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Report No: ICR00005730

IMPLEMENTATION COMPLETION AND RESULTS REPORT

TF0A2428

ON A

GRANT

FROM THE GLOBAL ENVIRONMENT FACILITY

IN THE AMOUNT OF US$9.5 MILLION

TO THE

People's Republic of China

FOR THE

GEF Mainstreaming Integrated Water and Environment Management

June 22, 2022

Water Global Practice

East Asia And Pacific Region

CURRENCY EQUIVALENTS

Exchange Rate Effective December 31, 2021

Currency Unit =	RMB
RMB 6.37 =	US$1
US$ 0.157 =	RMB 1

FISCAL YEAR
July 1 - June 30

Regional Vice President:	Manuela V. Ferro
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ABBREVIATIONS AND ACRONYMS

COD	Chemical Oxygen Demand
CPF	Country Partnership Framework
CPS	Country Partnership Strategy
EC	Environmental Carrying Capacity
ERR	Economic Rate of Return
ES	Ecosystem Services
ESMF	Environmental and Social Management Framework
ET	Evapotranspiration
FM	Financial Management
FRR	Financial Internal Rate of Return
FYP	Five-Year Plan
GEB	Global Environmental Benefit
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIS	Geographic Information System
GoC	Government of China
GRID	Green, Resilient and Inclusive Development
IPCC	Intergovernmental Panel on Climate Change
IWEM	Integrated Water and Environment Management
IWEMP	Integrated Water and Environmental Management Plan
M&E	Monitoring & Evaluation
MAR	Managed Aquifer Recharge
MEE	Ministry of Ecology and Environment
MEP	Ministry of Environmental Protection
MoF	Ministry of Finance
MWR	Ministry of Water Resources
NDRC	National Development and Reform Committee
NH_3-N	Ammonia Nitrogen
OHS	Occupational, Health and Safety
O&M	Operation and Maintenance
PAD	Project Appraisal Document
PDO	Project Development Objective
PIU	Project Implementation Unit
PMO	Project Management Office
PPP	Public-Private Partnership
PforR	Program-for-Results
RF	Results Framework
RS	Remote Sensing

TA	Technical Assistance
TN	Total Nitrogen
ToC	Theory of Change
TP	Total Phosphorus
TTL	Task Team Leader
TVAP	Target Value Allocation Plan
WETE	Water Environment Technology Extension
WUA	Water User Association
WWTP	Wastewater Treatment Plant
3iPET	Integrated, Intelligent and International Platform for Environmental Technology

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DATA SHEET

BASIC INFORMATION

Product Information

Project ID	Project Name
P145897	GEF Mainstreaming Integrated Water and Environment Management
Country	**Financing Instrument**
China	Investment Project Financing
Original EA Category	**Revised EA Category**
Partial Assessment (B)	

Organizations

Borrower	Implementing Agency
The People's Republic of China	Chengde Ecological Environment Bureau, The Ministry of Econogical Environment (MEE), The Ministry of Water Resources (MWR), Water Resources Department in Hebei Province

Project Development Objective (PDO)

Original PDO

The Project Development Objective (PDO) is to increase water productivity and reduce pollution discharges in the project areas to mainstream and scale up an innovative approach to integrated water and environmental management in the three river basins entering the Bohai Sea.

The PDO will be achieved through: (a) increasing irrigation water use efficiency and all other ways possible to effectively use water under a cap of water consumption; (b) reducing water pollution discharges under a cap of environment capacity and (c) increasing ecological river flows. The above measures will minimize the negative impacts on the ecosystem of Bohai Sea, contributing to the achievement of global environmental benefits (GEBs).

FINANCING

	Original Amount (US$)	Revised Amount (US$)	Actual Disbursed (US$)
World Bank Financing			
TF-A2428	9,500,000	9,500,000	9,499,561
Total	**9,500,000**	**9,500,000**	**9,499,561**
Non-World Bank Financing			
Borrower/Recipient	95,000,000	95,000,000	112,740,000
Total	**95,000,000**	**95,000,000**	**112,740,000**
Total Project Cost	**104,500,000**	**104,500,000**	**122,239,561**

KEY DATES

Approval	Effectiveness	MTR Review	Original Closing	Actual Closing
09-May-2016	27-Mar-2017	24-Nov-2020	31-Dec-2021	31-Dec-2021

RESTRUCTURING AND/OR ADDITIONAL FINANCING

Date(s)	Amount Disbursed (US$M)	Key Revisions

KEY RATINGS

Outcome	Bank Performance	M&E Quality
Highly Satisfactory	Satisfactory	Substantial

RATINGS OF PROJECT PERFORMANCE IN ISRs

No.	Date ISR Archived	DO Rating	IP Rating	Actual Disbursements (US$M)
01	01-Dec-2016	Satisfactory	Satisfactory	0
02	23-Jun-2017	Satisfactory	Satisfactory	.05
03	26-Dec-2017	Satisfactory	Satisfactory	.59

04	25-Jun-2018	Satisfactory	Moderately Satisfactory	.59
05	26-Dec-2018	Satisfactory	Moderately Satisfactory	1.34
06	21-Jun-2019	Moderately Satisfactory	Moderately Satisfactory	1.54
07	24-Dec-2019	Moderately Satisfactory	Moderately Satisfactory	1.96
08	26-Jun-2020	Moderately Satisfactory	Moderately Unsatisfactory	2.93
09	30-Dec-2020	Moderately Satisfactory	Moderately Unsatisfactory	5.07
10	25-Jun-2021	Satisfactory	Moderately Satisfactory	7.35
11	30-Dec-2021	Highly Satisfactory	Satisfactory	9.54

SECTORS AND THEMES

Sectors

Major Sector/Sector	(%)
Agriculture, Fishing and Forestry	**33**
Agricultural Extension, Research, and Other Support Activities	23
Irrigation and Drainage	10
Water, Sanitation and Waste Management	**67**
Sanitation	10
Public Administration - Water, Sanitation and Waste Management	57

Themes

Major Theme/ Theme (Level 2)/ Theme (Level 3)	(%)

Environment and Natural Resource Management	**99**
Environmental Health and Pollution Management	30
Air quality management	10
Water Pollution	10
Soil Pollution	10
Water Resource Management	69
Water Institutions, Policies and Reform	69

ADM STAFF

Role	At Approval	At ICR
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I. PROJECT CONTEXT AND DEVELOPMENT OBJECTIVES

A. CONTEXT AT APPRAISAL

Context

1. **At the time of appraisal of the Mainstreaming Integrated Water and Environment Management Project (P145897, the project), China faced severe water scarcity, especially in the northern part of the country.** The rapid growth of cities and industries had increased the demand for water in agriculture, industry and for domestic use. Water scarcity issues were particularly severe in the northern part of the country, such as the Hai, Huai, Liao, and Yellow River Basins, and were increasingly affected by droughts.[1] While northern China only had 19 percent of the country's water resources, it supported more than 65 percent of the national cultivated land and 50 percent of the national grain production.[2] Water scarcity also led to major groundwater overexploitation issues, including the formation of the world's largest of groundwater depression cone in the North China Plain.[3] Climate change exacerbated water scarcity, with historical precipitation reductions across much of northern China as well as an increased probability of extreme drought, placing additional strain on already overexploited groundwater and surface water resources.

2. **Water pollution further aggravated the water scarcity problem.** At appraisal, more than 97 percent of the monitored shallow groundwater sites in China were polluted and around one-third of monitored surface water failed to meet basic quality standards (Class I-III)[4] for drinking water.[5] This water quality degradation made water unsuitable for a variety of human uses, further exacerbating water scarcity. Moreover, increased water scarcity and the unsustainable use of water resources led to reduced downstream flows that dilute water pollutants. Water scarcity and pollution also contributed to serious environmental consequences, such as ecosystem degradation, ground subsidence, and saltwater intrusion. The Huai, Hai, Liao, and Yellow River Basins in northern China were the most polluted river basins in China at the time.[6] More than half of the areas in these basins faced both severe physical water scarcity and pollution-induced water scarcity throughout the year,[7] pointing to an urgent need for integrated water and environment management.

3. **For over two decades, the World Bank had supported China to develop evapotranspiration (ET)[8] management and integrated water and environment management (IWEM) approaches to address both water scarcity and pollution.** In water scarce areas, water management should not only focus on water withdrawal, but also pay attention to consumptive water use—the water is consumed and escapes river basin through evaporation and

[1] Northern China includes the North China Plain (Beijing and Tianjin municipalities, Hebei, Shanxi, and Inner Mongolia provinces), northeast China (Liaoning, Jilin, and Heilongjiang provinces), northwest China (Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang provinces), and part of Henan Province.
[2] Wang, J., Li, Y., Huang, J., Yan, T. and Sun, T. (2017). Growing water scarcity, food security and government responses in China, *Global Food Security*14, 9–17 (in Chinese).
[3] China Daily, Groundwater tapping out in North China. (*http://www.chinadaily.com.cn/china/2010-04/23/content_9768154.htm*)
[4] The Environmental Quality Standards for Surface Water (GB 3838-2002) have divided the surface water quality into five classes. Only the surface water with Class I-III quality can be used as drinking water sources.
[5] China Water Resources Bulletin (2016), Ministry of Water Resources *(http://www.mwr.gov.cn/sj/tjgb/szygb/201707/t20170711_955305.html*)
[6] China Ecology and Environment Bulletin (2016), Ministry of Ecology and Environment *(https://www.mee.gov.cn/hjzl/sthjzk/zghjzkgb/201706/P020170605833655914077.pdf*)
[7] Ma, T., Sun, S., Fu, G. et al. Pollution exacerbates China's water scarcity and its regional inequality. Nature Communication 11, 650 (2020). *(https://www.nature.com/articles/s41467-020-14532-5)*
[8] Evapotranspiration is a combined loss of water through evaporation and transpiration. Evaporation occurs when water changes into vapor from soil, water, land, and plant surfaces. Transpiration refers to the water loss through the stomates of plants. ET is actual water consumed in river basins, as water becomes vapor and escapes the river basins, which is no longer available for downstream users and the environment.

transpiration (i.e. ET), which cannot be reused by the downstream users and environment. Through the Tarim Basin II Project,[9] the Water Conservation Project,[10] and the Xinjiang Turpan Water Conservation Project,[11] the World Bank helped China to develop a water consumption management (i.e. ET management) approach, which aimed to save water by reducing water consumption. In 2004, the Global Environment Facility (GEF) provided a grant for the Hai Basin IWEM project[12] which supported the Ministry of Water Resources (MWR), the Ministry of Environmental Protection (MEP),[13] and related local governments and partner agencies, research institutes and universities to develop an IWEM approach. The maximum consumptive use of water (i.e. target ET) and the maximum allowed discharge of water pollution loads (i.e. target Environmental Carrying Capacity, or EC) were identified at both river basin and water user levels. With the support of the GEF grant, the World Bank worked with various counterparts in China to foster ET management and develop the IWEM approach to address the interconnections and trade-offs between water scarcity and pollution issues (annex 7) as well as inform government strategies and policies on water resources and pollution management and support the MWR and MEP to establish nationwide platforms for ET and pollution management.

4. **The Government of China (GoC) identified the World Bank Group as an important and unique partner to help address the water scarcity and pollution challenges.** Built upon the encouraging results of previous projects, the GoC requested the continuous supports from the Bank on IWEM to mainstream these innovative approaches in China, and to address the degradation issues of the Bohai Sea. Three large rivers flow into the Bohai Sea, including the Yellow, Hai and Liao Rivers which were the most water stressed and polluted rivers in China. Applying IWEM approach in the three large river basins could increase ecological flows and reduce water pollutants entering the Bohai Sea, contributing to the improvement of marine biodiversity and global environmental benefits (GEBs).

5. **This GEF project was designed to mainstreaming of IWEM approaches to address water scarcity and pollution issues.** This project was considered as the second phase of GEF project, which was built upon the IWEM approaches developed in the first phase GEF Hai Basin IWEM Project (P075035). The GEF grant was mainly used to support the key studies to further refine and develop the IWEM approaches, provide policy recommendations and operational manuals to guide the country to widely mainstream and apply the IWEM approaches, and support the MWR and MEP to establish nationwide platforms for ET and pollution management. Followed the lessons and recommendations from the GEF activities, the counterpart funds were leveraged to implement the IWEM approaches in the demonstration areas and in the major water scarce and polluted river basins connected to the Bohai Sea. The project also addressed the institutional collaboration issues to promote the collaboration between water resources and environmental sectors, by strengthening and deepening the collaboration between the MWR and MEP at the national level, promoting the joint work mechanism at the sub-national level, and enhancing the overall technical and operational supports.

6. **The project was well aligned with the World Bank's Country Partnership Strategy (CPS) (FY2013–2016), the country's priorities outlined in the 13th Five-Year Plan (FYP), (2016-2020), and the GEF international Waters Strategy.** The project supported key themes under the strategic theme of "*Supporting Greener Growth*" in the CPS (Report No. 67566-CN), including promoting sustainable agricultural practices, demonstrating pollution management, demonstrating sustainable natural resources management approaches, and strengthening mechanisms for managing climate change. The project also contributed to the cross-cutting theme in the CPS of "*Advancing Mutually Beneficial*

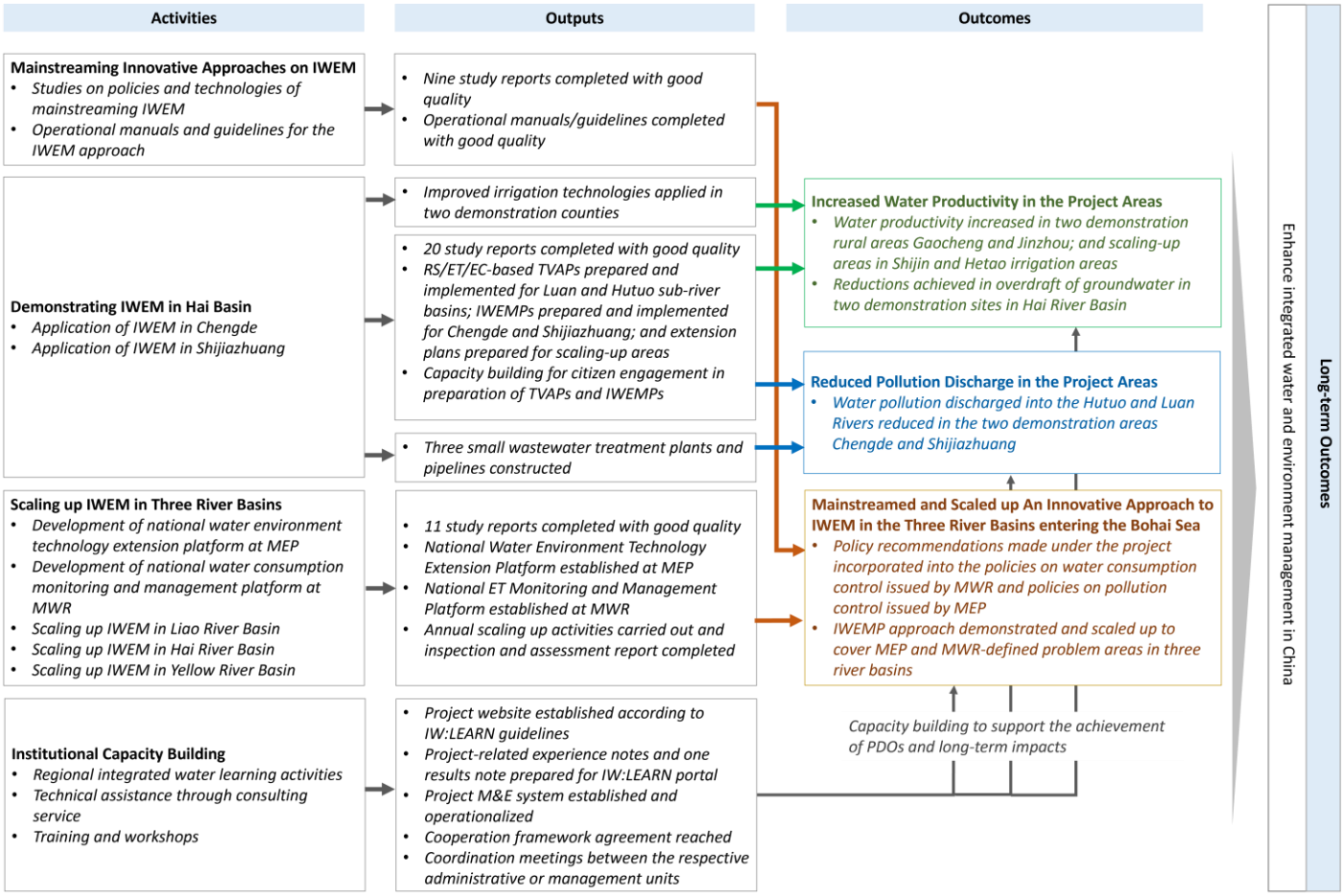
[9] Tarim Basin II Project (P046563, 1998-2004).
[10] Water Conservation Project (P056516, 2000-2006).
[11] Xinjiang Turfan Water Conservation Project (P111163, 2010-2017).
[12] Hai Basin Integrated Water and Environment Management Project (P075035, 2004-2011).
[13] During project implementation, in March 2018, China launched an institutional reform which reorganized MEP as the new Ministry of Ecology and Environment (MEE) (see paragraph 56).

Relations with the World" by supporting knowledge exchange to address water scarcity and pollution issues worldwide. The project was also closely aligned with the country's priorities highlighted in the national 13th FYP, including promoting water resources protection in river basins, strengthening water pollution management, effectively controlling the total amount and intensity of water consumption, promoting efficient utilization of water resources, improving water security, and enhancing sustainable agriculture development. The project supported the GEF-5 International Waters strategy[14] and its long-term goal of "*Promotion of collective management of transboundary water systems and implementation of the full range of policy, legal, and institutional reforms and investments contributing to sustainable use and maintenance of ecosystem services*."

Theory of Change (Results Chain)

7. Since there was no theory of change (ToC) in the Project Appraisal Document (PAD)[15], the ToC was derived from the description in the PAD and Results Framework (RF).

Figure 1. Theory of Change[16]



[14] GEF-5 Managing Document. [https://www.thegef.org/sites/default/files/council-meeting-documents/GEF_R5_31_CRP1.pdf]
[15] Report No: PAD1604.
[16] In the ToC, RS refers to remote sensing. EC refers to environmental carrying capacity. TVAP refers to targe value allocation plan.

Key assumptions
The water and environmental sectors would have joint decisions on ET and EC targets, which needs to be ensured by signing cooperation agreements. The cooperation agreements and institutional strengthening can promote cross-sectoral coordination to implement IWEM. The project entities have the capacity to adopt innovative techniques to mainstream the IWEM approaches.

