin'an River case.

Option 1: Do nothing

The central government could very well elect to not become involved in this issue, instead letting the provinces negotiate between themselves. While it was technically the role of provinces to meet the environmental targets laid out in the Five-Year Plan, there were some clear downsides to completely localising this issue:

- First, both provinces and the NEPB tried to arrive at an amenable solution for years with no result.[25]

- Second, there were moral and political reasons why the central government would not continuously ignore multiple requests for assistance from all parties on an issue as central as clean drinking water.

- Furthermore, Xin'an River was not unique; there were many transboundary rivers in China and many have pollution problems.

- Additionally, many other environment problems such as air pollution, soil erosion, and deforestation can all be negatively impacted by issues of standing, externalities, and discounting. Allowing these issues to be addressed only at the local level makes for poor policy, especially if there is a possibility one solution may be applied to all.

- Finally, this inaction on domestic environmental issues may also have a negative impact on China's foreign policy goals. As an increasingly salient global issue, China's poor past environmental record was early on a source for criticism from international organisations, foreign leaders, and civil society. As China increased its prominence on the world stage, becoming an environmental leader instead of a laggard had clear benefits in terms of moral authority and demonstrating technical capacity.

Option 2: Apply EKC

If the central government followed the neoclassical model of economics and using EKC theory to guide its thinking, then only two options exist:

Option 2a:

Ignore the environmental concerns and instead assist Anhui in growing its economy as fast as possible. Once Anhui has developed a post-industrial economy, then the pollution levels should naturally decrease. Many would argue this is exactly what China has done until the early 2000s. Many more would argue this is the approach Western governments took to reach their current level of development. Thus, the argument would be that it was only fair for developing countries to similarly worry about environmental issues only after per capita GDP has reached a certain level.

[25] Aern, Neve, and Jost, 2013.

However, there were clear problems with practically applying EKC to this case even if the empirical support was stronger. First, in Zhejiang's perspective, this still looked a lot like the 'do nothing' option previously described, and so the same downsides were likely to apply. Second, there was no telling how long it would take for Anhui to reach a "sufficient" wealth level. It could take years, decades, or never if growth never reaches the required level. Third, it is likely that even if Anhui does grow economically enough, polluting industries will not shut down but move further into other poorer parts of China, perpetuating the problem elsewhere.

Option 2b:

Prevent development from continuing in the Xin'an River basin completely. According to EKC, forcing Anhui to eschew development and remain a pre-industrialized economy would improve the pollution problem of the Xin'an River. While there is global precedent for governments to set land aside as national parks or reserves within which limited development is allowed, Anhui is home to over 60 million people. There would be clear ethical problems and social repercussions as this policy would effectively force generations to perpetually remain in poverty. Obviously, this would also be antithetical to the central government's national economic goals. However, as agriculture and livestock were the major sources of water and soil pollution, the environment problems may not go away. While many environmentalists rightly advocate for conserving land, it is extremely important to balance current and future environmental needs with other economic and social needs.

Option 3: Command-and-control

The definition of command-and-control in environmental policy used by the United Nations Environment Programme is:

> *The policy framework in which environmental (e.g., emission standards for each source and each pollutant) and resource (catch or logging limits for each site or species) management rules are prescribed by the regulator, leaving little flexibility for actors in the implementation.*[26]

Command-and-control policies are used widely around the world for policies such as capping fuel emissions from cars, standardising minimum flow requirements for rivers, and much more. These forms of polices are useful because they are fairly straightforward to write, set, and evaluate. However, the difficult part comes with implementation and monitoring, which are often left to companies and civil society to manage.

In the 1990s, the central government attempted a high-profile, top-down "Huai River Pollution Control Project" to improve water quality in Anhui and Shandong Provinces. However, the main policy levers were command-and-control measures to regulate or shut down polluting industries, which directly conflicted with local livelihoods and paths out of poverty.[27] In pitting environmental needs against both industry and social needs, the project was soon halted and regulations lowered.

