Annex-II Small-Scale Hydropower Subtask A5 "Sustainable Small-Scale Hydropower in Local Communities"

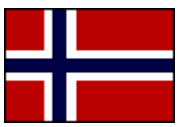
IEA Hydro Technical Report

Guide for Sustainable Small-Scale Hydropower Project

March 2019

IEA Hydropower Agreement: Annex II

JAPAN



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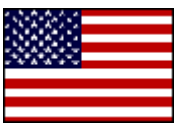

USA

OVERVIEW OF THE IEA TECHNOLOGY COLLABORATION PROGRAMME ON HYDROPOWER

The IEA Technology Collaboration Programme on Hydropower (IEA Hydro) is a working group of International Energy Agency member countries and others that have a common interest in advancing hydropower worldwide. Member governments either participate themselves, or designate an organization in their country to represent them on the Executive Committee (ExCo) and on the Annexes, the task forces through which IEA Hydro's work is carried out. Some activities are collaborative ventures between the IA and other hydropower organizations.

Vision

Through the facilitation of worldwide recognition of hydropower as a well-established and socially desirable energy technology, advance the development of new hydropower and the modernisation of existing hydropower

Mission

To encourage through awareness, knowledge, and support the sustainable use of water resources for the development and management of hydropower.

To accomplish its Mission, the Executive Committee has identified the following programme-based strategy to:

- Apply an interdisciplinary approach to the research needed to encourage the public acceptance of hydropower as a feasible, socially desirable form of renewable energy.
- Increase the current wealth of knowledge on a wide array of issues currently associated with hydropower.
- Explore areas of common interest among international organizations in the continued use of hydropower as a socially desirable energy resource.
- Bring a balanced view of hydropower to the worldwide debate on its feasibility as an environmentally desirable energy technology.
- Encourage technology development

IEA Hydro is keen to promote its work programmes and to encourage increasing involvement of non-participating countries. All OECD and non-OECD countries are eligible to join. Information about membership and research activities can be found on the IEA Hydro website www.ieahydro.org.

Quick Instructions

This guide is an interactive e-book based on the report "Sustainable Small-Scale Hydropower in Local Communities", Annex-II working group of the IEA Technology Collaboration Programme on Hydropower. In Chapter 3, about 290 "Effective Measures for Sustainability" extracted from Good Practices of small-scale hydropower project can be searched. Analyses on enablers of these measures are also provided.

Clicking on words, figure numbers or pages shown in blue letters move the user to the corresponding detailed charts when the user wants more information. Clicking the word of "back" under the chart, the user will be back to the previous pages. An example of the search in Chapter 3 is shown below.

Economic Benefits to local community

Effective Measures	Number of Corresponding Good Practices
Tax revenue and water rights income to local communities	13
Grant income to local communities	2
Revenue from public electric utilities	3
Local industrial development (Tourism and Recreation)	5
Local industrial development (Energy development)	9
Local industrial development (Agriculture · Forestry · Fishery Industries)	6
Creation of employment opportunities in the region	11
Economic benefits by promoting inter-regional human exchange	8
Sharing benefits with local communities	9

Click

Back

Link

Grant income to local communities

Effective Measures	Corresponding Good Practices		Reference
	Code	Page	
Revenue of grant to local municipality from the government	JP05	P79-80	Hydropower location grant
Revenue of grant equivalent to property tax to local municipality	JP06	P90	Fixed property tax for hydropower facility

Click

Back

Link

3. **Economic Benefits of the Project**

(1) Receiving fixed asset tax revenues

Both of the power stations pay fixed asset taxes to Jinsekikogen Town and Shobara City.

(2) Developing local infrastructures with grants

The government grant designed for communities hosting hydroelectric plants of a

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1. Introduction

1.1 Purpose of this Guide

In the planning of hydropower projects, it is increasingly important to incorporate the harmony with the environment and social acceptance of local communities in addition to the assurance of economic viability in order to enhance the sustainability of projects.