Project Development Objectives (PDO)

8. The PDO as stated in the Grant Agreement and the PAD was "to increase water productivity and reduce pollution discharges in the project areas to mainstream and upscale an innovative approach to integrated water and environmental management in the three river basins entering the Bohai Sea."

Key Expected Outcomes and Outcome Indicators

9. The key expected outcomes were water productivity increased in the project areas, pollution discharges reduced in the project areas, and an innovative approach to IWEM mainstreamed and scaled up in the three river basins entering the Bohai Sea. The project had five key outcome indicators:

1) Policy Recommendations made under the project incorporated into the policies on water consumption control issued by MWR and policies on pollution control issued by MEP, respectively (measuring unit: the number of policies issued and implemented by MWR and by MEP);
2) Water pollution discharged into the Hutuo and Luan Rivers reduced in the two demonstration areas Chengde and Shijiazhuang (measuring unit: tons of COD, NH_3-N, TN, and TP per year);[17]
3) Water productivity increased in (a) two demonstration rural areas Gaocheng and Jinzhou; and (b) scaling-up areas in Shijin and Hetao irrigation areas (measuring unit: kg of grain production per m^3);
4) Reductions achieved in overdraft of groundwater in 2 demonstration sites in Hai River Basin (Gaocheng and Jinzhou) (measuring unit: million m^3 per year);
5) IWEMP approach demonstrated and scaled up to cover MEP and MWR-defined problem areas in 3 river basins (measuring unit: km^2).

Components

10. At appraisal, the project had four components.

11. **Component 1: Mainstreaming of Innovative Approach on Integrated Water and Environment Management** (*Estimated cost:* US$3.45 million, with GEF Grant of US$1.20 million and counterpart fund of US$2.25 million; *Actual cost*: US$4.35 million, with GEF Grant of US$1.17 million and counterpart fund of US$3.18 million). This component included: (a) Conducting studies on the application of policies and technologies on mainstreaming the IWEM approach, which would lead to the formulation of new and/or application of existing supporting policies and technologies; and (b) Preparing operational manuals and guidelines for the IWEM approach.

12. **Component 2: Demonstration in Hai Basin on the Integrated Water and Environment Management Approach** (*Estimated cost:* US$90.10 million, with GEF Grant of US$2.80 million and counterpart fund of US$87.30 million; *Actual cost*: US$110.75 million, with GEF Grant of US$2.99 million and counterpart fund of US$107.76 million). This component supported the preparation and implementation of Target Value Allocation Plans (TVAPs) in two sub-river basins (Luan and Hutuo) with the consideration of climate change impacts. It also supported the preparation and

[17] Chemical Oxygen Demand (COD); Ammonia Nitrogen (NH_3-N); Total Nitrogen (TN); Total Phosphorus (TP).

implementation of IWEMPs in two demonstration city areas—Chengde (water pollution dominant area) and Shijiazhuang (water overuse dominant area) in the Hai River Basin.

13. **Component 3: Scaling up the Integrated Water and Environment Management Approach in Three River Basins** (*Estimated cost:* US$7.30 million, with GEF Grant of US$3.60 million and counterpart fund of US$3.70 million; *Actual cost*: US$5.14 million, with GEF Grant of US$3.41 million and counterpart fund of US$1.73 million). This component scaled up the ET/EC-based IWEM approach with innovative technologies and policy interventions in additional areas in the Liao, Hai, and Yellow River Basins and developed two national platforms, with accompanying databases, to monitor actual ET and EC values: (i) a National Water Environment Technology Extension Platform at MEP and (ii) a National Water Consumption Monitoring and Management Platform at MWR.

14. **Component 4: Institutional Capacity Building and Project Management** (*Estimated cost:* US$3.65 million, with GEF Grant of US$1.90 million and counterpart fund of US$1.75 million; *Actual cost*: US$2.00 million, with GEF Grant of US$1.93 million and counterpart fund of US$0.07 million). This component strengthened the capacity of the central and local governments to support IWEM through technical assistance and training, workshops, and regional learning activities such as study tours. This component also supported project management and monitoring and evaluation.

B. SIGNIFICANT CHANGES DURING IMPLEMENTATION

15. The project was not restructured.

II. OUTCOME

A. RELEVANCE OF PDOs

Assessment of Relevance of PDOs and Rating

Rating: High

16. **The PDOs were closely aligned with the current World Bank Country Partnership Framework (CPF) (FY2020–2025) at project closure.** This project directly supported the key engagement area of "Promoting Greener Development" in the CPF (Report No. 117875-CN) by reducing water pollution, demonstrating sustainable agricultural practices, and strengthening sustainable natural resources management. The project also directly addressed the institutional constraints identified in the CPF by enhancing the capacity to monitor, share, and report adequate environmental data as well as promoting data transparency, establishing and deepening coordination mechanism for water and pollution management, and providing policy recommendations on water governance issues. The project also supported the CPF's cross-cutting theme of 'Cooperating on Global Knowledge and Development' by promoting knowledge exchange in addressing the world's water scarcity, pollution, and ecosystem degradation challenges.

17. **The PDOs continued to be well aligned with China's national priorities at project closure, as articulated in the 14th FYP (2021–2025) and the Long-term Vision for 2035.** China's 14th FYP and Long-term Vision for 2035, announced in 2021,[18] both set water and environment management as top national priorities. The 14th FYP highlighted the needs of promoting IWEM in the key river basins, strengthening agricultural water saving and increasing water productivity,

[18] National Development and Reform Commission. 14th Five-Year Plan and the Long-term Vision for 2035. (*https://www.ndrc.gov.cn/xxgk/zcfb/ghwb/202103/t20210323_1270124_ext.html*)

enhancing the efficiency of water use, promoting market-based water rights trading, and establishing the policy system for green development.

18. **The PDOs also supported the national Yellow River Basin Ecological Protection and High-Quality Development Plan and the World Bank's latest engagement in the Yellow River Basin.** The project mainstreamed the ET/EC-based IWEM approach with innovative technologies and policy interventions in the Yellow River Basin. These interventions were well aligned with China's latest national Yellow River Basin Ecological Protection and High-Quality Development Plan announced in 2019[19] and the detailed Master Plan for this national strategy issued in 2021.[20] The Master Plan highlighted the need to control total water consumption, which was the key principle of ET management mainstreamed by this project. The Master Plan also called for the integration of water pollution management with water saving and water resources allocation, which was well aligned with the IWEM approaches scaled up in this project. The IWEM approaches developed under this project provided solutions for the government to tackle the trade-offs among water scarcity, pollution control, ecosystem restoration, and social and economic development. Furthermore, the World Bank recently approved a new Program-for-Results (PforR) operation[21] to support the national Yellow River Basin management strategy, which embedded the IWEM approaches demonstrated in this project into its design (see paragraph 50).

19. **The PDO was well aligned with both the country's and World Bank's priorities on climate adaptation and mitigation and contributed to the global environmental benefits (GEBs).** The project explored the IWEM approaches under climate change impacts. The PDO supported China's ambitious commitments on climate change articulated in its Nationally Determined Contribution by monitoring and reducing greenhouse gas (GHG) emissions from agriculture through better water and fertilizer management. The impacts of climate change on water resources and environment management were also considered in the preparation of TVAPs and IWEMPs (see Section II. B). The PDO was well aligned with the World Bank's priorities articulated in the Green, Resilient, and Inclusive Development (GRID) framework and the Climate Change Action Plan 2021-2025.[22] In addition, the project mainstreamed the IWEM approach in the three large river basins to reduce water pollution entering the Bohai Sea, which contributed to the GEBs of marine ecosystem sustainable development. The project was continuously aligned with the GEF-8 International Waters strategy,[23] which continued to emphasize the priorities of IWRM implementation, increased water efficiency and reduced pollution.

20. **The relevance of the PDO is rated High,** considering its close alignment with the current World Bank CPF objectives, the country's development priorities, the priorities on climate adaptation and mitigation, and the contributions to the GEBs.

[19] Keynote speech by President Xi Jinping on September 18, 2019, at the symposium on ecological protection and high-quality development in the Yellow River Basin.
[20] Yellow River Basin Ecological Protection and High-Quality Development Master Plan. (*https://www.mee.gov.cn/zcwj/zyygwj/202110/t20211009_955779.shtml*)
[21] Yellow River Basin Ecological Protection and Environmental Pollution Control Program (P172806), approved in March 2022.
[22] Alignment with GRID and the Climate Change Action Plan 2021–2025 is seen in the project's focus on environmental sustainability objectives while increasing resilience to climate change threats and mitigating emissions.
[23] GEF-8 Managing Document. [https://www.thegef.org/sites/default/files/documents/2022-04/GEF_R.08_29_Rev.01_GEF8_Programming_Directions.pdf]

B. ACHIEVEMENT OF PDO (EFFICACY)

Assessment of Efficacy
Rating: High

Assessment of Achievement of Each Objective/Outcome

21. **The assessment of PDO achievement was unpacked into three outcomes:** i) 'to increase water productivity in the project areas'; ii) 'to reduce pollution discharges in the project areas'; and iii) 'to mainstream and upscale an innovative approach to integrated water and environmental management in the three river basins entering the Bohai Sea'. All three outcomes were fully achieved, and all PDO-level and intermediate indicators were fully achieved or exceeded by project closure.

Outcome 1—To increase water productivity in the project areas

22. **The project increased water productivity and reduced groundwater overdraft in the project areas, fully achieving the two PDO indicators and one intermediate indicator measuring the achievement of this outcome (table 1).** Water productivity increased with improved engineering and agronomic practices (e.g. irrigation, precise fertilizer application) and institutional strengthening through comprehensive training and piloting innovative practices such as ET-based water rights trading. Improved irrigation technologies were widely applied in the demonstration counties through 19 sub-projects financed with counterpart funds. 17,938 hectares of the irrigated areas were equipped with improved irrigation technologies, exceeding the target of 13,300 hectares (Indicator I-8). This included modern irrigation techniques, such as drip irrigation and low-pressure irrigation systems, along with the lining of canals and improvement of water control and measuring facilities. The project also supported some farmers with cropping pattern adjustment to switch from high water consumption and low value crops (such as winter wheat) to low water consumption and high value crops (such as oilseed) to save water and increase their income. As a result,[24] the water productivity in the two demonstration rural areas (Indicator O-3)—Gaocheng and Jinzhou—was increased from 1.10 kg/m^3 to 1.94 kg/m^3 (Gaocheng) and 1.76 kg/m^3 (Jinzhou), respectively, exceeding the target of 1.26 kg/m^3. Similarly, the water productivities in the scaling-up areas in Shijin and Hetao irrigation areas were increased from 1.10 kg/m^3 to 1.79 kg/m^3, from 1.19 kg/m^3 to 2.29 kg/m^3, respectively, exceeding the target of 1.26 kg/m^3 and 1.29 kg/m^3, respectively. With the irrigation system modernization, groundwater overdraft was reduced with the reduction of agricultural water consumption, and some areas switching from groundwater irrigation to surface water irrigation. Guided by the ET-based groundwater management approach developed under the project (see paragraph 23), groundwater overdraft in Gaocheng and Jinzhou in Hai River Basin was reduced by 192.38 million m^3/year,[25] exceeding the target of 72.93 million m^3/year (Indicator O-4). The reduction of groundwater overdraft also led to other benefits, such as energy saving from water pumping estimated at RMB 2.48 million (US$390,000) per year in the demonstration sites.

[24] Water productivity was defined as kilograms of grain production per cubic meters of water consumption. In this project, water consumption was monitored by remote sensing technique, while grain production were the local data from agricultural department. The water productivity was estimated by the third-party consulting firm based on these data.
[25] The reduction of groundwater overdraft was estimated by the third-party consulting firm, using annual groundwater use data from local water departments.

23. **The GEF grant was used to support several studies** that monitored the water consumption, crop yield, and GHG emissions under different irrigation schemes, recommended the most suitable agricultural water management practices for the local conditions, and prepared the irrigation monitoring and management plans for Water User Associations (WUAs). The studies also provided the basis for a comprehensive training program for farmers to better manage water to reduce overall water consumption and increase yields. For example, in the groundwater overdraft areas, the project trained famers to switch to more drought resistant crops, improve tilling practices to better utilize precipitation and soil moisture, apply regulated deficit irrigation, and better utilize agricultural mulching. A groundwater management tool was developed for selected areas in Hebei Province, with the support of a 3-D groundwater model developed under the project. The tool can predict groundwater withdrawal under various cropping patterns and climate conditions. The studies built on the monitoring and model simulation and developed the approaches to identify agricultural water consumption and critical groundwater level management targets. The project then developed the manual on the ET-based groundwater management approach. A Five-Year Action Plan on integrated groundwater management (2018-2022) was developed and implemented, including actions to adjust cropping patterns, promote water-saving irrigation techniques, and enhance water saving from domestic and industrial sectors, contributing to both the water productivity increase and groundwater overdraft reduction.

Table 1. Achievement of Outcome 1[26]

Indicators		Baseline	Target	Actual Achievement	% Achievement of Target
PDO Indicators					
O-3. Water productivity increased in (a) two demonstration rural areas Gaocheng and Jinzhou; and (b) scaling-up areas in Shijin and Hetao irrigation areas (measuring unit: kg of grain production per m^3)	Demonstration Areas (Gaocheng and Jinzhou)	1.10	1.26	1.94 (Gaocheng) 1.76 (Jinzhou)	154 (Gaocheng) 140 (Jinzhou)
	Shijin	1.10	1.26	1.79	142
	Hetao	1.19	1.29	2.29	178
O-4. Reductions achieved in overdraft of groundwater in two demonstration sites in Hai River Basin (Gaocheng and Jinzhou) (measuring unit: million m^3 per year)		0	72.93	192.38	264
Intermediate Indicators					
I-8. Improved irrigation technologies applied in two demonstration counties in Shijiazhuang municipal city (measuring unit: the number of hectares of irrigated areas applied with improved irrigation technologies)		2,660	13,300	17,938	135

24. **Managed Aquifer Recharge (MAR) was piloted to better address groundwater overdraft issues.** MAR, also called groundwater replenishment, is the purposeful recharge of water to aquifers[27] for subsequent recovery or for environmental benefit. Supported by the GEF grant and supervised by the Hebei Provincial Water Resources Department, a MAR test was piloted to recharge the overexploited aquifer. Hydrogeological investigation was conducted to identify the suitable areas for MAR. A series of monitoring wells and equipment were installed to monitor water levels and water quality. Multiple surface and underground recharge techniques were tested, including the recharge through river, infiltration ponds and injection wells. The recharge efficiency, cost and benefits were compared

[26] As each component has the same indicator "All study reports prepared and completed as planned with good quality" with different target and implications, this ICR labelled the indicators in the RF according to the PAD labeling. "O-#" means the PDO (outcome) indicator number # (the number # is the same as the # in the PAD RF). "I-#" means the intermediate indicator number #.

[27] An aquifer is an underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials that saturated with groundwater. Aquifer can yield a usable amount of groundwater to wells.

for different recharge techniques. The MAR pilot laid the foundation for future aquifer recharge to recover the overexploited aquifers.

25. Another four intermediate indicators measured both the achievement of the first and second outcomes of increasing water productivity and reducing pollution discharge, as the water scarcity and water pollution issues were addressed in an integrated manner through the IWEM approaches. The achievements of those intermediate indicators are included in table 3 and are discussed further in this section.

Outcome 2—To reduce pollution discharges in the project areas

26. **Through the application of the IWEM approaches, the project reduced pollution discharge in the project areas, fully achieving one directly relevant PDO indicator and one intermediate indicator (table 2).** The IWEMPs and TVAPs prepared and implemented in the demonstration areas (see paragraph 31) helped identify the maximum allowed water pollution discharge and a series of water pollution reduction measures, including agricultural non-point source pollution control and point source pollution management, which were carried out. Market-based approaches, such as pollution emission trading, were also piloted in the demonstration areas to provide incentives to further reduce pollution (see paragraph 32). As a result, the project had reduced 9,162.0 tons of COD, 929.4 tons of NH_3-N, and 1,402.8 tons of TN and 123.8 tons of TP discharged into the Hutuo and Luan Rivers every year, exceeding the targets of indicator O-2.

27. **Three wastewater treatment plants (WWTP) and 72 kilometers of sewage pipelines were constructed and upgraded with counterpart funds.** Weichang WWTP was upgraded to increase its treatment capacity from 250,000 tons/day to 500,000 tons/day. Luanping's second WWTP was newly constructed with a capacity of 600,000 tons/day. Xinlong's second WWTP was newly constructed with a current treatment capacity of 200,000 tons/day and long-term capacity of 350,000 tons/day. These WWTPs reduced the pollution of nitrogen by 2,582.8 tons (Indicator I-7).[28] The indicator values were calculated using the WWTP monitoring data. However, as China only required the WWTPs to measure total phosphorous starting in 2019, the cumulative phosphorous reduction of 250.5 tons only included the reduction from 2019 to 2021. In addition, as China does not require the WWTPs at the county level to measure BOD, the results on BOD reduction are not available. Since the achievements of O-2 include the achievements of I-7 (see footnote 28), and with the measurement and monitoring issues discussed above, this report assesses the achievements of the PDO indicator O-2, rather than indicator I-7.

28. **The water quality monitoring network was further strengthened with advanced techniques.** Supported by the GEF grant, remote sensing techniques were developed to monitor non-point source pollution from agricultural sector (see paragraph 30). The in-situ monitoring was also improved. The Ministry of Ecology and Environment (MEE)[29] and local water and environmental agencies worked together to optimize the location and monitoring parameters of the cross-sections for water quality monitoring, consolidate the various monitoring standards to ensure data reliability

[28] This indicator actually shows the cumulative pollutant reduction, rather than the annual pollutant reduction. When comparing the targets of intermediate indicator I-7 and the PDO indicator O-2, it was discovered that indicator I-7 had an incorrect unit measure. As PDO indicator O-2 measured the pollutant reduction with a wider area and broader interventions, including the contributions of WWTPs, the achievements of O-2 should include the achievements of I-7. However, the targets of I-7 are much higher than the targets of O-2, in terms of annual nitrogen reduction and phosphorous reduction. After discussions with the clients, task team, PMOs and M&E consultants, it was confirmed that I-7 was actually understood to measure the cumulative pollutant reduction from 2017 to 2021 (measured in "tons"), rather than the annual pollutant reduction ("tons per year").

[29] In 2018, China carried out institutional reform and the Ministry of Ecology and Environment (MEE), formerly the Ministry of Environment Protection (MEP), was established with a broader mandate on managing China's air, water, and land pollution issues.

and consistency, and improve the monitoring capacity with some real-time monitoring facilities. The combination of remote sensing and in-situ monitoring network had improved the local capacity on monitoring and responding to water pollution issues. The related research reports and guidelines on water quality monitoring were prepared.