[26] Joseph Alcamo et. al., "Ecosystems and Human Well-Being: A Framework for Assessment," 2003, https://pdf.wri.org/ecosystems_human_wellbeing.pdf

[27] Xuemei Bai, Peijun Shi, and Yansui Liu, "Society: Realizing China's Urban Dream," *Nature News* 509, no. 7499 2014, https://www-nature-com.libproxy1.nus.edu.sg/news/society-realizing-china-s-urban-dream-1.15151

Other more recent studies in China have also found command-and-control policies can hurt green innovation in the private sector[28] and have mixed results on environmental impact.[29,30,31]

Option 4: Market mechanisms

While historically capitalistic systems have largely led to widespread environmental degradation through externalities and other issues previously discussed, in recent decades governments around the world have experimented using these same systems to undo or reduce environmental harms. The idea is to allow government to use the same underlying principles which drive markets – supply and demand – to remove negative externalities. Cap-and-trade, or carbon trading, is one well-known example of using market mechanisms to reduce carbon emissions.

Payment for Ecosystem Services (PES) is another category of environmental policy which utilises market mechanisms. Simply put, PES assumes that (a) ecosystem services have inherent value, and (b) both those who benefit from these services continuing as well as those threaten these services by polluting are liable to pay compensation.[32] If the environmental damage cannot be avoided or undone, those who are adversely impacted as external parties should be paid damages or dues from those who most benefited.

Market mechanisms tend to be seen as fairer to all and flexible enough to match changing needs over time. One study in China found policies utilising market mechanisms to have improved "green" productivity outcomes compared to command-and-control policies.[33] However, market mechanisms often very complex, require access to high quality data, and necessitate high technical capacity to design, implement, and monitor. Additionally, some environmentalists take offense at the way these policies seem solely value ecosystems for quantifiable services to humans instead of as something inherently valuable and worth protection for its own sake.

Resolution

The central government tried many different approaches to the Xin'an River pollution problem since the 1990s from leaving it as a provincial issue to implementing the Huai River Pollution Control Project. Doing nothing, applying AKC, nor command-and-control policies were able to resolve the pollution issue. This was one impetus for the government to explore market-based options and how market mechanisms could be adapted to suit the Chinese context.

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[28] Kai Tang, Yuan Qiu, and Di Zhou, "Does Command-and-Control Regulation Promote Green Innovation Performance? Evidence from China's Industrial Enterprises," *Science of The Total Environment,* 712, 2020, https://doi.org/10.1016/j.scitotenv.2019.136362

[29] Wanhong Li et al., "The Effect of Command-and-Control Regulation on Environmental Technological Innovation in China: A Spatial Econometric Approach," *Environmental Science and Pollution Research,* 26, no. 34, 2019: https://doi-org.libproxy1.nus.edu.sg/10.1007/s11356-018-3678-3

[30] Rong-hui Xie, Yi-jun Yuan, and Jing-jing Huang, "Different Types of Environmental Regulations and Heterogeneous Influence on "Green" Productivity: Evidence from China," *Ecological Economics,* 132, 2017, https://doi.org/10.1016/j.ecolecon.2016.10.019

[31] Genia Kostka, "Command without Control: The Case of China's Environmental Target System," *Regulation & Governance* 10, no. 1, 2016, https://doi-org.libproxy1.nus.edu.sg/10.1111/rego.12082

[32] Cheng Wen, Yim Ling Siu, and Klaus Hubacek, "Carrot and Stick a Novel Policy Experiment of Transboundary Watershed Protection in China," *Environmental science & technolog,y* 46, no. 12, 2012, https://doi.org/10.1021/es301971n

[33] Xie, Yuan, and Huang, 2017.

China developed its own concept of eco-compensation in the early 2000s based on global best practices with PES. The Asian Development Bank (ADB) listed six characteristics which distinguishes eco-compensation from PES:

> *(i) The state is the primary driver.*
> *(ii) The state is the primary payer.*
> *(iii) Market mechanisms are incipient.*
> *(iv) Participation is usually mandatory.*
> *(v) Eco-compensation is both vertical and horizontal.*
> *(vi) Natural, social, and administrative diversity influence eco-compensation.*[34]

From this list, it may seem like eco-compensation is not a market mechanism at all. After all, most free markets would eschew government taking any primary role. Furthermore, entry and exit from a market is supposed to be free, not mandatory. Still, the mechanisms of monetary incentives, rewards and punishments, agreement between stakeholders, externalities, and choice were incorporated into pilot eco-compensation agreement schemes. While non-market forces may have been needed to give structure and set prices, it was hoped these mechanisms would be sufficient in creating an enduring solution.

Eco-Compensation Begins

The pilot 'Compensation for Water Environment of the Xin'an River' project began in 2012 after its initial announcement in 2007. Led by the Ministry of Finance and NEPB working with Anhui and Zhejiang provinces, the pilot hinged on a relatively simple mechanism: conditional cash transfer.

The agreement set a very clear water quality parameter (P) calculated by the quantity of phosphorus, nitrogen, ammonia, and chemical oxygen demand, with P less than or equal to one meaning the pollution is sufficiently low.[35] Both provinces jointly monitor these values every month at the border. Then, each year either Anhui or Zhejiang will have to pay the other US$16 million to mitigate or clean pollution in the Xin'an River. Additionally, regardless of the value of P, the central government agreed to pay Anhui province US$48 million each year to support start-up and transition costs.[36] Thus, each year Anhui has two market-based options:

1) Invest and regulate its pollution to sufficiently low levels such that $P \leq 1$, then collect US$48 million from the central government and another US$16 million from Zhejiang, earning a total of US$64 million.
2) Do not regulate or otherwise mitigate pollution resulting in high levels of pollution (P>1). Anhui would still receive US$48 million from the central government, but would also owe Zhejiang Province US$16 million compensation. This would result in only earning US$32 million, half the previous amount.

Exhibit 10 details this agreement further.

Pros of eco-compensation for the Xin'an River

[34] Asian Development Bank, *Toward a National Eco-Compensation Regulation in the People's Republic of China,* 2016*,* https://www.adb.org/sites/default/files/publication/212726/eco-compensation-regulation-prc.pdf
[35] Ibid.
[36] Aern, Neve, and Jost, 2013.

In the first five years of the pilot scheme, the central and provincial governments contributed over US$500 million and succeeded in meeting the required water quality target value.[37] A recent evaluation of the Xin'an River eco-compensation programme called the programme's environmental results "remarkable."[38] While the same evaluation did list areas for improvement, eco-compensation is clearly a solution which can be scaled and applied elsewhere. Another recent study similarly recommended the programme continued, however with larger compensation allotments as the first years of the pilot did in fact see a widening economic inequality gap between impacted Anhui and Zhejiang districts.[39]

While the calculation of P does not cover all possible pollutants or factors, there is major benefit in P being calculated this way. As Xueliang Cai, an ADB expert working on eco-compensation, explained:

> *"It's very effective. That is one of the good things about it. It's so simple. There's no sort of arguments about methods of data collection . . . and that is by design."*[40]

While this static P equation did not directly incentivise Anhui to pollute below the set amount, the basic calculation for P made it easy to monitor progress and enforce the eco-compensation agreement. The calculation parameters could be made more stringent every few years when the agreement is renewed.

While still not as straightforward as a command-and-control policy, this eco-compensation agreement neatly addresses the issues of standing, externalities, and discounting described previously. With the involvement of the central government, all residents in both provinces are granted standing and all environmental costs are considered as part of the agreement, not externalities. Additionally, this project would now use the national government's standard discount rate for public projects. While previously Anhui was not interested in reducing pollution partly due to its own discounting logic, the central government's influx of funding for environmental purposes makes the project much more appealing.

Cons of eco-compensation for the Xin'an River

Unfortunately, eco-compensation is still imperfect. It took many years to negotiate the current eco-compensation arrangement, and it would not have been possible without the central government's involvement and funding.

Financial sustainability is also in question. Eco-compensation agreements must be continually renewed as they cannot create a permanent fix. While the ecosystem service itself may be sustainable, the financial compensation portion may not be. When first initiated, the compensation scheme was largely vertical, with the central government providing the lion's share of the funding. Additionally, the central government was involved in continued monitoring and enforcement of the agreement. The central government increasingly experimented with more horizontal compensation which would place more of this burden on the provinces involved. In 2015, the central government

[37] Asian Development Bank, 2019.
[38] Junran Dong and Desheng Wu, "An Evaluation of the Impact of Ecological Compensation on the Cross-Section Efficiency Using Sfa and Dea: A Case Study of Xin'an River Basin," *Sustainability,* vol 12, no. 19, 2020: https://doi.org/10.3390/su12197966
[39] Bing Yu and Linan Chen, "Interventional Impacts of Watershed Ecological Compensation on Regional Economic Differences: Evidence from Xin'an River, China," *International journal of environmental research and public health* 17, no. 17, 2020: https://doi.org/10.3390/ijerph17176389
[40] Cai, Xueliang, interview with author, January 19, 2021.

increased its own contributions while also doubling the amounts either province was responsible for, then slowly decreased its own commitments.[41] Since 2017, all three parties were liable for US$32 million annually.[42]

Eco-compensation agreements are also context-specific, which is useful in tailoring each agreement to the needs of individual stakeholders. However, this also means that each agreement must be negotiated separately. Unlike other national environmental policies, an eco-compensation agreement is not readily adaptable to the national scale.