Table 2. Achievement of Outcome 2: Reduced pollution discharge

Indicators		Baseline	Target	Actual Achievement	% Achievement of Target
PDO Indicators					
O-2. Water pollution discharged into the Hutuo and Luan Rivers reduced in the two demonstration areas Chengde and Shijiazhuang (measuring unit: tons of COD, NH_3-N, TN, and TP per year).	COD	0	8,074	9,162.0	113
	NH_3-N	0	547	929.4	170
	TN	0	670	1,402.8	209
	TP	0	85	123.8	146
Intermediate Indicators					
I-7. Construction of the 3 small wastewater treatment plants and pipelines, two in Chengde county and one in Kuancheng county with good quality in demonstration areas as planned (measuring unit: municipal wastewater pollution reduction—N, P & BOD (tons per year).[30]	N	0	2,136	2,582.8	/
	P	0	303.6	250.5	/
	BOD	0	2,796	/	/

29. **In addition, the project achieved another four intermediate indicators that supported the achievement of both PDO outcomes, which were fully achieved or exceeded (table 3).** The project prepared 32 reports on IWEM in the demonstration areas (Indicator I-3, annex 6), using a combination of remote sensing techniques[31] and water quality modelling**.** Building on these studies, the project: (i) prepared the IWEMPs and TVAPs to guide the overall IWEM, (ii) demonstrated the integrated approaches for water productivity improvement, groundwater management and water pollution management, (iii) prepared ET-based water balance/water accounting and auditing manual and technical guideline; (iv) promoted market-based approaches for IWEM, (v) enhanced water consumption and water pollution monitoring with advanced techniques, and (vi) supported training and capacity building. First, detailed water balance assessments were carried out for the two demonstration areas to analyze the water consumption that could be reduced by improved agricultural water management, advanced industrial technology, and the adjustment of cropping patterns and industrial development patterns. The studies identified the cap on total water consumption (ET target) based on historical water balance assessments and the projection and optimization of future development, estimated the maximum water pollutant discharge loads under certain flow conditions and water quality targets (EC target), and defined the target ecosystem services (ES) as the needs of environmental water for terrestrial and aquatic ecosystems (ES target). The water resources allocation considered the trade-offs among ET, EC and ES as water scarcity, pollution, and ecosystem degradation issues are interconnected (paragraph 33). Then, through an iterative process, water resources were allocated to define the targets for ET, EC, and ES, which formed the TVAPs. Based on the TVAPs, the IWEMPs were prepared with specific actions on water consumption reduction, water pollution reduction and ecosystem protection and restoration to achieve the targets identified in the TVAPs. The impacts of climate change were also incorporated in the IWEMPs. Eight reports were prepared for the TVAPs and IWEMPs (Indicator I-4) addressing the critical issues of IWEM.

[30] See footnote 288.

[31] Various sources of remote sensing data, such as the data from MODIS, Sentinel, GF-1 and Landsat, were applied to generate ET data with different resolutions.

30. **As mentioned earlier, remote sensing techniques were applied and demonstrated to monitor water consumption and water pollution and to conduct water accounting and auditing**. Supported by the GEF grant, a remote sensing-based ET monitoring technique was introduced and applied to measure the actual water consumption in the project areas. Various sources of remote sensing data, such as the data from MODIS, Sentinel, GF-1 and Landsat, were applied to generate ET data with different resolutions. In addition, the project carried out studies to prepare an ET-based water balance/water accounting and auditing manual and technical guideline, which were applied in the project areas to better monitor and manage water consumption. Remote sensing was combined with the water quality model to monitor and simulate non-point source pollution, including the spatial distribution of TN, TP, NH_3-N, and COD. Since the remote sensing monitoring techniques were demonstrated to be accurate, efficient, and low cost, they were further scaled up in the national monitoring platforms (see paragraph 34).

31. **The IWEMP and TVAP preparation and implementation were done with active citizen engagement and women's participation**. Citizen engagement was widely carried out in rural and urban areas. In rural areas, workshops, stakeholder consultations and trainings were conducted to introduce the concept of "real water saving" in ET management. Experts and farmers worked together to analyze the challenges to adopt ET management and laid down the key actions and roadmaps to reduce water consumption. In urban areas, information, education, and communication (IEC) activities were conducted to introduce water saving techniques in daily life. A series of surveys was carried out to study the water use in agricultural, industrial, and domestic sectors. A total of 22 consultations and capacity building events were carried out (Indicator I-5), with participation by 7,577 farmers, including 3,800 women, accounting for 50.2 percent of participants (Indicator I-6).

Table 3. Achievement of Integrated Intermediate Indicators for Outcomes 1 and 2

Indicators	Baseline	Target	Actual Achievement	% Achievement of Target
Intermediate Indicators				
I-3. All study reports prepared and completed as planned with good quality (measuring unit: number of study reports prepared, revised, and completed with good quality)	0	20	32	160
I-4. RS/ET/EC-based TVAPs prepared and implemented with good quality for Luan sub-river basin and Hutuo sub-river basin respectively, and the IWEMPs prepared and implemented for Chengde Municipal City and Shijiazhuang Municipal City and extension plans prepared for scaling-up areas, respectively (measuring unit: TVAP IWEMP and extension plan prepared, revised, and completed with good quality and implemented with good results)	0	8	8	100
I-5. Capacity building for citizen engagement in preparation of TVAPs and IWEMPs - Channels are institutionalized for citizens to engage with government agencies and other stakeholders (measuring unit: number of consultation activities)	0	8	22	275
I-6. Women participation to increase water productivity and reduce water pollution through WUAs during IWEMP implementation (measuring unit: increased percentage of female membership in the WUAs)	30	50	50	100

32. **The project promoted and piloted market-based approaches, such as water right trading and pollution emission trading.** The government-administered water allocation systems usually delay in response to the rapidly

changing water demands in different sectors. The government managed systems also often fail to provide adequate incentives for water users to use water efficiently. Therefore, supported by the GEF grant, water right trading, or water market, was piloted in Ancheng county and Yuanshi county in Hebei Province to provide a market-based mechanism to reallocate water resources. Water rights were reassessed based on historical water consumption. In order to sell their saved consumption-based (i.e. ET-based) water rights, farmers had the incentives to increase water use efficiency and reduce overall water consumption. Similarly, water pollution can be managed by government administration and/or market mechanism. Water quality trading can provide incentives for further reducing the emissions of pollutants. Thus, the project also tested and promoted water quality trading in Chengde city with the support of the GEF grant. The pilot identified the cap of maximum pollutant discharge, and established a cap-trade system for Chengde city. The pollution emission entities were encouraged to explore new techniques to economically lower their pollution discharges, enabling them to sell their excess reductions to other entities. A successful trading case was completed for the thermal power station in Chengde city. Water right trading and pollution emission trading worked along with the government's water and environmental regulation to provide incentives to the stakeholders to further increase water use efficiency, reduce overall water consumption, and improve water quality. In addition, the project also leveraged other economic instruments to promote IWEM, including agricultural water tariff reform to incentivize water saving, and the Public-Private Partnership (PPP) to better improve environment (see paragraph 48).

Outcome 3—To mainstream and upscale an innovative approach to integrated water and environmental management in the three river basins entering the Bohai Sea

33. **The project mainstreamed and upscaled IWEM in the three river basins entering the Bohai Sea, fully achieving outcome 3 and the two PDO indicators and six intermediate indicators directly measuring its achievement (table 4).** This included the completion of nine policy reports (Indicator I-1, annex 6), an IWEM technical guideline and other operational manuals and guidelines (Indicator I-2), and 12 studies for scaling up IWEM approaches in the three river basins. The policy reports provided policy recommendations on: i) the improvement of point source pollution emission permit system and the market-based pollution emission trading; ii) the assessment and control of comprehensive toxicity in water bodies; iii) the allocation and trading of water rights based on water consumption; and iv) the establishment of local water service delivery system. These policy recommendations presented innovative and key IWEM approaches, such as market-based IWEM approaches, which were further incorporated into the policies issued by the government (see paragraph 37). The IWEM technical guideline expanded the ET-EC based IWEM approaches to the ET-EC-ES based approaches, given northern China's severe ecosystem degradation issues linked with water scarcity and pollution, including sustaining water resources for downstream biodiversity and groundwater dependent ecosystems. Streamflow reduction has the effect of concentrating the significant pollution loads, increasing pressure on water pollution and exposing ecosystems to risks of both water scarcity and pollution. Ecosystem restoration interventions, especially afforestation, may also increase water consumption and reduce streamflow and groundwater recharge. Therefore, the IWEM technical guideline summarized the lessons learned from the domestic and international IWEM experiences, and expanded the ET-EC based IWEM approaches to the ET-EC-ES based approaches.[32] The guideline provided detailed technical guidance on mainstreaming IWEM approaches, such as afforestation, on a large scale. Other operational manuals/guidelines were also developed to provide guidance on applying some innovative techniques, such as remote sensing based non-point source pollution monitoring, ET-based water accounting and auditing, ET-based groundwater management, and toxicity indicator development. Along with the IWEM technical guideline, there were five operational manuals/guidelines completed under this project, fully achieving the target (Indicator I-2). Finally, 12 studies were completed to scale up the IWEM approaches in the three river basins (Indicator I-9, annex 6). These studies

[32] "ET" is Evapotranspiration, referring to water consumption; "EC" is Environmental Carrying Capacity, referring to the maximum allowed pollution load of a certain water body; "ES" is Ecosystem Services, referring to the basic service provided by ecosystems.

supported the development of the national geographic information system (GIS) platform for EC-based river basin management, the Integrated, Intelligent and International Platform for Environmental Technology (3iPET), remote sensing-based ET monitoring and groundwater use assessment, the 3-D groundwater model, and total phosphorous assessment and control. They also supported the development of the national water environmental technology extension platform and the nation ET monitoring and management platform.

34. **With GEF support, the project also established a National Water Environment Technology Extension (WETE) Platform at MEE and a National ET Monitoring and Management Platform at MWR.** The WETE Platform can calculate the EC values for water quality management units and integrate the monitoring data on actual water pollution discharges at key river cross-sections to estimate water pollution risk and propose responding actions. The platform integrated the environmental and ecosystem monitoring data to form a "One-Map" system to display and assess the local environmental and ecosystem status, with the support of the environment sensitivity assessment and environmental carrying capacity assessment models. It can also identify spatial environmental issues, such as illegal construction within the buffer zones of nature reserves and critical wetlands, and suitable wastewater treatment techniques for key polluting industries, such as plating, coking, tanning and fur processing. Based on the national technical standards and expert consultations, the platform can help the key polluting industries to select suitable wastewater treatment techniques. The platform was established under the MEE (Indicator I-10)**.**

35. **The ET Monitoring and Management Platform supports ET management in agricultural sector.** It integrated remote sensing-based ET management, groundwater use monitoring and assessment, actual irrigated area monitoring and assessment, and other meteorological and hydrological data such as irrigation water fee collection and precipitation. The platform can analyze the reduction of water consumption, integrated water resources management, and groundwater use for each national irrigation district. This platform provides interactive information and assessments on water consumption, water use efficiency, water productivity, and the water balance for irrigation at the district level. The platform was established under the MWR to provide critical information for ET management (Indicator I-11).

Table 4. Achievement of Outcome 3: Mainstream and upscale IWEM in the three river basins entering the Bohai Sea

Indicators		Baseline	Target	Actual Achievement	% Achievement of Target
PDO Indicators					
O-1. Policy Recommendations made under the project incorporated into the policies on water consumption control issued by MWR and policies on pollution control issued by MEP, respectively (measuring unit: the number of policies issued and implemented by MWR and MEP).	MWR	0	2	4	200
	MEP	0	2	3	150
O-5. IWEMP approach demonstrated and scaled up to cover MEP and MWR-defined problem areas in 3 river basins (measuring unit: km^2)	MWR	4,278.4	28,420	29,810.4	105
	MEP	0	125,380	152,701.8	122
Intermediate Indicators					
I-1. All study reports prepared and completed as planned with good quality (measuring unit: the number of study reports prepared, revised, and completed with good quality)		0	9	9	100
I-2. Operational manuals/guidelines completed and accepted with good quality (measuring unit: the number of operational manuals		0	5	5	100

prepared, revised, and completed with good quality)					
I-9. All study reports prepared and completed as planned with good quality (measuring unit: the number of study report prepared, revised and completed with good quality)		0	11	12	109
I-10. National Water Environment Technology Extension Platform established at the MEP (measuring unit: percentage of software development and study progress completed with good quality)		0	100	100	100
I-11. National ET Monitoring and Management Platform established at the MWR (measuring unit: percentage of software development and study progress completed with good quality)		0	100	100	100
I-12. Annual scaling-up activities carried out and inspection and assessment reports prepared and completed for the scaling-up areas (measuring unit: the number of inspection and assessment reports prepared with actions recommended for improvements)	MWR	0	6	6	100
	MEP	0	6	6	100

36. **Based on the experiences from the pilots and the related studies and techniques, the IWEM approaches were scaled up in the Liao, Hai, and Yellow River Basins entering the Bohai Sea.** The MWR and MEP identified areas with water scarcity and pollution issues in the three river basins, covering 35 percent of the three river basins. In the Liao River Basin, IWEM approaches were scaled up in Shenyang, Anshan, Panjin, and Fushun cities, with a focus on reducing water consumption to increase streamflow and improve water quality. In the Hai River Basin, IWEM approaches were scaled up in Xingtai, Tangshan, and Langfang cities as well as the Shijin irrigation district, with a focus on reducing water consumption from agriculture and improving water use efficiency to reduce groundwater overuse and increase ecological flow. In the Yellow River Basin, IWEM approaches were scaled up in Inner Mongolia, with a focus on adjusting cropping patterns and improving agronomic and irrigation practices to reduce total water consumption and improve soil salinity. A total of 12 inspection and assessment reports were prepared to monitor and assess project implementation in these three basins, fully achieving the target (Indicator I-12). IWEM approaches were scaled up over 182,512.2 km^2, including 29,810.4 km^2 identified by MWR and 152,701.8 km^2 identified by MEP, exceeding the targets (Indicator O-5).

37. **The lessons learned and policy recommendations made under the project were incorporated into policies issued by the national and provincial governments (O-1).** This included incorporating suggestions related to point source pollution, IWEMPs and TVAPs, ET management, groundwater overdraft management, water rights trading, and local water service development into the following: (i) Pollution emission permit management (trial) (2018),[33] Regulation on pollution emission permit management (2021),[34] Working mechanisms for identifying water ecological and environmental problems (2021), Opinions on Yellow River Basin water saving (2021),[35] Groundwater management regulation (2021),[36] Options on payment for water resources utilization (2018),[37] and Opinions on deepening irrigation reform' (2018).[38] The findings and suggestions stemming from this project were also adopted by provincial policies and

[33] MEE, Pollution emission permit management (trail), 2018. [http://www.gov.cn/gongbao/content/2018/content_5288829.htm]
[34] State Council, Regulation on pollution emission permit management, 2021. [http://www.gov.cn/zhengce/content/2021-01/29/content_5583525.htm]
[35] MWR, Opinions on Yellow River Basin water saving, 2021. [http://www.gov.cn/gongbao/content/2021/content_5651741.htm]
[36] State Council, Groundwater management regulation, 2021. [http://www.gov.cn/zhengce/content/2021-11/09/content_5649924.htm]
[37] MWR, NDRC, MOF, Options on payment for water resources utilization, 2018. [http://qgjsb.mwr.gov.cn/zcfg/bmgzjgzxwj/201810/t20181019_1053117.html]
[38] MWR, Opinions on deepening irrigation reform, 2018. [http://www.mwr.gov.cn/xw/slyw/201802/t20180228_1031603.html]

regulations, such as the Regulations on water pollution prevention and control for Hebei Province (2018), Regulations on water saving for Hebei Province (2021), and Regulations on groundwater management for Hebei Province (2018).

38. **The enhanced institutional capacity and improved project management supported the project to achieve its PDO and long-term outcomes.** Although the institutional capacity building and project management did not directly contribute to the achievement of the PDOs, these activities paved the ground to ensure smooth implementation and to support the project to achieve its objectives. All six intermediate indicators on capacity building and project management were fully achieved or exceeded (table 5), and the related discussions were included in the sections of Institutional Strengthening (Section II. E), key factors during implementation (Section III.B) and M&E (Section IV. A).

Table 5. Achievement of Intermediate Indicators for Institutional Capacity Building and Project Management

Indicators	Baseline	Target	Actual Achievement	% Achievement of Target
Intermediate Indicators				
I-13. Establishment of project website according to IW: LEARN guidelines: (measuring unit: functioning website)	0	1	1[39]	100
I-14. Preparation of project-related experience notes (2) and one results note (1) for IW: LEARN portal: (measuring unit: completed documents)	0	3	4	133
I-15. Establish and made it operational the project monitoring and evaluation (M&E) system: (measuring unit: functioning M&E system capable to generate semi-annual M&E reports).	1	10	11	110
I-16. Female staff and specialists participation in the project workshops, study tours and training at the central, provincial, municipal, and county levels (measuring unit: increased percentage of female staff and specialists of the total number)	30	40	45.4	114
I-17. Cooperation Framework Agreement reached to facilitate the development and implementation of TVAP/IWEMP between the respective administrative units responsible for environment and water at the central, provincial and municipal levels, respectively (measuring unit: the number of signed agreements)	0	5	5	100
I-18. Coordination meetings between the respective administrative or management units to support the implementation of the framework agreements at the three levels on an annual basis (measuring unit: the number of meetings held and minutes prepared and completed with decisions and actions recommended for problem resolution)	4	24	70	292

Utilization of GEF and Counterpart Funding

39. **The GEF grant was mainly used to support the innovative studies and pilots, while the counterpart funding was leveraged to implement IWEM.** The US$9.5 million GEF grant supported the innovative studies on IWEM approaches, application of advanced techniques of remote sensing and MAR, piloting of market-based policies on water rights trading and pollution emissions trading, development of national level ET and pollution management platforms, and the

[39] Project website: *http://www.3ipet.cn/mainstream_file/intro_cn.html*

preparation of related technical guidelines and policy reports. The lessons learned from these GEF supported activities were used to guide the implementation of the IWEM approach supported by the counterpart funds, such as irrigation technique improvement, cropping pattern adjustment, groundwater protection and restoration, and WWTP construction. Through the GEF activities, the central and local governments embraced the new IWEM approaches to address water scarcity, pollution, and ecosystem degradation issues in an integrated manner. The project successfully leveraged around US$113 million in counterpart funds, which mainstreamed and dramatically scaled up IWEM in China.

Justification of Overall Efficacy Rating

40. **The overall efficacy is rated High,** considering that all three outcomes were fully achieved. The project had demonstrated a significant water productivity improvements and pollution discharges reduction in the project areas, mainstreamed the approached in three river basins, and contributed to national policies and regulations. The IWEM approach was expanded during implementation to incorporate ecosystem protection and restoration, was further applied to support the new national strategy for the sustainable development of the Yellow River Basin.