Additionally, the pilot programme focused on top-down negotiations between central and provincial governments and did not lay out clear guidelines as to how the compensation would be distributed at the county level and to individual firms and farms. One recent study found that county-level compensation distribution was not fully equitable based on local pollution levels and opportunity costs.[43]

Epilogue

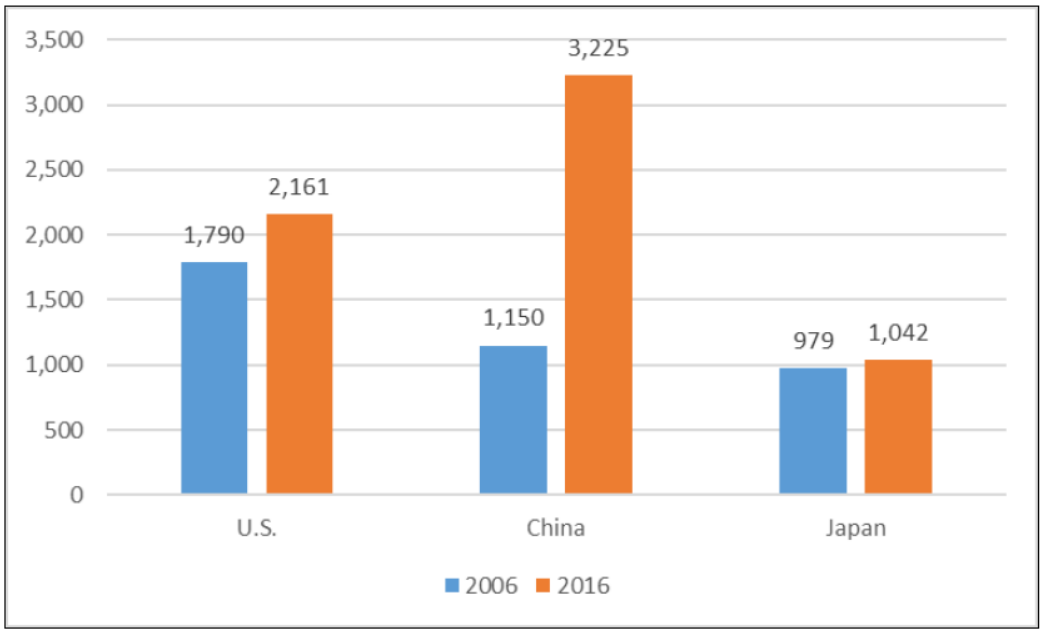
After the success of the pilot Xin'an River eco-compensation programme and others like it, China implemented dozens of other eco-compensation schemes across the country for many other rivers and even for forests, grasslands, wetlands, marine areas, and mineral deposits.[44] Since 2009, China far outstripped all other countries in the world in terms of watershed services investments.[45] The Xin'an River case as well as eco-compensation in general gained much global interest and support. International organisations increasingly analyse China's model as well as entering as prominent stakeholders to rectify some of the cons described above.

In 2018, the World Bank provided a loan worth US$150 million for pollution control, watershed management, and improved access to potable water in the Xin'an River Basin.[46] This loan was part of an overarching plan to promote "green growth" at a national scale.[47] In 2020, ADB partnering with a German development bank also signed a six-year US$ 158.8 million loan with the intended outcome of improving "economic and environmental conditions in the upstream of Xin'an River."[48] The ADB funding could address several areas, such as gender mainstreaming and lack of outreach to rural areas.[49] With more support from leaders, researchers, and international organisations, eco-compensation schemes will hopefully continue to improve and expand to other areas to promote both stable growth and concern for the environment.

[41] Yuxiang Cheng, Desheng Wu, and Yuan Bian, "A Systematic Approach of Determining Compensation and Allocation for River Basin Water Environment Based on Total Pollutants Control," *Journal of environmental management* 271, 2020: https://doi.org/10.1016/j.jenvman.2020.110896
[42] Ibid.
[43] Ibid.
[44] Asian Development Bank, 2016.
[45] Ibid.
[46] World Bank, "China - Zhejiang Qiandao Lake and Xin'an River Basin Water Resources and Ecological Environment Protection Project," *Loans and Credits,* June 6, 2018, https://www.worldbank.org/en/news/loans-credits/2018/06/06/china-zhejiang-qiandao-lake-and-xinan-river-basin-water-resources-and-ecological-environment-protection-project
[47] World Bank, 2018.
[48] ADB, 2019.
[49] Ibid.

Exhibits

Exhibit 1: Comparative gross value-added manufacturing in USD billions[50]



Source: The World Bank.

Exhibit 2: Top 10 Chinese exports in 2018[51]

HS Code	Description	$ Billions	Percentage of Total Exports	2017/2016 % Change
	Total Commodities	2,489	100	9.2
85	Electrical machinery	664	26.7	10.6
84	Nuclear reactors, boilers, and machinery	429	17.3	12.0
94	Furniture and bedding	96	3.9	5.6
39	Plastics and articles thereof	80	3.2	12.1
87	Vehicles, except railway, and parts	75	3.0	11.4
61	Apparel articles and accessories, knit or crochet	74	3.0	1.9
62	Apparel articles and accessories, woven	71	2.9	-3.3
90	Optical, photographic, cinematographic, measuring checking, precision, medical or surgical instruments and apparatus; parts and accessories thereof	71	2.9	0.8
73	Articles of iron or steel	65	2.6	13.0
29	Organic chemicals	60	2.4	20.3

Source: *World Trade Atlas*, using official Chinese statistics.
Note: Top 10 exports in 2018, two-digit level, harmonized tariff system.

[50] Morrison, 2019.
[51] Ibid.

Exhibit 3: Decreasing poverty in China as percent of population[52]

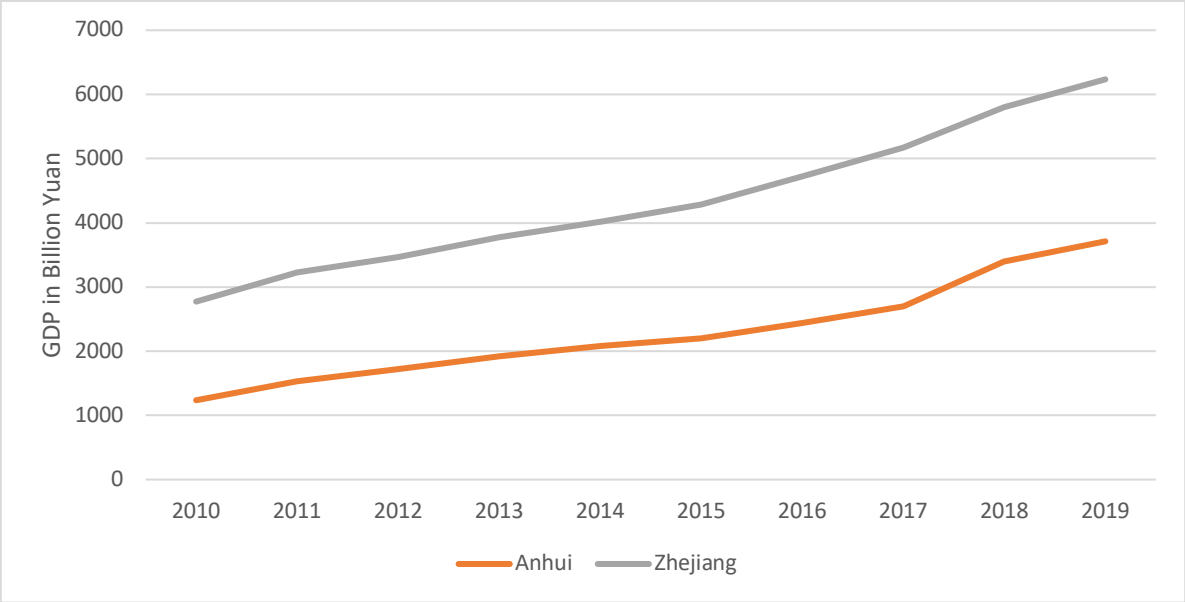
	National	Rural	Urban
1981	88.32	95.59	59.43
1984	75.75	85.21	42.60
1985	—	83.62	#N/A
1987	60.84	72.55	24.27
1990	66.58	78.95	32.16
1992	—	60.64	9.01
1993	57.00	71.83	20.86
1994	—	52.50	9.46
1995	—	46.55	6.84
1996	42.05	55.26	13.85
1997	—	33.35	5.91
1998	—	31.10	12.25
1999	40.54	56.38	10.96
2002	31.95	48.80	4.95
2005	18.75	30.63	2.69
2008	14.76	26.25	1.33
2010	11.18	21.30	0.74
2011	7.9	15.44	0.54
2012	6.47	12.98	0.42
2013	1.85	3.38	0.51