C. EFFICIENCY

Assessment of Efficiency

Rating: High

41. **Economic Analysis:** Following the approach adopted at appraisal, a cost-benefit analysis was conducted, mainly for the demonstration of IWEM water activities implemented under Component 2, including the reduction of groundwater overdraft. The quantifiable benefits from the reduced groundwater overdraft included: (a) economic values of saved water, which can be alternatively used for industry and urban development. (b) direct benefits to the project beneficiaries from less groundwater drawdown resulting in less energy, O&M, and replacement costs of wells in pumping areas; and (c) increased agricultural production. In addition, the benefits of wastewater treatment and reuse were included. The economic rate of return (ERR) for the project was 16.8 percent, which was economically viable[40] and higher compared to the PAD estimation of 14.5 percent.

42. The analyses did not include significant environmental and institutional benefits that were not readily quantifiable. The results were a conservative estimation, without including the non-qualifiable benefits, such as (a) the reduction of pollution, resulting in improved availability of drinking water sources with improved water quality, improved health and livelihoods, and improved ecosystems at the river basins; (b) the improved river basin management capacity; and (c) the improved water supply condition for reliable and sustainable industrial, agricultural, and economic development. Thus, the ERR of 16.8 percent would be higher if these unquantifiable benefits could be included in the analysis.

43. **Financial Analysis:** Following the approach adopted at appraisal, a financial analysis was carried out. It confirmed: (a) the financial feasibility of the investments for stabilizing groundwater levels in selected demonstration areas, considering the annual incremental financial value of groundwater saving and its related financial benefits on reduced O&M costs, increased crop production, and increased land, energy, and labor savings; (b) the financial viability and sustainability of the WWTFs, with adequate water utility tariffs to cover O&M costs; and (c) the project

[40] The social discount rate currently adopted by NDRC in China is 8 percent for general investment projects and 6 percent for environmental projects.

generated financial incentives (increased income) for farmers' participation. The FIRR was viable at 11.06 percent, which is comparable to the PAD estimation of 10.48 percent.

44. **Implementation efficiency.** Although project implementation progress was delayed at a late stage because of the COVID-19 pandemic, all project activities were completed before project closure. Government financing accounted for 92 percent of the total project cost, laying a solid foundation for other IWEM interventions funded by the GEF grant (8 percent of the total project cost). The GEF grant was fully disbursed at project closure. The project also complied with World Bank fiduciary and safeguard policies.

D. JUSTIFICATION OF OVERALL OUTCOME RATING

Rating: Highly Satisfactory

45. **The overall Outcome rating is Highly Satisfactory**, based on the High Relevance of the project's objective to national and World Bank priorities at appraisal and closing; the High Efficacy of the project, with all PDO-level and intermediate indicators achieved or exceeded at closing; and High Efficiency of the project.

E. OTHER OUTCOMES AND IMPACTS

Gender

46. **The project encouraged women participation and enhanced the capacity of female farmers and professionals.** For example, in Anjiazhuan village in Jinzhou, the project encouraged farmers to establish WUAs to improve agricultural water management. Through intensive consultations and training, the WUAs were established with 809 women participants. Initial water use rights were allocated through the WUAs, and the WUAs played a key role to organize and train farmers to adopt water saving techniques. In Yongan village in Gaocheng, farmers, including 1,905 women, were trained to better manage their wells and groundwater use. Women participated in groundwater use monitoring and provided data on 117 wells to monitor the relationships between water level and water withdrawal. Female professionals also widely participated in project implementation and management. There were 196 experts (including 89 female experts) from the MEE and 231 experts (including 98 female experts) from the MWR who participated in the studies and research under this project.

Institutional Strengthening

47. **The project strengthened institutional collaboration between the water resources and environmental sectors at the national and municipal levels.** Building on the collaboration mechanism established in the first phase GEF Hai Basin IWEM Project, a Cooperation Agreement for IWEM was signed in 2015 between the ministers of MWR and MEP during project preparation. To deepen this collaboration, five cross-sectoral collaboration agreements at different levels were signed under this project (Indicator I-17), including between: (i) the central project management offices (PMOs) at MWR and MEP for national collaboration; (ii) central PMOs at MWR and MEP and the water and the environmental and ecological bureaus in Shijianzhuang to support TVAP and IWEMP implementation; (iii) central PMOs and the water and the environmental and ecological bureaus in Chengde to support TVAP and IWEMP implementation; (iv) the water bureau and the environmental and ecological bureau in Shijianzhuang for municipal level collaboration; and (v) the water bureau and the environmental and ecological bureau in Chengde. Based on these agreements, the project further requested regular coordination meetings among various agencies, parties, and stakeholders (Indicator I-18). More than 70 coordination meetings were carried out to support overall project

implementation, facilitate communications on project progress and study and research findings, and enhance overall technical and operational management.

Mobilizing Private Sector Financing

48. **The project helped mobilize private sector financing to support IWEM through PPPs.** The project prepared the TVAP and IWEMP for the Hutuo River Basin in Shijiazhuang, which laid down the key actions and plans to improve water resources and environmental management in Hutuo River Basin. Some actions and plans were further incorporated into the Hutuo River environment and ecosystem restoration project initiated in 2018. In April 2018, through the national PPP information management platform, the government promoted the PPP model and successfully leveraged RMB 13.2 billion (US$ 2.05 billion) of private financing and social capital to implement the government's Hutuo River environment and ecosystem restoration project, which included activities for ecosystem restoration, water pollution control, and flood management.

Poverty Reduction and Shared Prosperity

49. **The project increased farmer's incomes and contributed to shared prosperity.** The project promoted cropping pattern adjustment, water saving techniques, and advanced agronomic practices to reduce water and energy consumption and increase farmers' incomes. In addition, for the farmers who migrated to work in urban areas, the project piloted a rural cooperative model to introduce professional agricultural technique companies to manage the farmlands collectively. The professional companies applied advanced irrigation and fertilizer techniques and widely used modern machinery, which significantly reduced the costs of water, fertilizer, and labor and generated income of RMB 3,000 per mu (US$6,977 per ha), on average.

Other Unintended Outcomes and Impacts

50. **The ET-EC-ES based IWEM approach developed under this project was applied in the new PforR program to support Yellow River Basin management.** China launched the new national strategy of Yellow River Basin Ecological Protection and High-Quality Development in 2019.[41] China highlighted that Yellow River Basin protection needs to control both total water consumption amount and intensity, and consider the trade-offs between water resources and ecosystem restoration, in particular the potential impacts of reforestation program 'Grain for Green' on streamflow.[42] These principles are well aligned with the ET-EC-ES based IWEM approach developed under this project. Therefore, the ET-EC-ES based IWEM approach was used to design the latest PforR program.[43] Remote sensing-based water balance assessments were conducted during program preparation. The interactions among increased water consumption in agricultural sector and reforestation, water pollution control, and environmental flow safeguard were assessed to guide the selection of program interventions during program preparation. During program implementation, the basin organization and the provincial governments are expected to further conduct detailed water balance/accounting and develop and implement the ET-EC-ES based IWEM plans. The government fully supports the ET-EC-ES based IWEM approach, which will be further scaled up to support the sustainable development of the Yellow River Basin.

[41] Keynote speech by President Xi Jinping on September 18, 2019, at the symposium on ecological protection and high-quality development in the Yellow River Basin.
[42] Yellow River Basin Ecological Protection and High-Quality Development Master Plan. (*https://www.mee.gov.cn/zcwj/zyygwj/202110/t20211009_955779.shtml*)
[43] Yellow River Basin Ecological Protection and Environmental Pollution Control Program (P172806), approved in March 2022.

III. KEY FACTORS THAT AFFECTED IMPLEMENTATION AND OUTCOME

A. KEY FACTORS DURING PREPARATION

51. **The project design built on the World Bank's long engagement in IWEM in China and leveraged international experiences and best practices.** The decades-long engagement of the World Bank and China in IWEM has formed a series of innovative approaches, particularly the ET management and the ET-EC-ES based IWEM approaches (annex 7). This project design aimed to further scale up IWEM at the national and sub-national levels. International experiences and best practices in IWEM were incorporated into the project design, including developing and demonstrating remote sensing applications, MAR, and water rights and pollution emission trading.

52. **The project benefited from a well-conceived design with clear objectives.** The PDO was clear and achievable. The project components directly supported the PDO with clear operational logic. The components were interconnected, with the methodology and techniques piloted in the demonstration areas under Component 2 further scaled up in three large river basins and nationally under Component 3, while the lessons learned from Components 2 and 3 were summarized in the IWEM guideline and recommendations were incorporated into the policies in Component 1. The use of the GEF grant and counterpart funding were clearly defined.

53. **The project preparation enhanced the readiness for implementation and developed appropriate risk mitigation measures.** Since IWEM approaches require strong coordination between the water and environment sectors, the importance of institutional collaboration was highlighted in the project design. During project preparation, the project managed to sign the Cooperation Agreement between the ministers of MWR and MEP in 2015, which laid a solid foundation for cross-sectoral collaboration during implementation and enhanced the readiness for implementation. The risks of difficulties in data collection and sharing and limited project management capacity were identified. Proper risk mitigation measures were developed to promote institutional collaboration, strengthen data monitoring and collection, and build institutional capacities to address these risks.

B. KEY FACTORS DURING IMPLEMENTATION

54. **Well-organized and coordinated implementation management arrangements were critical to effective implementation of the IWEM approaches.** The project established a well-organized and coordinated implementation arrangement at different levels (figure 2): i) the Cooperation Agreement between MWR and MEP laid down the overall coordination mechanism; ii) the steering committees in MWR and MEP (and later, MEE) were responsible for overall implementation coordination; iii) the central PMOs at MWR and MEP were responsible for overall project implementation and technical support to the joint municipal PMOs; iv) two joint municipal PMOs in the demonstration cities of Chengde and Shijiazhuang were responsible for municipal project implementation; v) the Panel of Experts at the central level, including international and domestic experts, was responsible for overall technical support and review; and vi) provincial water resource and environmental and ecological sectors worked with MWR and MEP to implement the scale up activities in three river basins; and vii) sub-grant Project Implementation Units (PIUs) in public research institutes and universities were responsible for carrying out related studies and research.

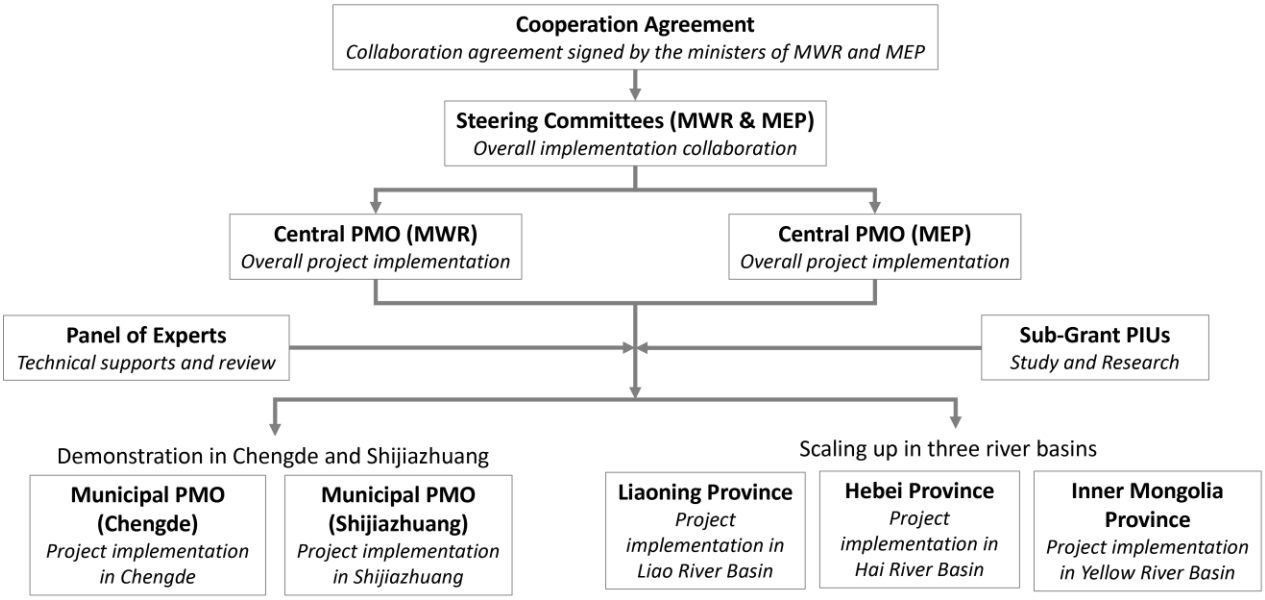


Figure 2. Implementing Arrangement

55. **The project experienced implementation delays during early implementation.** The project had a large number of studies and research, along with vast investments in the demonstration cities and across three large river basins. The procurement delays occurred, especially early in implementation, as two municipal PMOs lacked experience to manage World Bank-funded projects. Therefore, the World Bank team provided intensive training on project management, financial and procurement management, and safeguard management, which helped the PMOs strengthen their capacity. In addition, there was a long and slow "learning curve" during early implementation, as the project introduced many innovative techniques and policies, such as remote sensing, groundwater modeling, water accounting, water trading, and pollution emission trading. Intensive training and workshops were provided to the government agencies, PMOs, PIUs, and stakeholders on these innovations. As the PMOs enhanced their capacity and resolved the procurement bottleneck, the project implementation gradually caught up.

56. **Institutional reforms and the COVID-19 pandemic impacted project implementation.** In March 2018, the National People's Congress approved the Plan to Deepen Reform of Party and State Institutions, which reorganized the ministries under the State Council. The responsibilities and mandates of MWR and MEE (formerly MEP) were significantly changed. In particular, the mandate of monitoring and managing water pollution issues was transferred from MWR to MEE. As a result, the project needed to adapt to these institutional changes to better coordinate across the water and environment sectors. In addition, due to the impact of COVID-19 pandemic, international experts were unable to visit China to conduct field studies and workshops. Four international workshops were carried out online with a large number of attendances to learn and discuss the IWEM approaches. The planned domestic and oversea study tours were cancelled, because of the travel constraints. Instead, virtual workshops and meetings were carried out to reach the objectives set at appraisal.

57. **The World Bank task team provided effective support.** The same task team leader (TTL) who led the first phase of the GEF Hai Basin IWEM Project (P075035), Water Conservation Project (P056516), and Xinjiang Turpan Water Conservation Project (P111163) served as the TTL of this project, ensuring the continuous development and application of IWEM and ET management approaches. The World Bank team conducted adequate implementation

support missions and visited the project sites regularly, supplemented by interim missions and technical visits. The team identified problems in a timely manner and provided effective support to address them. The team also included international and national experts who provided technical oversight and recommendations throughout project implementation.

IV. BANK PERFORMANCE, COMPLIANCE ISSUES, AND RISK TO DEVELOPMENT OUTCOME

A. QUALITY OF MONITORING AND EVALUATION (M&E)

M&E Design

58. **The M&E system had a clear RF with realistic targets but had some shortcomings in indicator design.** The RF provided a clear set of indicators to measure progress against the achievements of the PDOs. Adequate indicators were identified in the RF. The outcome indicators captured the project's comprehensive objectives. However, there were some shortcomings in indicator design: i) The RF has three of the same intermediate indicators (I-1, I-3, I-9 – "All study reports prepared, revised, and completed with good quality") measuring different outputs, while the definitions were relatively generic; ii) The RF has a large number of intermediate indicators, some of which could be further refined, especially those measuring institutional strengthening and project management; iii) The unit and target of intermediate indicator I-7 could be improved (see discussion in paragraph 27) and the sub-indicators should be refined or extra monitoring should be arranged, as the measurement of phosphorous and BOD were not requested by Chinese authorities at appraisal; and iv) the wording of all indicators could be tightened, more concise, and specific.

M&E Implementation

59. **The M&E data were collected and analyzed in a methodologically sound manner, with support from the M&E agency, the Panel of Experts, and the PMOs.** All PMOs had dedicated staff who were responsible for M&E. A third-party independent consulting group was hired to support M&E. The M&E report was updated semi-annually and submitted to the World Bank for review during project implementation. The PMOs consolidated all the data and reported in a comprehensive and timely manner through semiannual project progress reports. The reports showed progress of studies and research, civil works, consulting services, institutional strengthening and training, and the results as measured by all the project indicators. The Panel of Experts are responsible to review the project studies to ensure all study reports were prepared, revised, and completed with good quality. The progress reports were complemented by adequate and timely monitoring reports on the implementation of the Environmental and Social Management Framework (ESMF).

M&E Utilization

60. **The M&E data collected were used effectively to inform project implementation and support project management decisions.** The monitoring and reporting from the third-party consulting group and the PMOs helped the project identify implementation bottlenecks on time. Through regular coordination meetings and the World Bank missions, the PMOs, PIUs, and the task team had regular discussions on these bottlenecks and developed practical solutions. The monitoring and reports also clearly tracked the project implementation supported by the counterpart funds. The M&E data were collected and reported in a timely manner and used to inform project implementation and decision making.

Justification of Overall Rating of Quality of M&E

61. **The overall quality of M&E was rated Substantial.** Although there were some shortcomings in the M&E design, the implementation arrangements for M&E were adequate, data were collected systematically, and the information was used to inform project management and support management decisions.

B. ENVIRONMENTAL, SOCIAL, AND FIDUCIARY COMPLIANCE

62. **The project complied with all triggered safeguards policies. Environmental Compliance:** The project was classified as Category B-partial assessment and triggered two environmental safeguards policies: Environmental Assessment (OP/BP4.01), and Natural Habitats (OP/BP4.04). During project preparation, an Environmental and Social Management Framework (ESMF) was developed, which set out environmental and social management and monitoring procedures and measures for the technical assistance (TA) and pilot physical subprojects. The ESMF was locally disclosed in January 2016 and disclosed at the World Bank's Infoshop in February 2016***. Environmental Assessment (OP/BP4.01):*** The PMOs provided annual progress reports on the ESMF implementation showing that: i) there was no reporting of environmental complaints or Occupational, Healthy, and Safety (OHS) accidents throughout project implementation; ii) the project has followed the ESMF to screen, assess, manage, and monitor the environmental impacts from TA and physical subprojects; iii) the environmental performance during operation of counterpart funded WWTFs was regularly monitored and showed compliance with domestic regulatory standards by project closing. The project contributed to improved water quality and water resource management in the demonstration sub-basins through the implementation of counterpart-funded subprojects such as WWTPs and pipelines and water-saving irrigation facilities. Downstream environmental benefits are also expected from applying the TA outputs to future project design and implementation. *Natural Habitats (OP/BP4.04):* The project activities did not cause any significant conversion or degradation of natural habitats. Rather, the restoration of ecological flow in the demonstration river has resulted in improved biodiversity and the TA outputs on protecting water ecology represent downstream opportunities for habitat and biodiversity protection.