Source: PovcalNet, Shaohua Chen prepared data for this study.

This chart looks at the percent of national, rural, and urban populations in China consuming below the poverty line (set at $1.90 USD in 2011 dollars with PPP) over time. Poverty has been reduced drastically across the board over the past 30 years, however inequality between rural and urban areas has increased.

[52] World Bank, *China - Systematic Country Diagnostic*, 2018.

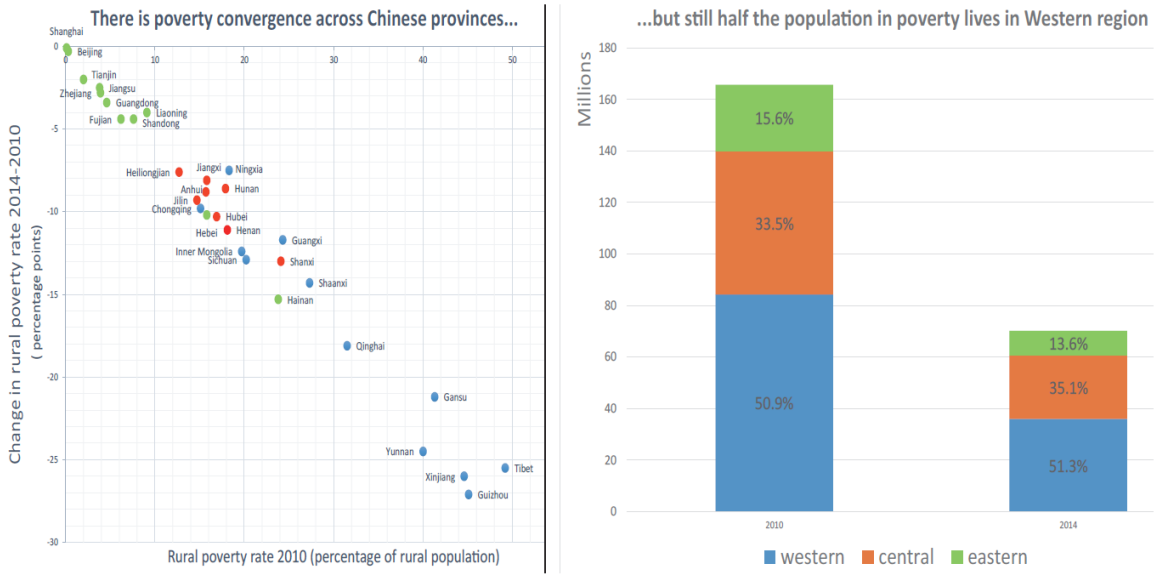
Exhibit 4: Comparing total GDP over time in Anhui[53] and Zhejiang[54] provinces



[53] C. Textor, "Gross Domestic Product (Gdp) of Anhui Province, China 2010-2019," *Statista*, November 27, 2020: https://www.statista.com/statistics/1092997/china-gross-domestic-product-of-anhui-province/

[54] C. Textor, "Gross Domestic Product (Gdp) of Zhejiang Province, China from 2010 to 2019," *Statista*, Mpve,ber 27, 2020: https://www.statista.com/statistics/1092992/china-gross-domestic-product-of-zhejiang-province/

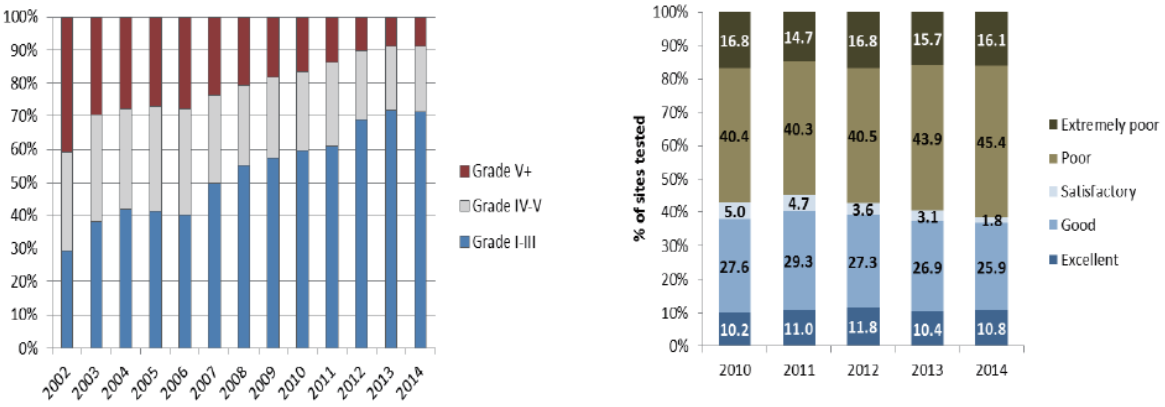
Exhibit 5: Poverty by province and region[55]



Source: China NBS, 2015

(Left) Poverty convergence of all provinces; (Right) Poverty distribution by region.

Exhibit 6: Water quality over time in China[56]



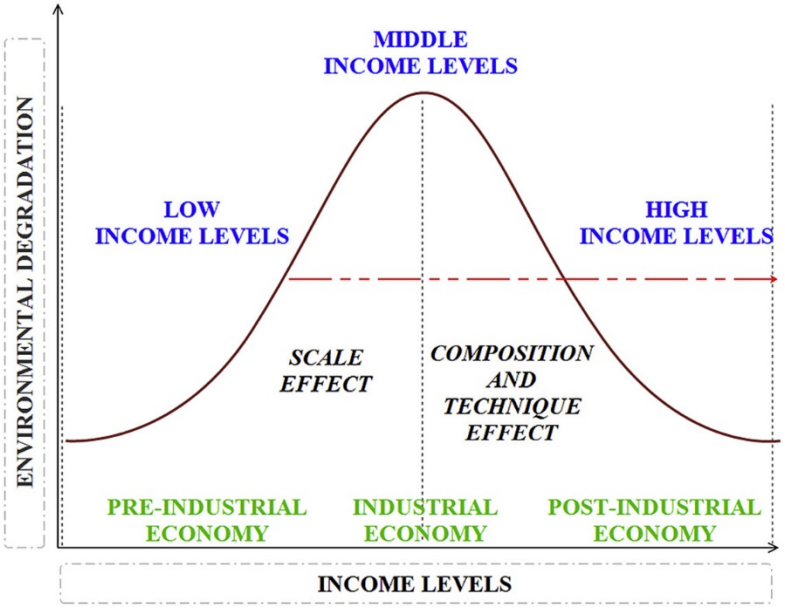
Sources: MEP, State of the Environment (various years).

The left-hand chart shows improvement in quality of surface water sources in China since 2002. Still, only some 70% is fit for human use (Grade I-III). The right-hand chart, however, shows stagnant and some worsening conditions for groundwater sources since 2010, although this is based on limited testing sites.

[55] World Bank, *China - Systematic Country Diagnostic*, 2018.
[56] Ibid.

Exhibit 7: Map of Xin'an River basin[57]

Exhibit 8: Generalized Environmental Kuznets Curve[58]



[57] Yu and Chen, 2020.
[58] Sarkodie and Strezov, 2018.

Exhibit 9: Discount rates by country[59]