63. **Social Compliance: Involuntary Resettlement (OP 4.12)** applied to the project. The PMOs engaged a professional social consultant to support ESMF implementation. Overall, the ESMF was consistently applied for the screening, social audit, and monitoring of the activities funded by the grant and counterpart funding. Only two associated WWTPs induced minor land acquisition (4.87 ha). The social monitoring concludes that the associated resettlement was satisfactorily completed in compliance with domestic regulations and OP 4.12 requirements. For the minor works on farms, the social audit concluded that the temporary impacts were well managed and the contractors timely restored the affected land to its previous conditions. There were no outstanding social issues or complaints. The project also promoted female participation (over 50 percent of participants) in the project design and implementation. The demonstration activities improved water-saving and achieved substantive ecological, social, and economic sustainability and spill-over effects. The ICR indicates that more than 90 percent of respondents were satisfied with the project outcomes.

64. **Financial Management.** The project had adequate project financial management (FM) system that provided, with reasonable assurance, accurate and timely information that the grant was being used for the intended purposes. The project accounting and financial reporting were in line with the regulations issued by MoF and the requirements specified in grant agreement. No significant FM issues were noted throughout project implementation and the FM-related issues or weaknesses raised during implementation were resolved in a timely manner. The project audit reports were all completed with unqualified audit opinions. In addition, the withdrawal procedure and funds flow arrangement were appropriate. The grant proceeds were disbursed in a timely manner.

65. **Procurement.** The procurement was considered satisfactory and in compliance with World Bank procurement policy and procedural requirements. Procurement progress was not even among the PIUs in the beginning but it eventually improved with strengthened institutional arrangements and additional resource mobilization, per the task team's advice. The majority of the procurement under this project was for selection of small consultancy services and goods contracts. There were also a few large consultancy contracts using a complex selection method, for which the selection process experienced some delays at the initial stage. The World Bank task team closely monitored procurement and provided guidance. Post reviews were carried out regularly on a sampling basis. The World Bank task team constantly helped the PMO staff enhance their capacity through trainings and workshops. In addition to traditional procurement, the project involved the application of sub-grants which also followed World Bank procurement policies and procedures.

C. BANK PERFORMANCE

Quality at Entry

66. **The World Bank performance at entry was Satisfactory.** The project design was built upon the innovative ET management and IWEP approaches developed in China through the decades of engagement between the World Bank and China in the areas of water and environment management. The World Bank team also applied international best practices to design the comprehensive project to solve water scarcity, pollution, and ecosystem degradation issues in an integrated manner. The project was well designed, with the interventions strategically influencing the IWEM at the national, municipal, and basin levels. The project highlighted the importance of cross-sectoral coordination in implementing IWEM approaches. Through the task team's coordination and efforts, the Cooperation Agreement between two key ministries of MWR and MEP was signed during project preparation, which enhanced the readiness for implementation. The task team properly identified the risks of implementing a cross-sectoral project at different levels and prepared appropriate mitigation measures. The counterpart was highly satisfied with the World Bank performance at entry, stating in the counterpart's ICR that "the project design was advanced and strategic with comprehensive components, and the Bank team clearly defined the project objectives, consisting with the river basin challenges and characteristics."

Quality of Supervision

67. **The World Bank performance of supervision was also Satisfactory.** The World Bank set up a multidisciplinary team of experienced staff and consultants to supervise the project and provide quality implementation support and practical training on procurement, financial management, safeguards, and project management. The World Bank conducted adequate implementation support missions and visited project sites regularly, supplemented by interim missions and technical visits. The project had the same TTL from identification to completion, which ensured the stability of project management and improved overall management efficiency. The project established a well-organized implementation arrangement and mobilized a group of international and domestic experts to ensure the international best practices and advanced techniques were demonstrated and mainstreamed through this project. The task team significantly promoted the coordination and data sharing between the water and environmental sectors. The team supported the government to establish the coordination mechanism and effectively involved different agencies and stakeholders in project implementation, discussions, and research. In response to the early implementation delays and unexpected impacts of institutional reform and the COVID-19 pandemic, the World Bank team worked closely with the counterparts to solve bottlenecks proactively and ensured the project was completed on time without any restructuring and extension.

Justification of Overall Rating of Bank Performance

68. **The overall World Bank performance is rated Satisfactory.** The World Bank team developed a concrete and comprehensive project with international best practices and advanced techniques. The team provided adequate and timely implementation support and significantly promoted institutional coordination. The borrower also highly appraised the World Bank performance.

D. RISK TO DEVELOPMENT OUTCOME

69. **The project outcomes are likely to be sustained.** The recommendations and findings under this project were incorporated into the policies and regulations to ensure long-term impacts and implications in IWEM. The potential impacts of climate change on IWEM were considered and incorporated into the TVAPs and IWEMPs. The project had conducted a series of studies, pilots, and scaling-up interventions and remote sensing based monitoring systems were adopted and the national ET and pollution management platforms were developed, providing useful tools for long-term monitoring and management. In addition, sustainable funds for the operation and maintenance (O&M) of the interventions on irrigation system improvement and WWTPs have been allocated in line with government stipulations. The irrigation water pricing reform piloted under this project will also cover some O&M costs.

V. LESSONS AND RECOMMENDATIONS

70. **Addressing water scarcity, water pollution, and ecosystem degradation issues in an integrated manner.** Innovative IWEM approaches were effectively prepared and implemented under the project across five key aspects:

- **Infrastructure**: Interventions to modernize irrigation systems, adopt water saving techniques, and improve wastewater treatment facilities.
- **Financial**: Building on government administrated water and environment management systems, market-based approaches such as water rights trading and pollution emission trading, irrigation tariff reform, and PPP models provided incentives.
- **Monitoring:** Remote sensing tools, along with improved in-situ monitoring networks, to monitor ET and water pollution.
- **Institutional:** Cross-sectoral coordination and capacity building and training were critical for farmers and other stakeholders to understand and adopt the IWEM approaches.
- **Policy**: IWEM approaches were incorporated into policies and regulations to further guide IWEM application at a larger scale.

71. **Adopting innovative IWEM approaches needs to consider specific country and sectoral contexts.** Although this project demonstrated and mainstreamed various innovative IWEM approaches, adopting these approaches in other countries and regions needs to consider the contextual differences. For example, adopting water rights trading and pollution emission trading requires that a basic water rights system and emissions permit system is in place. Also, in countries that provide free irrigation water, a fee policy may not be suitable for irrigation water tariff reform. In addition, adopting the innovative approaches is associated with risks.

72. **Applying an adaptive "learning by doing" approach helps to reduce potential risks and effectively scale activities at a larger basic scale.** The project activities were arranged as "Studying—Piloting and Demonstration—Upscaling and Mainstreaming—Incorporating into Policy". These innovative IWEM approaches were first thoroughly studied to identify the challenges and solutions, and then piloted and demonstrated at small scale. The lessons learned from pilots were used to guide the mainstreaming at a larger basin scale and the key recommendations were incorporated into policies and regulations to guide IWEM application in the country.

73. **A coordination mechanism covering the water and environment sectors is key for implementing IWEM.** The project emphasized institutional coordination from a very early stage. A Cooperation Agreement was signed by the ministers of MWR and MEP during project preparation, which enhanced the readiness of implementation and laid the foundation for institutional coordination during implementation. A well-organized, coordinated implementing arrangement was established, with cross-sectoral coordination at national, municipal, and basin levels. Five cross-sectoral collaboration agreements were signed, providing clear guidelines on collaboration and data sharing. The World Bank team and PMOs played critical roles to involve different agencies and stakeholders in the coordination meetings and consultations. As the project studied and applied various advanced techniques and innovative mechanisms, the strong technical support from the Panel of Experts was crucial to ensure the studies and applications were technically sound. The Panel consisted of international and domestic experts who were familiar with both international good practices and China. In addition, coordinated with the dedicated M&E staff in each PMOs, the third-party independent M&E team conducted comprehensive M&E across the national, municipal and basin levels to support project implementation.

74. **Long-term engagement supported China to enhance IWEM.** The ET management and IWEM approaches were gradually developed and fostered through several World Bank supported projects since the late 1990s.[44] Built upon the lessons learned from the previous projects, this project further expanded the IWEM approaches to consider the ET-EC-ES interconnections and mainstreamed the IWEM approaches. This long engagement involved a considerable number of policy makers in China, from the central to local levels, who gradually embraced the IWEM approaches developed through various World Bank supported projects. The long-term engagement also significantly influenced China's water and environmental management policies and strategies. For example, the new controls on the total water consumption amount and intensity were stipulated in the latest national strategy for the protection of the Yellow River. The stability of the World Bank team and TTL also contributed to this long engagement, with cumulative knowledge and operational experience to continuously develop and promote IWEM approaches. The GEF grant provided the opportunities to study, test, and pilot these innovative IWEM approaches, which provided lessons and confidence for the counterparts to adopt and mainstream with the counterpart funding. This project engaged with the governments from national to basin levels and laid the foundation for different levels of governments to adopt IWEM approaches in the future.

[44] In late 1990s, the Tarim Basin II Project first proposed the idea of reducing non-beneficial ET. In early 2000s, the Water Conservation Project introduced the concept of "real" water saving and piloted ET reduction approaches. In late 2000s, the first phase of GEF Hai Basin IWEM project developed the ET-EC based IWEM approaches and widely applied remote sensing and model techniques to support IWEM planning and implementation. In the 2010s, the Xinjiang Turpan Water Conservation Project successfully applied the basin-wide, comprehensive ET management approaches to reduce groundwater overexploitation. See more details in annex 7.

ANNEX 1. RESULTS FRAMEWORK AND KEY OUTPUTS

A. RESULTS INDICATORS

A.1 PDO Indicators

Objective/Outcome: PDO Indicators

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
1. Policy Recommendations made under the project incorporated into the policies on water consumption control issued by MWR, and on pollution control issued by MEP, respectively (measuring unit: the	Number	0.00 01-Sep-2016	4.00 01-Sep-2016	4.00 01-Sep-2016	7.00 31-Dec-2021

Comments (achievements against targets):
175 percent achievement. Seven policy recommendations made under the project incorporated into the policies on water consumption control issued by MWR and policies on pollution control issued by MEP.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
2-A. Water pollution (COD) discharged into the Hutuo and Luan Rivers reduced in the two demonstration areas Chengde and Shijiazhuang (measuring unit: tons of COD)	Metric tons/year	0.00 01-Sep-2016	8,074.00 01-Sep-2016	8,074.00 01-Sep-2016	9,162.00 31-Dec-2021
2-B. Water pollution (NH3-N) discharged into the Hutuo and Luan Rivers reduced in the two demonstration areas Chengde and Shijiazhuang (measuring unit: tons of NH3-N).	Metric tons/year	0.00 01-Sep-2016	547.00 01-Sep-2016	547.00 01-Sep-2016	929.40 31-Dec-2021
2-C. Water pollution discharged into the Hutuo and Luan Rivers reduced in the two demonstration areas Chengde and Shijiazhuang (measuring unit: tons of TN).	Metric tons/year	0.00 01-Sep-2016	670.00 01-Sep-2016	670.00 01-Sep-2016	1,402.80 31-Dec-2021
2-D. Water pollution discharged into the Hutuo	Metric tons/year	0.00	0.00	85.00	123.80

and Luan Rivers reduced in the two demonstration areas Chengde and Shijiazhuang (measuring unit: tons of TP).		01-Sep-2016	01-Sep-2016	01-Sep-2016	15-Jun-2021

Comments (achievements against targets):
113 percent achieved.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
3-A. Water productivity increased in two demonstration rural areas Gaocheng and Jinzhou (measuring unit: kg of grain production per/m3).	Cubic Meter(m3)	1.10 01-Sep-2016	1.26 01-Sep-2016	1.26 01-Sep-2016	1.85 31-Dec-2021
3-B. Water productivity increased in scaling-up areas in Shijin irrigation areas (measuring unit: kg of grain production /m3)	Cubic Meter(m3)	1.10 01-Sep-2016	1.26 01-Sep-2016	1.26 01-Sep-2016	1.79 31-Dec-2021
3-C. Water productivity increased in scaling-up	Cubic Meter(m3)	1.19	1.29	1.29	2.29

areas in Hetao irrigation areas (measuring unit: kg of grain production /m3)		01-Sep-2016	01-Sep-2016	01-Sep-2016	01-Dec-2021

Comments (achievements against targets):
147 percent achieved. Water productivity in Gaocheng increased to 1.94 kg/m3 and water productivity in Jinzhou increased to 1.76 kg/m3.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
4. Reductions achieved in overdraft of groundwater in 2 demonstration sites in Hai River Basin (Gaocheng and Jinzhou) (measuring unit: million m3/year).	Cubic meters/year	0.00 01-Sep-2016	72.93 01-Sep-2016	72.93 01-Sep-2016	192.38 31-Dec-2021

Comments (achievements against targets):
264 percent achieved. The project reduced 192.38 million tons of groundwater overdraft per year.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
5-A. IWEMP approach demonstrated and scaled up	Square kilometer(km2)	4,278.40	28,420.00	28,420.00	29,810.40

to cover the MWR defined problem areas in 3 river basins (measuring unit: km2)		01-Sep-2016	01-Sep-2016	01-Sep-2016	31-Dec-2021
5-B. IWEMP approach demonstrated and scaled up to cover the MEP defined problem areas in 3 river basins (measuring unit: km2)	Square kilometer(km2)	0.00 01-Sep-2016	125,380.00 01-Sep-2016	125,380.00 01-Sep-2016	152,701.80 31-Dec-2021

Comments (achievements against targets):
105 percent achieved.

A.2 Intermediate Results Indicators

Component: Component 1: Mainstreaming of Innovative Approach on Integrated Water and Environment Management

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
1-A. All study reports prepared and completed as planned with good quality (measuring unit: the number of study reports prepared, revised and completed with good quality) (GEF Financed)	Number	0.00 01-Sep-2016	4.00 01-Sep-2016	4.00 01-Sep-2016	4.00 31-Dec-2021

1-B. All study reports prepared and completed as planned with good quality (measuring unit: the number of study report prepared, revised and completed with good quality) (Government Financed)	Number	0.00 01-Sep-2016	5.00 01-Sep-2016	5.00 01-Sep-2016	5.00 31-Dec-2021

Comments (achievements against targets):
100 percent achieved.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
2. Operational manuals/guidelines completed and accepted with good quality (measuring unit: the number of operational manuals prepared, revised and completed with good quality)	Number	0.00 01-Sep-2016	5.00 01-Sep-2016	5.00 01-Sep-2016	5.00 31-Dec-2021

Comments (achievements against targets):
100 percent achieved.

Component: Component 2: Demonstration in Hai Basin on Integrated Water and Environment Management

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
3-A. All study reports prepared and completed as planned with good quality (measuring unit: the number of study reports prepared, revised and completed with good quality) (GEF Financed)	Number	0.00 01-Sep-2016	10.00 01-Sep-2016	10.00 01-Sep-2016	13.00 31-Dec-2021
3-B. All study reports prepared and completed as planned with good quality (measuring unit: the number of study reports prepared, revised and completed with good quality) (Government Financed)	Number	0.00 01-Sep-2016	10.00 01-Sep-2016	10.00 01-Sep-2016	19.00 31-Dec-2021

Comments (achievements against targets):
130 percent achieved.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised	Actual Achieved at

				Target	Completion
4-A. RS/ET/EC-based TVAPs prepared and implemented with good quality for Luan sub-river basin and Hutuo sub-river basin, respectively (TVAP GEF Financed).	Number	0.00 30-Jan-2017	2.00 01-Sep-2016	2.00 01-Sep-2016	2.00 31-Dec-2021
4-B. RS/ET/EC-based the IWEMPs prepared and implemented for Chengde Municipal City and Shijazhuang Municipal City and extension plans prepared for scaling-up areas (the IWEMP, MTR and ICR GEF Financed	Number	0.00 01-Sep-2016	6.00 01-Sep-2016	6.00 01-Sep-2016	6.00 31-Dec-2021

Comments (achievements against targets):
100 percent achieved.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
5. Capacity building for citizen engagement in preparation of TVAPs and IWEMPs - Channels are institutionalized for citizens	Number	0.00 01-Sep-2016	8.00 01-Sep-2016	8.00 01-Sep-2016	22.00 31-Dec-2021

to engage with government agencies and other stakeholders.					

Comments (achievements against targets):
275 percent achieved.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
6. Women participation to increase water productivity and reduce water pollution through WUAs during IWEMP implementation (measuring unit: increased percentage of female membership in the WUAs)	Percentage	30.00 01-Sep-2016	50.00 01-Sep-2016	50.00 01-Sep-2016	50.00 31-Dec-2021

Comments (achievements against targets):
100 percent achieved.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
7-A. Construction of 3 small	Tons/year	0.00	2,136.00	2,136.00	2,582.80

wastewater treatment plants and pipelines, 2 in Chengde County and 1 in Kuancheng County with good quality in demonstration areas as planned (Wastewater pollution-N)		01-Sep-2016	01-Sep-2016	01-Sep-2016	31-Dec-2021
7-B. Construction of 3 small wastewater treatment plants and pipelines, 2 in Chengde County and 1 in Kuancheng County with good quality in demonstration areas as planned (Wastewater pollution-P)	Tons/year	0.00 01-Sep-2016	303.60 01-Sep-2016	303.60 01-Sep-2016	250.50 31-Dec-2021
7-C. Construction of 3 small wastewater treatment plants and pipelines, 2 in Chengde County and 1 in Kuancheng County with good quality in demonstration areas as planned (Wastewater pollution-BOD)	Tons/year	0.00 01-Sep-2016	2,796.00 01-Sep-2016	2,796.00 01-Sep-2016	0.00 31-Dec-2021

Comments (achievements against targets):

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
8. Improved irrigation technologies applied in 2 demonstration counties in Shijiazhuang Municipal City (measuring unit: No. of hectares of irrigated areas applied with improved irrigation technologies	Number	2,660.00 01-Sep-2016	13,300.00 01-Sep-2016	13,300.00 01-Sep-2016	17,938.00 31-Dec-2021

Comments (achievements against targets):
135 percent achieved

Component: Component 3: Scaling up the Integrated Water and Environment Management Approach in Three River Basins

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
9-A. All study reports prepared and completed as planned with good quality (measuring unit: the number of study reports prepared, revised and completed with good quality) (GEF Financed)	Number	0.00 01-Sep-2016	7.00 01-Sep-2016	7.00 01-Sep-2016	8.00 31-Dec-2021
9-B. All study reports	Number	0.00	4.00	4.00	4.00

prepared and completed as planned with good quality (measuring unit: the number of study reports prepared, revised and completed with good quality) (Government Financed)		01-Sep-2016	01-Sep-2016	01-Sep-2016	31-Dec-2021

Comments (achievements against targets):
114 percent achieved

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
10. National Water Environment Technology Extension Platform established at the MEP (measuring unit: percentage of software development and study progress completed with good quality)	Percentage	0.00 01-Sep-2016	100.00 01-Sep-2016	100.00 01-Sep-2016	100.00 31-Dec-2021

Comments (achievements against targets):
100 percent achieved.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
11. National ET Monitoring and Management Platform established at the MWR (measuring unit: percentage of software development and study progress completed with good quality) (GEF Financed)	Percentage	0.00 01-Sep-2016	100.00 01-Sep-2016	100.00 01-Sep-2016	100.00 31-Dec-2021
Comments (achievements against targets): 100 percent achieved.					