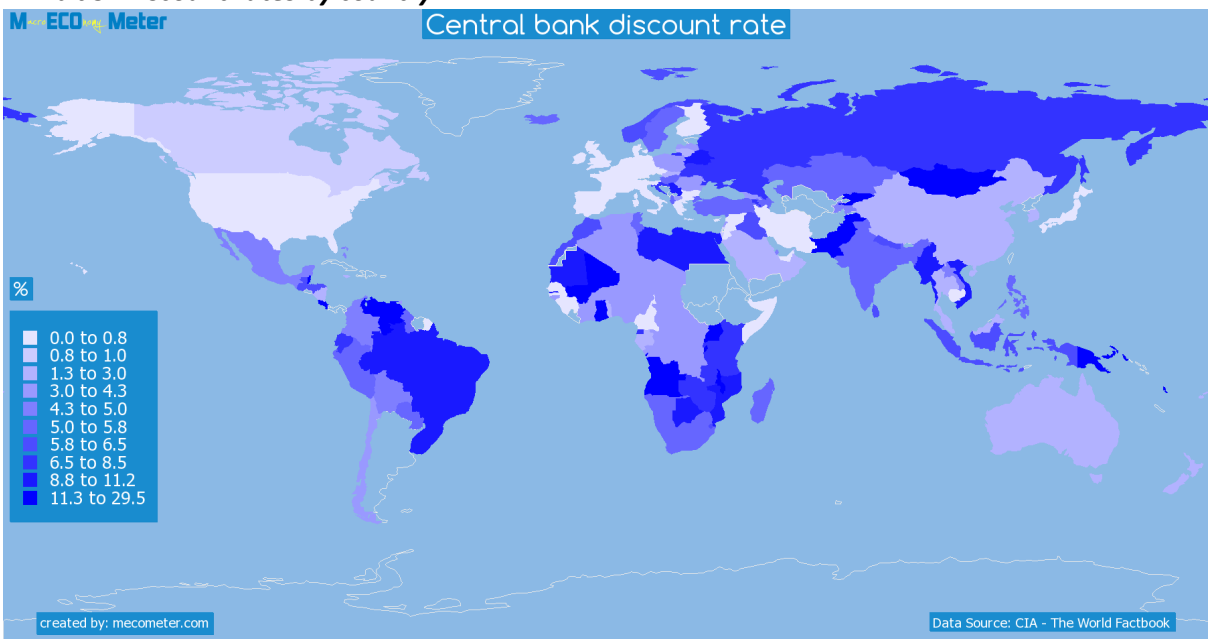
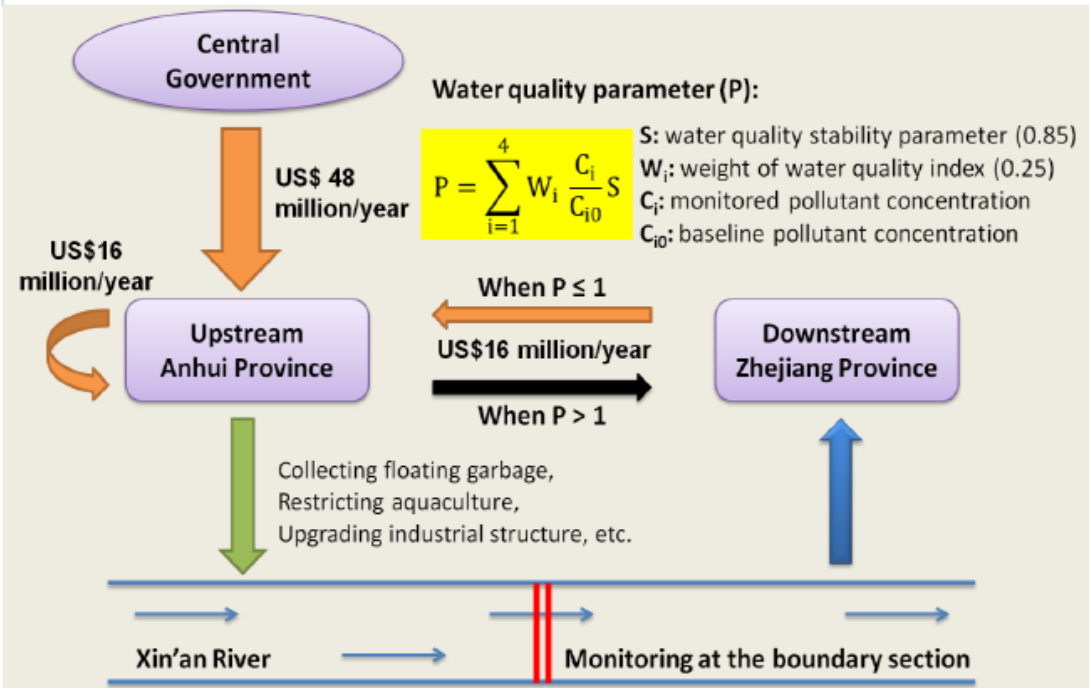


Exhibit 10: Diagram of payment agreement of eco-compensation for Xin'an River[60]



[59] Mecometer.
[60] Aern, Neve, and Jost, 2013.