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
12-A. Annual scaling-up activities carried out and inspection and assessment reports prepared and completed for the up-scaling areas for MEP (GEF Financed)	Number	0.00 01-Sep-2016	6.00 01-Sep-2016	6.00 01-Sep-2016	6.00 31-Dec-2021
12-B. Annual scaling-up activities carried out and inspection and assessment reports prepared and	Number	0.00 01-Sep-2016	6.00 01-Sep-2016	6.00 01-Sep-2016	6.00 31-Dec-2021

completed for the up-scaling areas for the MWR (GEF Financed)					

Comments (achievements against targets):
100 percent achieved.

Component: Component 4: Institutional Capacity Building and Project Management

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
13. Establishment of project website according to IW: LEARN guidelines: (measuring unit: functioning website with the number of hits recorded by site) (GEF Financed)	Number	0.00 01-Sep-2016	1.00 01-Sep-2016	1.00 01-Sep-2016	1.00 31-Dec-2021

Comments (achievements against targets):
100 percent achieved.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion

14. Preparation of project-related experience notes (2) and one results note (1) for IW: LEARN portal: (measuring unit: completed documents) (GEF Financed)	Number	0.00 01-Sep-2016	3.00 01-Sep-2016	3.00 01-Sep-2016	4.00 31-Dec-2021

Comments (achievements against targets):
133 percent achieved.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
15. Establishment and made operational project monitoring and evaluation (M&E) system: (measuring unit: functioning M&E system capable to generate semi-annual M&E reports) (GEF Financed)	Number	1.00 30-Jan-2017	10.00 01-Sep-2016	11.00 01-Sep-2016	11.00 31-Dec-2021

Comments (achievements against targets):
110 percent achieved.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
16. Female staff and specialists participation in the project workshops and training at the central, provincial, municipal and county levels (increased % of female staff & specialists of the total num	Percentage	30.00 01-Sep-2016	40.00 01-Sep-2016	40.00 01-Sep-2016	45.40 31-Dec-2021

Comments (achievements against targets):
114 percent achieved.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
17. Cooperation Framework Agreement reached to facilitate the development and implementation of TVAP/IWEMP between the respective administrative units responsible for environment and water at all leve	Number	0.00 01-Sep-2016	5.00 01-Sep-2016	5.00 01-Sep-2016	5.00 31-Dec-2021

Comments (achievements against targets):
100 percent achieved.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
18. Coordination meetings between the respective administrative units to support the implementation of the framework agreements at the three levels on an annual basis (GEF Financed)	Number	4.00 01-Sep-2016	24.00 01-Sep-2016	24.00 01-Sep-2016	70.00 31-Dec-2021

Comments (achievements against targets):
292 percent achieved.

B. KEY OUTPUTS BY COMPONENT

Objective/Outcome 1 To increase water productivity in the project areas	
Outcome Indicators	1. Water productivity increased in (a) two demonstration rural areas—Gaocheng and Jinzhou; and (b) scaling-up areas—Shijin and Hetao irrigation areas (measuring unit: kg of grain production per m^3) 2. Groundwater overdraft reduced in two demonstration sites in Hai River Basin—Gaocheng and Jinzhou (measuring unit: million m^3 per year)
Intermediate Results Indicators	1. Improved irrigation technologies were applied in two demonstration counties in Shijiazhuang municipality (measuring unit: number of hectares of irrigated areas applied with improved irrigation technologies)
Key Outputs by Component (linked to the achievement of the Objective/Outcome 1)	1. Water productivity increased to 1.94 (Gaocheng), 1.76 (Jinzhou), 1.79 (Shijin) and 2.29 (Hetao) kg of grain production per m3 2. Groundwater overdraft reduced 192.38 million m3 per year 3. 17,938 hectares of irrigated areas applied improved irrigation technologies
Objective/Outcome 2 To reduce pollution discharges in the project areas	
Outcome Indicators	1. Water pollution discharged into the Hutuo and Luan Rivers reduced in the two demonstration areas—Chengde and Shijiazhuang (measuring unit: tons of COD, NH3-N, TN, and TP per year).
Intermediate Results Indicators	1. Construction of the 3 small wastewater treatment plants and pipelines, two in Chengde county and one in Kuancheng county, with good quality in demonstration areas as planned (measuring unit: municipal wastewater pollution reduction—N, P & BOD (ton per year).

Key Outputs by Component (linked to the achievement of the Objective/Outcome 2)	1. Water pollution discharged into the Hutuo and Luan Rivers reduced: COD- 9,162.0; NH_3-N- 929.4; TN- 1,402.8; TP- 123.8 tons per year 2. Water pollution discharged reduced through 3 WWTPs: N- 2,582.8; P- 250.5 tons.
Objective/Outcome 1&2 Integrated intermediate indicator for Outcome 1&2	
Intermediate Results Indicators	1. All study reports prepared and completed as planned with good quality (measuring unit: the number of study reports prepared, revised, and completed with good quality) 2. RS/ET/EC-based TVAPs prepared and implemented with good quality for Luan sub-river basin and Hutuo sub-river basin, respectively, and the IWEMPs prepared and implemented for Chengde Municipal City and Shijiazhuang Municipal City and extension plans prepared for scaling-up areas, respectively (measuring unit: TVAP IWEMP and extension plan prepared, revised, and completed with good quality and implemented with good results) 3. Capacity building for citizen engagement in preparation of TVAPs and IWEMPs - Channels are institutionalized for citizens to engage with government agencies and other stakeholders (measuring unit: the number of consultation activities) 4. Women participation to increase water productivity and reduce water pollution through WUAs during IWEMP implementation (measuring unit: increased percentage of female membership in the WUAs)
Key Outputs by Component (linked to the achievement of the Objective/Outcome 2)	1. 32 study reports prepared and completed as planned with good quality 2. 8 TVAP IWEMP and extension plan prepared, revised, and completed with good quality and implemented with good results

	3. 22 consultation activities carried out for capacity building for citizen engagement in preparation of TVAPs and IWEMPs 4. 50 percent of female membership in the WUAs
Objective/Outcome 3 **To mainstream and upscale an innovative approach to integrated water and environmental management in the three river basins entering the Bohai Sea**	
Outcome Indicators	1. Policy Recommendations made under the project incorporated into the policies on water consumption control issued by MWR and policies on pollution control issued by MEP, respectively (measuring unit: the number of policies issued and implemented by MWR and MEP). 2. IWEMP approach demonstrated and scaled up to cover MEP and MWR-defined problem areas in 3 river basins (measuring unit: km^2)
Intermediate Results Indicators	1. All study reports prepared and completed as planned with good quality (measuring unit: the number of study reports prepared, revised, and completed with good quality) 2. Operational manuals/guidelines completed and accepted with good quality (measuring unit: the number of operational manuals prepared, revised, and completed with good quality) 3. All study reports prepared and completed as planned with good quality (measuring unit: the number of study report prepared, revised and completed with good quality) 4. National Water Environment Technology Extension Platform established at the MEP (measuring unit: percentage of software development and study progress completed with good quality) 5. National ET Monitoring and Management Platform established at the MWR (measuring unit: percentage of software development and study progress completed with good quality) 6. Annual scaling-up activities carried out and inspection and assessment reports prepared and completed for the scaling-up areas

	(measuring unit: the number of inspection and assessment reports prepared with actions recommended for improvements)
Key Outputs by Component (linked to the achievement of the Objective/Outcome 2)	1. 7 Policy Recommendations made under the project incorporated into the 4 policies on water consumption control issued by MWR and 3 policies on pollution control issued by MEP, respectively 2. IWEMP approach demonstrated and scaled up to cover 152,701.8 km^2 MEP and 29,810.4 km^2 MWR-defined problem areas in 3 river basins 3. 9 study reports prepared and completed as planned with good quality 4. 5 operational manuals/guidelines completed and accepted with good quality 5. 12 study reports prepared and completed as planned with good quality 6. National Water Environment Technology Extension Platform established at the MEP 7. National ET Monitoring and Management Platform established at the MWR 8. 12 inspection and assessment reports prepared with actions recommended for improvements for the scaling-up activities

ANNEX 2. BANK LENDING AND IMPLEMENTATION SUPPORT/SUPERVISION

A. TASK TEAM MEMBERS

Name	Role
Preparation	
Liping Jiang	Task Team Leader
Zheng Liu	Procurement Specialist
Fang Zhang	Financial Management Specialist
Qun Li	Economic and Financial Specialist
Zongcheng Lin	Social Specialist
Songling Yao	Social Specialist
Zhuo Yu	Disbursement Specailist
Rong Chen	Water Auditing Specialist, IFC
Feng Ji	Social Specialist
Jose Ramon R. Pascual IV	Counsel
Dan Xie	Team Member
Supervision/ICR	
Liping Jiang	Task Team Leader
Si Gou	ICR Primary Author
Zheng Liu	Procurement Specialist
Fang Zhang	Financial Management Specialist
Zongcheng Lin	Social Specialist
Kai Shang	Social Specialist
Xinchen Zhang	Environmental Specialist
Zhuo Yu	Disbursement Specialist
Dan Xie	Team Member (Co-author of ICR with responsibility of economic and financial analysis for the ICR)
Yan Zhang	Team member (Procurement)
Ru Xin Zhao	Team Member

B. STAFF TIME AND COST

Stage of Project Cycle	Staff Time and Cost	
	No. of staff weeks	US$ (including travel and consultant costs)
Preparation		
FY13	3.300	38,091.55
FY14	8.700	42,407.54
FY15	3.100	19,639.54
FY16	16.700	164,746.14
FY17	.700	6,177.41
FY18	0	- 33.52
Total	**32.50**	**271,028.66**
Supervision/ICR		
FY17	8.550	46,886.11
FY18	9.364	53,302.55
FY19	9.750	96,252.43
FY20	7.025	69,905.98
Total	**34.69**	**266,347.07**

ANNEX 3. PROJECT COST BY COMPONENT

Components	Amount at Approval (US$, million)			Actual at Project Closing (US$, million)			Percentage of Approval
	Total	GEF Grant	Government Funds	Total	GEF Grant	Government Funds	
Component 1: Mainstreaming of Innovative Approach on Integrated Water and Environment Management	3.45	1.20	2.25	4.35	1.17	3.18	126
Component 2: Demonstration in Hai Basin on Integrated Water and Environment Management	90.10	2.80	87.3	110.75	2.99	107.76	123
Component 3: Scaling up the Integrated Water and Environment Management Approach in Three River Basins	7.30	3.60	3.7	5.14	3.41	1.73	70
Component 4: Institutional Capacity Building and Project Management	3.65	1.90	1.75	2.00	1.93	0.07	55
Total	104.5	9.5	95	122.24	9.5	112.74	117

ANNEX 4. EFFICIENCY ANALYSIS

Economic Assessment

1. Following the approach adopted at appraisal, a cost-benefit analysis was conducted mainly for the demonstration of IWEM water activities implemented under Component 2, specifically for reducing groundwater overdraft and increasing wastewater treatment and reuse.

2. **Project Costs under Component 2.** The total project costs for Component 2 were CNY 603.33 million, including Chengde City Wastewater Treatment Plant Demonstration Project (CNY 245.82 million) and Shijiazhuang City Water Saving Irrigation Demonstration Project (CNY 357.51 million).

3. **Annual O&M Cost.** The estimated annual operating cost is divided into agricultural water-saving irrigation facilities and county-level wastewater treatment facilities. Based on M&E data, the project total annual operation cost is CNY 24.48 million, of which, the annual operation and maintenance cost of Shijiazhuang IWEM Project is CNY 7.15 million; the annual operating and maintenance cost of Chengde IWEM Project is CNY 17.33 million.

4. **Project Benefits**: The quantifiable benefits from the reduced groundwater overdraft included: (a) economic values of saved water, which can be alternatively used for industry and urban development; (b) direct benefits to the project beneficiaries from less groundwater drawdown resulting in less energy, O&M, and replacement costs of wells in pumping areas; and (c) increased agricultural production; In addition, the benefits of wastewater treatment and reuse were also included.

5. **The economic benefit from water saving:** The demonstration project area reduces the amount of groundwater increased by groundwater overdraft can be adjusted for industrial and future agricultural water use in the area. According to the project's technical design and 2021 M&E data, the Shijiazhuang pilot demonstration project area has developed a total of 269,100 mu of water-saving irrigation area, with an annual water saving of 17.5034 million m3. It is estimated that 50% of the saved groundwater will be used for industrial water use, and 50% will be used for agricultural water use calculation. By using alternative cost of CNY 1 per m^3 for the groundwater supply, the annual economic value of the reduced groundwater overdraft is about CNY 17.5 million.

6. Based on M&E data, the Shijiazhuang Water-Saving Irrigation Demonstration Project completed a water-saving irrigation area of 269,100 mu. The ET management comprehensive water-saving measures, monitoring evaluation and management measures have been taken in the project area of Shijiazhuang City have saved irrigation water, reduced the amount of groundwater exploitation, in controlled the decline of groundwater level, and reduce the cost of pumping and operation, maintenance and management of wells. The benefits of increasing crop production and saving expenses include energy saving, land saving, labor saving and yield increasing benefits.

1) Energy-saving benefits: The project saves water and energy consumption, reduces operation and management fees and wells renewal costs. According to the M&E data, the annual average groundwater extraction volume of the pilot demonstration area in Shijiazhuang City is 225.89 million m^3, the pump

efficiency coefficient is 0.55, and the electricity price is CNY0.67/Kw.h; energy saving benefit = 0.002724 × annual mining volume × average reduced pressure head / efficiency × electricity price = CNY 2.25 million.

2) Land-saving benefits: The field water supply facilities were changed from open channels to underground low-pressure water supply pipelines, which reduced the occupation of cultivated land. According to the M&E data, during the project implementation period, Shijiazhuang City project area have completed water-saving irrigation area of 269,100 mu, the land saving coefficient is about 0.5 percent, the average yield of wheat is 450kg per mu, the unit price is CNY2.2 /kg , and the average yield of corn is 550kg per mu, the unit price is CNY2.2 /kg; Land saving benefit = land saving coefficient × (wheat yield per mu × wheat unit price + corn yield per mu × corn unit price) × project implementation area * 50% = CNY 1.48 million;

3) Labor saving benefits: Implementing agricultural water saving irrigation and high-efficiency water-saving irrigation technical services reduced labor costs. According to the statistical data of Shijiazhuang, combined with the field research, the average labor per day saving per mu is 0.5 person/day, and the unit labor price per day is CNY 100 / day: Labor saving benefit = the average labor per day saving per mu x labor price per day x project Implementation area = CNY 13.46 million.

4) Benefit of increasing crop yield: By adopting agricultural measures and strengthening field management, the yield of crops in the project area of Shijiazhuang City have been increased. According to the M&E data, after the project is implemented, the crop water productivity in the pilot demonstration project areas of Gaocheng District of Shijiazhuang City and Jinzhou City have increased from 1.10 kg/ m^3 to 1.97 kg/ m^3, an increase of 79.1 percent. Average incremental wheat production per mu is 75 kg, and average incremental corn production per mu is 75 kg. Yield increase benefit = increased yield per mu × unit price × area of the project implementation area × 50% = CNY 44.40 million.

7. **Benefits of wastewater treatment and reuse**. Improve the urban wastewater pipeline network collection system, build urban wastewater treatment and reuse facilities to reduce environmental pollution, it can also increase the amount of reclaimed water and increase the available water resources. Based on the M&E data, the total annual wastewater treatment capacity increased by 34.65 million tons in the demonstration project of wastewater collection and treatment in Chengde City. The economic benefit is calculated based on the wastewater treatment fee paid by the drainage households plus the income from the sale of reclaimed water. Calculation based on the amount of wastewater, the unit price of wastewater treatment fee is 0.9 CNY/m^3, the unit price of reclaimed water is 0.8 CNY/m^3, and the annual economic benefit is CNY 58.91 million.

8. **Non-quantifiable social and environmental benefits**. The project's social and environmental benefits have been achieved mainly through various demonstration investment activities related to the comprehensive water quality improvement measures in selected river basin pilot areas such as: (a) the reduction of pollution, especially the water pollution discharged into the Hutuo and Luan Rivers, resulted in improved availability of drinking water sources with improved water quality, improved health and livelihood, and improved ecosystem at the river basins and the related Bohai sea; (b) the improved river basin management capacity with project activities implemented jointly by the national river basin and local water and environment authorities, through their effective cooperation and coordination

mechnisms built and tested during the project's life; and (c) the improved water supply conditions have contributed directly to a reliable and sustainable industrial, agricultural, and economic development.

9. **Main Assumptions for Economic Analysis**. The assumptions used in the financial analysis, except for the differences indicated below:

a. The opportunity cost of capital in China is estimated at 8 percent (the discount rate).
b. The economic life has been assumed to be 15 years, including 5 years for the project implementation and 10 years for the operations.
c. All project costs, including project investment, physical contingencies, and O&M costs have been considered in estimating the economic costs of the project, but price contingencies, taxes, duties and other charges were excluded; and
d. Table A4.1 below provides the unit price and assumptions applied at the Cost and Benefit Analysis

Table A4.1 Unit Price and Assumptions Applied at the Cost and Benefit Analysis

Name	Unit Price	Name	Unit price
Alternative cost for groundwater supply	CNY 1.0 per m^3	Yield/wheat	450 kg per mu
Average pressure head reduced	3m	Wheat price	CNY 2.2 per kg
Pump efficiency coefficient	0.55	Yield/corn	550 kg per mu
Electricity cost	CNY 0.67 per KWh	Corn price	CNY 2.2 per kg
Average labor saving per mu	0.5 day per mu	Average incremental wheat production	75 kg per mu
Labor rate/day	CNY 100 per day	Average incremental corn production	75 kg per mu
Land saving coefficient	0.5%		

10. Based above assumptions, the cash flows and for cost benefit analysis were prepared to calculate the ERR (*See annex A4.2 for details*). The results show that the ERR is at 16.8 percent. The analyses did not include significant benefits that were not readily quantifiable as explained above. Thus, the ERR of 16.8 percent would be higher if those unquantifiable benefits were included in the analysis.

Financial Assessment

11. **Financial Analysis:** Financial analysis has been carried out to confirm: (a) the financial feasibility of Component 2; (b) the financial viability and sustainability of the wastewater treatment facilities (WWTFs). All the WWTFs are financially sustainable with adequate water utility tariffs to cover O&M costs; and (c) farmers' income increases, which generated financial incentives for farmers' participation.

12. **Financial viability of Component 2.** The costs and benefits for financial analysis following the same approach and assumptions as for economic analysis except for (i) Investment costs include taxes, duties; (ii) the taxes and fees paid by the WWTFs were treated as cash outflow. As such, the financial internal rate of return is estimated at 11.06 percent (see table A4.3 for details), which is financially viable against the discount rate of 8 percent.

13. **Financial viability of WWTFs.** Improving the urban wastewater pipeline network collection system and building urban wastewater treatment and reuse facilities increase the amount of the available water resources. Based on the M&E data, the Chengde city wastewater collection and treatment pilot demonstration project invested CNY 245.82 million, and the total annual wastewater treatment capacity increased by 34.65 million tons. Among them, Weichang County Wastewater Treatment Plant invested CNY 96 million, increased the wastewater treatment capacity by 25,000 t/day, Luanping County Wastewater Treatment Plant (Phase II) invested CNY 64.42 million, increased wastewater treatment capacity by 60,000 t/day, and Xinglong County Wastewater Treatment Plant (Phase II) invested CNY 85.4 million, increased the wastewater treatment capacity by 20,000 t/day. The financial income is derived from the wastewater treatment fee paid by the water user plus the income from the sale of reclaimed water. By using total amount of wastewater of 34.65 million tons, the unit price of wastewater treatment fee is CNY 0.90/m^3, which is paid by the drainage households, and the unit price of reclaimed water is CNY 0.80/m^3, which is charged to the reclaimed water users. The annual financial income is CNY 58.91 million, while the annual operating and maintenance cost of Chengde IWEM Project is CNY 17.33 million. The financial income is therefore more than enough to cover the O&M costs *(see* Table A4.4 *for details*).

14. **Farmers' income analysis.** The project has increased beneficiary farmers' income and improve their living standards. The project's agricultural net output value increases directly increased the income of the beneficiary farmers in the project areas. After farmers' net income increases, farmers can strengthen their responsibility for operation and management and their willingness to pay water fees. Based on the M&E data, the net income of farmers in the project area has increased significantly compared with the conditions without the project. The per capita net income increased from CNY 1,330 in 2015 to CNY 1,619 in 2020, an increase of 21.7 percent. The net income of households with high-, middle- and low-income levels increased by 16.0 percent, 19.8 percent and 30.0 percent, respectively *(see table A4.2 for details).*

Table A4.2 Typical Farm Household Average Increased Income

Farmer's Income Level	Number of Households	Baseline (2015)			2020		Growth Rate (%)	
		Number of Family	Average Income per	Per Capita Income	Average Income per	Per Capita Income	Annual Growth	Total Increased

		Members	Households (CNY)	(CNY)	Households (CNY)	(CNY)	Rate	Growth Rate
High-income	4	3	4878	1626	5658	1886	3.01	16.0
Middle-income	4	3	4091	1363.7	4901	1634	3.68	19.8
Low-income	4	4	4333	1083.3	5631	1408	5.38	30.0
Average	**4**	**3.33**	**4434**	**1330.2**	**5397**	**1619**	**4.01**	**21.7**

15. Conclusions. The ERR for this project is 16.8 percent, which is economically feasible. The FRR is 11.06 percent shows that the demonstration project is financially viable. In addition, the implementation of the project also has huge environmental and social benefits, including a large-scale improvement of water resources and water environment management, reducing groundwater overdraft, improving groundwater environment, increasing groundwater strategic reserves, and regulating environmental flow along the reservoir. The water quality and quantity have met the requirements, achieved the goal of water quality improvement, adjusted the industrial structure. The implementation of the project has controlled agricultural non-point source pollution and improved the health and livelihood. The project achieved the goal of improve water quality and adjusted the industrial structure, the project controlled agricultural non-point source pollution, improved the production and environment quality of regional residents, and improved the health and livelihood. It has made positive contributions to promoting the construction of regional ecological civilization and improving the environmental quality at the river basins and the related sea.

Table A4.3 GEF Mainstreaming Integrated Water and Environment Management Project - Economic Benefit Cost Flow Table

No	Project	Construction period and initial Operation period					Operation period										Total
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1	Project benefit		**1380**	**4830**	**8279**	**11729**	**13799**	**13799**	**13799**	**13799**	**13799**	**13799**	**13799**	**13799**	**13799**	**20006**	**170415**
1.1	The benefit of increasing agricultural income and reducing expenditure		616	2155	3695	5235	6159	6159	6159	6159	6159	6159	6159	6159	6159	6159	73286
1.2	Reduce the benefits of groundwater overdraft		175	613	1050	1488	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	20825
1.3	Wastewater treatment and reuse benefits		589	2062	3534	5007	5891	5891	5891	5891	5891	5891	5891	5891	5891	5891	70097
1.4	Recovery of residual value of fixed assets															6033	6033
1.5	Recovery of working capital															173	173
2	Project cost	**3017**	**15206**	**15818**	**16430**	**14025**	**2621**	**2448**	**2448**	**2448**	**2448**	**2448**	**2448**	**2448**	**2448**	**2448**	**89148**
2.1	Fixed asset investment	3017	15083	15083	15083	12067											60333
2.2	Annual operating cost of water conservancy projects		36	215	393	572	715	715	715	715	715	715	715	715	715	715	8366
2.3	Annual operating cost of environmental protection projects		87	520	953	1386	1733	1733	1733	1733	1733	1733	1733	1733	1733	1733	20276
2.4	Working capital for environmental protection projects						173										
3	Net benefit flow	**-3017**	**-13826**	**-10988**	**-8150**	**-2296**	**11178**	**11351**	**11351**	**11351**	**11351**	**11351**	**11351**	**11351**	**11351**	**17558**	**81267**
4	Cumulative net benefit flow	**-3017**	**-16842**	**-27830**	**-35981**	**-38276**	**-27099**	**-15748**	**-4397**	**6954**	**18305**	**29656**	**41007**	**52358**	**63709**	**81267**	

Economic internal rate of return	**16.79%**	**%**	**〉8%**	**Financial benefit cost ratio**	**1.48**
Economic net present value	**CNY22,762**	**million**	**〉0**		

Annex Table A4.4 GEF Mainstreaming Integrated Water and Environment Management Project - Financial Cash Flow Statement

No.	Project	Construction period and initial operation period					Operation period										Total
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1	Project financial income		**1205**	**4217**	**7229**	**10242**	**12049**	**12049**	**12049**	**12049**	**12049**	**12049**	**12049**	**12049**	**12049**	**18256**	149590
1.1	Water Saving Irrigation Demonstration Project		616	2155	3695	5235	6159	6159	6159	6159	6159	6159	6159	6159	6159	6159	73286
1.1.1	Energy saving		22	79	135	191	225	225	225	225	225	225	225	225	225	225	2676
1.1.2	Increase income		15	52	89	126	148	148	148	148	148	148	148	148	148	148	1761
1.1.3	Save labor and expenses		135	471	807	1144	1346	1346	1346	1346	1346	1346	1346	1346	1346	1346	16011
1.1.4	Increased production net income		444	1554	2664	3774	4440	4440	4440	4440	4440	4440	4440	4440	4440	4440	52838
1.2	Wastewater Treatment Demonstration Project		589	2062	3534	5007	5891	5891	5891	5891	5891	5891	5891	5891	5891	12097	76304
1.2.1	Wastewater treatment fee income		312	1091	1871	2651	3119	3119	3119	3119	3119	3119	3119	3119	3119	3119	37110
1.2.2	Income from the sale of recycled water		277	970	1663	2356	2772	2772	2772	2772	2772	2772	2772	2772	2772	2772	32987
1.3	Recovery of residual value of fixed assets															6033	6033
1.4	Recovery of working capital															173	173
2	Cash outflow	**3017**	**15285**	**16097**	**16908**	**14702**	**3418**	**3245**	**3245**	**3245**	**3245**	**3245**	**3245**	**3245**	**3245**	**3245**	**98632**
2.1	Fixed asset investment in water saving projects	1788	8938	8938	8938	7150											35751
2.2	Annual operating fee of water saving project		36	215	393	572	715	715	715	715	715	715	715	715	715	715	8366
2.3	Wastewater project investment	1229	6146	6146	6146	4916											24582
2.4	Annual operating fee of wastewater project		87	520	953	1386	1733	1733	1733	1733	1733	1733	1733	1733	1733	1733	20276
2.5	Sewage sales tax surcharge		14	49	83	118	139	139	139	139	139	139	139	139	139	139	1649
2.6	Income tax on wastewater projects		66	230	395	560	658	658	658	658	658	658	658	658	658	658	7834
2.7	Working capital for wastewater projects						173										173
3	Net cash flow	**-3017**	**-14080**	**-11879**	**-9678**	**-4461**	**8631**	**8804**	**8804**	**8804**	**8804**	**8804**	**8804**	**8804**	**8804**	**15011**	**50958**
4	Cumulative net cash flow	**-3017**	**-17097**	**-28977**	**-38655**	**-43116**	**-34485**	**-25681**	**-16877**	**-8073**	**731**	**9535**	**18339**	**27143**	**35948**	**50958**	

financial internal rate of return	**11.06%**	**%〉8%**	**benefit cost ratio**	**1.20**	**〉1.00**
financial net present value	**CNY7608**	**million 〉0**			

ANNEX 5. BORROWER, CO-FINANCIER AND OTHER PARTNER/STAKEHOLDER COMMENTS

Foreign Environmental Cooperation Center, Ministry of Ecology and Environment
Feedback on the Implementation Completion Report (ICR)

The Implementation Completion Report (ICR) of the GEF Mainstreaming Integrated Water and Environment Management Project (hereinafter, the "Project") has been received. We fully agree with the contents and assessment results of the ICR without objection.

Since the Grant Agreement of the Project was signed and the Project was started in 2016, World Bank Project Manager Mr. Jiang Liping and his expert team have conducted comprehensive inspection, guidance and technical support in terms of project management, technical assistance, procurement management, safeguard policies, etc. The GEF PMOs of the Ministry of Ecology and Environment, the Ministry of Water Resources, and Shijiazhuang and Chengde Municipalities in Hebei Province have established a cross-sectoral cooperation mechanism, and signed a cross-sectoral cooperation agreement in light of the Grant Agreement, Project Appraisal Document (PAD), Project Implementation Plan (PIP), and other relevant documents of the Project to promote project implementation actively. Based on the project inspection and performance evaluation results, the water resources, environment and ecology in the project area, extension area and pilot areas (the Chengde demonstration area in the Luan River sub-basin and the Shijiazhuang demonstration area in the Hutuo River sub-basin) have been improved comprehensively, and excellent economic, social and ecological benefits generated. Based on the comprehensive evaluation by the World Bank ICR mission, the project outcome and process indicators reach or exceed the expected target values, and the final evaluation result is "highly satisfactory".

As the next step, the GEF PMOs of the Ministry of Ecology and Environment, and the Ministry of Water Resources will continue to give play to the cooperation mechanism between the environmental protection and water resources sectors, and actively communicate and extend the advanced concept of basin and regional integrated water resources and environment management (IWEM) based on evaporation and transpiration (ET), environmental capacity (EC) and ecosystem services (ES), technical approaches, and pilot area practices advocated by the Project to China and the international community together with the competent authorities and GEF PMOs of Shijiazhuang and Chengde Municipalities in Hebei Province, thereby promoting the active application of the project outcomes and cases to the integrated water and environment management, and ecological protection of more regions and basins, and further serving China's ecological civilization construction and green development. In addition, we will continue to strengthen good cooperation with the World Bank and other international organizations, further share China's practices of strengthening basin and regional integrated water resources and environment management with the international community and contribute to the UN 2030 Sustainable Development Goals.

GEF PMO, Ministry of Water Resources
Feedback on the Implementation Completion Report (ICR)

The Implementation Completion Report (ICR) of the GEF Mainstreaming Integrated Water and Environment Management Project (hereinafter, the "Project") has been received. We fully agree with the contents and assessment results of the ICR without objection.

Since the Grant Agreement of the Project was signed and the Project was started in 2016, you and the World Bank expert team have offered thorough and comprehensive technical guidance and support in terms of project direction, key technologies, project management, procurement, finance, securities, project monitoring, project development, etc. The GEF PMOs of the Ministry of Water Resources and Shijiazhuang Municipality in Hebei Province have established a ministerial project leading group, a cross-sectoral cooperation mechanism and a multi-party implementation system, and signed a cross-sectoral cooperation agreement in light of the Feasibility Study Report, Grant Agreement, Project Appraisal Document (PAD), Project Implementation Plan (PIP), memorandum, and other relevant documents of the Project. By conducting extensive public participation and coordination, and pooling grassroots forces, you have overcome impacts of COVID-19 and promoted project implementation effectively. The project inspection and performance evaluation results show that the water resources, environment and ecology in the project area, extension area and the Shijiazhuang demonstration area in the Hutuo River sub-basin have been improved comprehensively, significant effects achieved in ecological civilization construction and sustainable development, and excellent economic, social and ecological benefits generated. Based on the comprehensive evaluation by the World Bank ICR mission, the project outcome and process indicators reach or exceed the expected target values, and the final evaluation result is "highly satisfactory".

The Project has creatively developed new ideas, approaches, technologies and systems by integrating evaporation and transpiration (ET), environmental capacity (EC) and ecosystem services (ES), and based on human-nature harmony. It surpasses ideas and dimensions of traditional water resources and environment management, and embodies the philosophy of harmonious coexistence and a shared fate between humans and nature. This is the unification between humans and nature, between passivity and initiative, between necessities and limitations, and between natural and social productivity, an objective choice for high-quality and green economic and social development, and an embodiment of sustainable development and ecological civilization, and provides a beneficial code of conduct and strategy for human-nature harmony. As the next step, we will continue to give play to the cooperation mechanism between the environmental protection and water resources sectors, and actively communicate and extend the advanced concept of basin and regional integrated water resources and environment management (IWEM) based on ET, EC and ES together with the competent authorities, thereby promoting the active application of the project outcomes and cases to the IWEM and ecological protection of more regions and basins, and further serving China's ecological civilization construction and high-quality development. In addition, we will continue to strengthen good cooperation with the World Bank and other international organizations, further share China's practices of strengthening basin and regional IWEM with the international community, promote sustainable resource utilization and social development, contribute to the building of a community with a shared future for mankind using Chinese wisdom, and take human civilization to the next level.

ANNEX 6. SUPPORTING DOCUMENTS

List of Studies under Intermediate Indicator I-3

Studies supported by the GEF Grant

1. Luan river basin water pollution integrated monitoring and evaluation
2. Luan river basin water ecology evaluation and protection study
3. Pollutant discharge quota management based on ET and EC approaches in Luan river basin
4. Development and application of remote sensing monitoring of non-point source pollution
5. ET-based water accounting and auditing in industrial parks
6. Point source pollution emission trading study and demonstration
7. Chengde IWEM integrated management platform development
8. Chengde IWEM and ecosystem protection and restoration study and dissemination
9. Piloting and demonstration of ET-based water right allocation and trading (Jinzhou)
10. Demonstration and promotion of IWEM approaches
11. Piloting and demonstration of ET-based groundwater management (Gaocheng)
12. Piloting and demonstration of ET-based water accounting and auditing in industrial parks and irrigation districts (Gaocheng)
13. Piloting ET-based agricultural water management in WUAs (Jinzhou)

Studies supported by the Government's Counterpart Funds

14. Demonstration and implementation report on integrated groundwater management in Zhengding, 2016
15. Implementation report on integrated groundwater management in Yuanshi, 2016
16. Demonstration and implementation report on integrated groundwater management and agricultural water saving in Luancheng, 2016
17. Demonstration and implementation report on integrated groundwater management and agricultural water saving in Zhengding, 2017
18. Demonstration and implementation report on integrated groundwater management and agricultural water saving in Jinzhou, 2017
19. Demonstration and implementation report on integrated groundwater management in municipal areas, 2016
20. Demonstration and implementation report on integrated groundwater management and agricultural water saving in Shenzhe, 2017
21. Demonstration and implementation report on integrated groundwater management and agricultural water saving in Luquan, 2017
22. Demonstration and implementation report on integrated groundwater management and surface water irrigation management in Zhengding, 2018
23. Demonstration and implementation report on integrated groundwater management and surface water irrigation management in Luquan, 2018
24. Demonstration and implementation report on integrated groundwater management and surface water irrigation management in Pingshan, 2018
25. Demonstration and implementation report on groundwater overdraft management and agricultural water saving in Luquan, 2018

26. Demonstration and implementation report on surface water irrigation management in Yuanshi, 2018
27. Demonstration and implementation report on groundwater irrigation management in Yuanshi, 2018
28. Demonstration and implementation report on surface water irrigation management in Zanghuang, 2018
29. Demonstration and implementation report on groundwater irrigation management in Zanghuang, 2018
30. Demonstration and implementation report on surface water irrigation management in Pingshan, 2018
31. Demonstration and implementation report on irrigation modernization in Lingshou, 2018
32. Demonstration and implementation report on high quality farmland development in Lingshou, 2018

List of Studies under Intermediate Indicator I-1

Reports supported by the GEF Grant

1. Urban environmental evaluation methodology based on environmental carrying capacity (Chengde)
2. Policy study on point source pollution emission permit management and trading (Chengde)
3. Policy study on ET-based water right allocation and trading
4. Policy study on local water service delivery

Reports supported by the Government's Counterpart Fund

5. Managed aquifer recharge in Hebei (2017-2022)
6. Integrated groundwater management model study in Hebei
7. Water quality compliance research (Chengde, 2016)
8. Water pollution management plan (Chengde, 2016)
9. Precise water quality monitoring and regulation (Chengde)

List of Studies under Intermediate Indicator I-9

Reports supported by the GEF Grant

1. EC-based national river basin GIS management platform development
2. Integrated, Intelligent and International Platform for Environmental Technology
3. Information system development, operation and maintenance
4. Assessment and control of comprehensive toxicity pollution control and management
5. ET-based water resources evaluation
6. Water consumption management for irrigation districts
7. Remote sensing-based groundwater withdrawal assessment and model simulation
8. Remote sensing-based ET monitoring and assessment for irrigation district

Reports supported by the Government's Counterpart Fund

9. Hebei hydrogeological assessment and 3-D groundwater development (Shijia Zhuang)
10. Groundwater overdraft management and evaluation (2018-2019)
11. Total phosphorous assessment and control (Chengde, 2018-2019)
12. Integrated monitoring on water quality and water function zone (Chengde, 2020-2021)

ANNEX 7. HISTORY OF ET MANAGEMENT AND IWEM DEVELOPMENT IN CHINA

World Bank and China's Engagement in Irrigation Sector in 40 Years—History of ET Management and IWEM Development

1. **There are four stages of engagement between the World Bank and China in irrigation sector.** Driven by the Government's needs of expanding irrigated lands and rehabilitating deteriorated irrigation infrastructure in 1980s, the initial World Bank's irrigation investments in China mainly focused on the irrigation development at farmland scale (Stage I, 1980s-mid-1990s); Recognizing the impacts of continuous expansion of irrigated areas on the downstream industrial, domestic and environmental water use, the World Bank's supports shifted from farmland-scale irrigation improvement to integrated agricultural water management at basin scale (Stage II, 1990s-early 2000s); Built upon the irrigation management experience in water scarcity areas and the advanced remote sensing technology, the World Bank supported China to explore a new approach of ET (evapotranspiration) management to address the "Paradox of Irrigation Efficiency"[45] (Stage III, 2000s-2010s); The ET management approach was gradually accepted by the governments. Currently, the engagement moves to a new stage—the World Bank is supporting the Chinese central government to mainstream the ET management approach (Stage IV, mid-2010s-present).

Stage I. Irrigation Improvement at Farmland Scale (1980s-mid-1990s)

2. **While China had achieved significant development in irrigation sector before 1978, there were emerging challenges of irrigated land area decline and infrastructure deterioration in 1980s.** Since the founding of the People's Republic of China in 1949, the Government of China had invested heavily in irrigation infrastructure, as the new nation struggled with low agricultural productivities and poverty. The effective irrigated land areas had increased three times from 1950 to 1978, and near half of the cultivated land areas already had access to irrigation water by 1978. Since the reforms and opening-up in 1978, China's infrastructure investment shifted from agriculture sector to industrial and other sectors. The development of new irrigation infrastructure slowed down and the operation and maintenance (O&M) of existing irrigation facilities was widely neglected. As a result, the irrigated land areas were slightly declined in 1980s and many irrigation facilities became deteriorated or dysfunctional. The grain production peaked in 1984 and then declined and stagnated in the late 1980s. [46]

3. **Driven by the government's urgent needs, the World Bank supported the country to develop and rehabilitate irrigation facilities at farmland scale to increase productivity.** The projects at this stage focused on developing and rehabilitating the irrigation and drainage systems for the low yielding lands. Meanwhile, these projects also had alleviated waterlogging and salinity issues; intensified crops and diversified crop types; and provided reliable irrigated water by building reservoirs and applying conjunctive surface water and groundwater use. The projects covered some major grain production regions in China, including the North China Plains, Songliao Plain, Hetao Irrigation District, Pishihang

[45] "Paradox of Irrigation Efficiency" refers that an increase in irrigation efficiency at a farm scale fails to increase the water availability at a basin scale. See more explanation in paragraph 13.
[46] Wang, J., Zhu, Y., Sun, T., Huang, J., Zhang, L., Guan, B. and Huang, Q. (2020), Forty years of irrigation development and reform in China. Aust J Agric Resour Econ, 64: 126-149. doi:10.1111/1467-8489.12334

Irrigation District, and other wide irrigated lands in Gansu, Hebei, Henan, Jiangsu, Ningxia, Shaanxi, Shandong, Sichuan and other provinces.

Stage II. Integrated Irrigation Management at Basin Scale (1990s-early 2000s)

4. **The increased water competition between agriculture and other sectors required a more integrated irrigation management beyond the farmland scale**. The unprecedented economic and social development after 1978 reforms led to increasing competition of water resources among different sectors. The expansion of irrigated areas and the increasing water demands had significantly impacted the downstream environment, especially in water scarcity areas. For example, the lower reach of the Yellow River dried up for 226 days in 1997. Recognizing these challenges, the government's strategies shifted from expanding irrigated lands to promoting water-saving irrigation techniques and increasing irrigation efficiency. However, to fully address these issues, irrigation management should move beyond the farmland scale to establish a more integrated agricultural water management approach at river basin scale.

5. **The Tarim Basin I and II Projects[47] are the World Bank's first endeavor to manage irrigation at basin scale in China.** The Tarim River is the longest inland river in China under an extremely arid climate with the annual precipitation of 60 mm. The large expansion of irrigated lands caused severe ecosystem degradation since 1970s. Over 300 km long lower reaches totally dried up for decades, the downstream lakes of Lopnor and Taitema vanished, and large areas of natural riparian vegetation died. The World Bank supported the irrigation development, integrated water resources management and ecosystem restoration through the Tarim Basin Project (1991-1997) and the Tarim Basin II Project (1998-2004).

6. **A water quota system was developed to restrict irrigation water use and allocate water for downstream environment.** The Tarim Basin Project improved irrigation and drainage systems, while attempted to partially restore downstream ecosystem by releasing water to downstream. The follow-up Tarim Basin II Project further rehabilitated irrigation infrastructure and supported the farmers to improve productivity and diversity crops into higher-value agricultural products. As a result, the farmers' incomes were increased, while the irrigated water use was reduced and the expansion of irrigated lands was under control. A water quota system was introduced to establish annual water quota for each sub-basin every year, restrict irrigation water use, and allocate the reduced water consumption to downstream environment. A total of 1.7 billion cubic meters of water was released to downstream during the project implementation, leading to the restoration of Taitema Lake, rising of groundwater level, and revitalization of riparian vegetation.

7. **Tarim Basin Water Resources Commission (TBWRC) was established and enhanced to manage the basin water resources and implement the water quota system.** In 1992, the Xinjiang Uygur Autonomous Region (XUAR) government issued three regulations to establish the Tarim River Basin Management Committee and the Tarim River Basin Management Bureau (TRBMB) under the Tarim Basin Project. The TRBMB was upgraded into the TBWRC during the preparation of the Project II. The Project II further strengthened the institutional capacity and reformed the institution structure of the TBWRC. International experience, especially the experience from the Murry-Darling River Basin management in Australia, was introduced to support the institutional reforms through the AusAID grant.

[47] Tarim Basin Project (P003556, 1991-1997), Tarim Basin II Project (P046563, 1998-2004)

Headed by the Vice Governor of the XUAR government, the TRBMB was responsible for basin planning, water allocation, annual water quota development and implementation, and water user engagement.

8. **The new ideas of reducing non-beneficious ET and increasing beneficial ET were supported in the Tarim Basin II Project.** In arid areas, water management should pay attention to consumptive water use—the water is consumed and escapes river basin through evaporation and transpiration, which cannot be reused by the downstream users and environment. Built upon the estimation of water consumption of different land use types in the Project I, the Project II proposed the ideas to reduce non-beneficial evapotranspiration (ET) and increase the beneficial ET for crops.[48] The water quota system was based on the analysis of consumptive water use. The Project also supported a series of research to study how to convert non-beneficial ET to beneficial ET, and explore the possibilities of applying remote sensing to monitor ET. However, the remote sensing technology was not mature enough to separate beneficial and non-beneficial ET at that stage.

9. **The basin-scale irrigation management was also carried out in other basins, such as the Yellow River Basin and Yangtze River Basin.** For example, the Second Loess Plateau Watershed Rehabilitation Project[49] addressed the water scarcity and soil erosion issues in the Yellow River Basin. The Project supported the conversion of slope lands to terraced lands to reduce soil erosion and increase water retention, and the development of small-sized irrigation schemes by catching surface runoff. The Yangtze Basin Water Resources Project[50] addressed both infrastructure and institutional areas. It rehabilitated a large area of irrigation systems and established Self-financing Irrigation and Drainage Districts (SIDDs) to build a cost-effective system for infrastructure O&M through the farmer participatory irrigation management.

Stage III. Pilots of ET Management (2000s-2010s)

10. **More evidences identified the "Paradox of Irrigation Efficiency" that increasing irrigation efficiency at farmland scale may fail to increase water availability at basin scale, especially in water scarcity areas.** The government promoted water-saving irrigation techniques to increase irrigation efficiency and improve the "crop per drop". The original purpose was to "save" water by increasing irrigation efficiency and the "saved" water was expected be reallocated to other sectors, including cities and environment. However, the water-saving irrigation techniques may increase on-farm water consumption per hectare and reduce return flows. The water consumption escapes the basin through ET and is no longer available for other sectors. But the return flows, perceived as water losses in irrigation sector, are usually reused by the other sectors within the basin. Therefore, contrary to the policy intent, the investments in irrigation efficiency improvement may lead to the increases in water consumption, rather than the increases in water availability within the basin—a phenomena called "Paradox of Irrigation Efficiency". [51]

[48] Beneficial ET (or Beneficial Water Consumption) refers to the water evaporated or transpired for the intended purpose. The beneficial ET for crops means the transpiration from crops, which is critical for crop production. Non-beneficial ET (or Non-beneficial Water Consumption) is the water evaporated or transpired for non-intended purposes, such as the evaporation from weeds, soil and open water surfaces in the field.
[49] Second Loess Plateau Watershed Rehabilitation Project (P056216, 1999-2005)
[50] Yangtze Basin Water Resources Project (P003596, 1995-2005)
[51] Grafton, R. Q., J. Williams, C. J. Perry, F. Molle, C. Ringler, P. Steduto, B. Udall, S. A. Wheeler, Y. Wang, D. Garrick, R. G. Allen (2018), The paradox of irrigation efficiency, Science, Vol 361, Issue 6404: 748-750

11. **To address the "Paradox of Irrigation Efficiency", the World Bank worked with the Ministry of Water Resources (MWR) to demonstrate the application of ET management in the Water Conservation Project.**[52] At the time of project identification, the government was implementing its national irrigated agriculture water saving program, which widely invested in water-saving irrigation techniques without explicitly addressing water scarcity and groundwater overdraft issues. This Project targeted a reduction in consumptive water use, instead of increases in irrigation efficiency. Therefore, the MWR considered this Project as a demonstration project of ET management in order to provide guidance on the government's water saving strategy. The Project introduced a concept of "real" water saving, indicating the return flows saved by water saving techniques are not "real" water saving because the return flows can recharge the groundwater or return to downstream surface water system and may become available for other users. The "real" water saving should address the water escapes the basin hydrologic system, such as ET. The Project tested how to combine different irrigation system improvement at the tertiary level and on-farm with various agronomic measures to optimize soil water availability for crops and increase agriculture production per unit of ET. Four irrigation technologies were provided, including the surface irrigation, low pressure pipe irrigation, sprinkler irrigation and drip irrigation. To test the most appropriate irrigation technology, the Project was designed on a programmatic basis to determine the first-year investment at appraisal, adjust the subsequent investments based on the lessons learned from previous years, and agree on the following investments based on annual work programs. This flexible approach allowed mixing and testing different technologies in different project areas. The Project aimed to reduce total water consumption (ET), rather than reduce beneficial or non-beneficial ET. Remote sensing technology was also tested to monitor the ET.

12. **The ET management approach was further developed to set up a cap on basin water consumption (target ET) and incorporated the cap into basin water resources management**. A grant from the Global Environment Facility (GEF)[53] was provided to further develop the ET management approach. The maximum consumptive use of water (target ET) and the maximum discharge of water pollution loads were identified at both river basin level and water user level. An integrated water and environment management planning was developed for the Hai River Basin, considering the constrains of the cap on water consumption (target ET) and the cap on water pollution discharge. Remote sensing technology was widely used to monitor the spatial and temporal changes of ET and land cover types. With the support of this GEF grant, the ET management approach was further fostered—the procedures of ET-based water resources management became clear and the advanced remote sensing technologies were demonstrated to be mature enough to support the ET management.

13. **Built upon the previous experience, the Xinjiang Turpan Water Conservation Project[54] was the first comprehensive, basin-wide application of the ET management**. The Turpan Prefecture in Xinjiang Uygar Autonomous Region is one of China's poorest and most arid regions. Since 2000, the local government promoted the investments in modern irrigation technologies (mainly drip irrigation) with the intention to save water. Meanwhile, the irrigated land areas were significantly increased. However, the expected water savings were not realized. The unsustainable irrigation modernization and irrigated

[52] Water Conservation Project (P056516, 2000-2006)
[53] Hai Basin Integrated Water and Environment Management Project (P075035, 2004-2011)
[54] Xinjiang Turfan Water Conservation Project (P111163, 2010-2017)

land expansion had increased basin water consumption and groundwater overdraft, leading to the continuous groundwater decline, degradation of oasis and the vanishment of Aiding Lake. The Xinjiang Turpan Water Conservation Project applied an ET-based integrated water resources management in the Turpan Prefecture to address these irrigation associated issues.

14. **During project preparation, a comprehensive and detailed water balance analysis was carried out at basin level using remote sensing technology, in order to setup a cap for basin water consumption.** A water balance analysis was conducted based on water consumption—the actual water consumed by agriculture, ecosystems, bare lands and water surface was estimated through remote sensing using satellite images; the actual water consumption by the industrial and domestic sectors were converted from the water use data collected through field studies; the precipitation and surface water inflow and outflow were from local hydrological data; and the total groundwater withdrawal was estimated from the water balance equation. A cap for basin water consumption (target ET) was setup to reduce the overexploitation of groundwater, based on the water balance results and the negotiation with the governments and stakeholders. The basin-level water consumption cap was then allocated to farmland level, so that the farmers knew how much water consumption they needed to reduce in their lands.

15. **A series of agronomic, engineering and institutional practices were implemented to reduce water consumption to achieve ET reduction target, while increase farmer's incomes.** The crop pattern adjustment was promoted, to shift from high-water demand, low-value crops to low-water demand, high-value agricultural products. Various agronomic practices were applied to optimize irrigation water use and control soil salinity. The engineering approaches were used to increase water productivity by installing modern drip and low-pressure irrigation systems and lining the canals. These engineering approaches were carefully planned under the cap of water consumption. Some innovative institutional practices, such as ET-based water right system and ET-based water pricing, were piloted and tested. The Project also made a difficult decision to reduce the low-productive irrigated lands—the water balance analysis showed that the local water resources was unable to sustain the water use of large irrigated land areas. The uncontrolled, rapid irrigated land expansion had already threatened the safety of drinking water and the sustainability of ecosystems. Therefore, with strong government commitment and proper incentives to farmers, the Project was able to gradually reduce a portion of low-productive irrigated lands.

16. **Remote sensing technology played a critical role to support project preparation and implementation.** During project preparation, remote sensing technology was used to carry out a comprehensive water balance and gather historical data on farmland-level water consumption. During project implementation, remote sensing was used to monitor the actual ET from each farmland, which provided clear evidence on how much ET was reduced at farmland level and across the basin. Remote sensing was also applied to monitor the changes of crop pattern, the reduction of irrigated lands and the restoration of ecosystems. In addition, an ET-based water management platform was developed using the data derived from satellite images. Remote sensing technology provided high-resolution, basin-wide water and land use information at relatively low costs, and demonstrated to be a powerful tool for the ET management.

17. **The institutional development, especially the water user associations (WUAs), acted as a**

channel to embrace the new irrigation management approach in many projects. For example, the WUAs were established in the Tarim Basin II Project and the Yangtze Basin Water Resources Project, in order to promote participatory irrigation management, introduce efficient irrigation and agronomic practices, and collect and use irrigation water tariffs. In the Turpan Water Conservation Project, the ET information derived from the remote sensing was distributed to the WUAs. Then the WUAs informed farmers whether their water consumption exceeded the target ET based on remote sensing data. If the actual water consumption was higher than the target, the WUAs would organize the farmers to make improvement for the next year. The WUAs also played important roles to organize the farmer to adjust crop patterns, and provide trainings on the application and O&M of modern irrigation facilities and the agronomic practices.

Stage IV. Mainstreaming ET Management (Stage IV, mid-2010s-present)

18. **While the World Bank supported the ET management in water scarcity regions, the government also gradually recognized the issues associated with irrigation efficiency improvement and adjusted its strategies accordingly**. In 2007, the National Development and Reform Commission (NDRC), the MWR, and the Ministry of Construction jointly launched the *"Water Saving Society Construction for the 11th Five-Year Plan"*,[55] which mentioned that "agricultural water saving may have some negative impacts on ecology and environment…in the Northwest regions, the water saving in surface water irrigation districts may reduce the discharge to groundwater." But it also concluded that "the positive effects of agricultural water saving are much greater than its negative impacts." However, the government's strategies changed in recent years. For example, eight ministries jointly issued the *"National Agricultural Sustainable Development Plan (2015-2030)"*.[56] The Plan highlighted that "in the areas of surface water and groundwater overused, it is needed to reduce irrigated lands, adjust crop patterns, and reduce the cropping areas of high water consuming crops." In 2018, the MWR issued the "*Guiding Opinions on Deepening Farmland Water Conservancy Reform*",[57] emphasizing the needs to determine irrigated land areas and agricultural production based on water availability, and determine a rational cap for irrigation water use. In 2019, NDRC and MWR jointly issued the "*National Water Saving Action Plan*",[58] which urges the optimization and adjustment of crop pattern according to water resources availability. These new national strategies are well aligned with the Bank's practices in the ET management.

19. **The World Bank worked with the central government to mainstream the ET management approach**. Supported by the GEF Mainstreaming Integrated Water and Environment Management Project,[59] the World Bank worked with the MWR and the Ministry of Environmental Protection (MEP) to

[55] National Development and Reform Commission, Ministry of Water Resources, Ministry of Construction, Water Saving Society Construction for the 11th Five-Year Plan, https://www.ndrc.gov.cn/fggz/hjyzy/sjyybh/200702/t20070215_1133556.html
[56] Ministry of Agriculture, National Development and Reform Commission, Ministry of Science and Technology, Ministry of Finance, Ministry of Land and Resources, Ministry of Environmental Protection, Ministry of Water Resources, State Forestry Administration, National Agricultural Sustainable Development Plan (2015-2030), http://www.gov.cn/xinwen/2015-05/28/content_2869902.htm
[57] Ministry of Water Resources, Guiding Opinions on Deepening Farmland Water Conservancy Reform, http://www.gov.cn/xinwen/2018-03/04/content_5269774.htm
[58] National Development and Reform Commission, Ministry of Water Resources, National Water Saving Action Plan, https://www.ndrc.gov.cn/xxgk/zcfb/ghxwj/201904/t20190418_960963.html
[59] GEF Mainstreaming Integrated Water and Environment Management (P145897, 2016-2021)

increase irrigation water use efficiency under a cap of water consumption, and reduce water pollution under a cap of pollution discharge. The policy recommendations suggested under this Project were incorporated into the water consumption control policies issued by the MWR and the pollution control policies issued by the MEP. The Project prepared the operational manuals and guidelines to mainstream the ET management approach. The Project also supported the MWR to develop a National Water Consumption Monitoring and Management Platform to monitor and manage ET nationwide based on remote sensing technology.