Small-scale hydropower projects are normally less efficient economically than large-scale projects, but they usually have less impact on the natural and social environments. They are also diversified in business, such as utilization of head in agricultural irrigation channels, electrification of off-grid remote areas or islands, adding to the traditional run-of-river projects in natural rivers.

This Guide is aimed at improving the economic and social sustainability of small-scale hydropower projects by systematically referring to effective measures in various existing schemes which can help enhance social acceptance of local communities as well as business profitability.

1.2 Structure and How to Use this Guide

This guide is intended to be used by planners, operation officers and decision makers of small-scale hydropower projects. The user can search and compare effective measures for sustainability systematically and efficiently in various types of existing projects. Such information helps them to improve sustainability of their relevant projects and facilitation measures.

This Guide consists of the main text (this document), reports of IEA Technology Collaboration Programme on Hydropower (IEA Hydro) and reference documents.

In the main text, Chapter 2 describes the concept of sustainability of small-scale hydro project and an overview of the data referable in this guide, Chapter 3 systematically presents the specific measures found in Good Practices of small-scale hydropower project and Chapter 4 provides notes on successful implementation of the measures.

The IEA Hydro reports referable in this guide summarize case history surveys conducted by a subtask group of the Small-Scale Hydropower Working Group, Annex-2, from 2012 to 2016. These reports can be downloaded in either English or Japanese from the following websites:

English version: https://www.ieahydro.org/about/past-achievements-and-completed-activities
(follow the links to Annex II)

Japanese version: http://www.nef.or.jp/ieahydro/actnow.html

We recommend that the user should understand the basic information in Chapter 2 and then conduct search for the specific measures in Chapter 3.

Search can be conducted in the group of measures categorized by the purpose of improving economic and social sustainability, and then the descriptions of specific measures from (in many cases more than one) corresponding IEA reports are displayed. There may be a number of description hits. Information from the IEA reports may be found also in chapters discussing the backgrounds or reasons of success other than the chapter introducing the corresponding measures. Not all descriptions, however, may be in detail. The information found in this Guide is limited to what is described in the IEA reports.

Chapter 4 provides a list of success factors of the measures and topics considered in each stage of the project in order to smoothly implement the measures for improving sustainability.

2. Concept of Sustainable Small-Scale Hydropower Project and Overview of Good Practices

2.1 Criteria of Sustainability and Definition of Good Practices

The Good Practices of small-scale hydropower project referred to in this guide are defined as “existing small-scale hydropower projects which have been proven economically and socially sustainable in the local community from the commissioning to the present time.”
“Economic sustainability” is required to meet the following three criteria by the revenue from the project:

- Recovering initial investment cost
- Paying for operation and maintenance cost
- Gaining appropriate profit

“Social sustainability” is evaluated by the economic and social benefits the project endows the local communities thereby establishing and maintaining favorable relationship.
Economic benefits are evaluated by the following five factors:

- Tax revenue or grant income of local municipality
- Creation of employment opportunities
- Local industry development
- Economic benefits from promotion of inter-regional human exchange
- Sharing of project benefits with local communities

Social benefits are evaluated by the following seven factors which are categorized into contributions to local environments and local communities:

Contributions to local environments:

- Improvement of local infrastructure (including energy infrastructure)
- Conservation of natural environment and ecological system
- Conservation of history and culture

Contribution to local communities:

- Activation of local community by promoting inter-regional human exchange
- Education, training and human resources development
- Development of local resources
- Contributions to policies of national and local governments

The above “development of local resources” includes energy, water, tourism resources, special local products, recreational opportunities, local brand and other hardware / software resources which activate local society.

2.2 Overview of Good Practices Referable in this Guide

The Good Practices collected by IEA Hydro are 23 cases from 10 countries shown in attached Table 2.1.

Breakdowns by region, ownership type and market type are shown in attached Figures 2.1-2.3.

The “ownership type” is categorized into five types below: The Good Practice reports also specify the organizational type in case the owner is not primarily running a power generation business.

- Electric Utility (UT)
- Public Electric Utility (PUT: local municipality or its public bureau)
- Wholesale Power Supplier (WP)
- Power Producer (PP)
- On-site Power Generator (OP)

The “market type” is categorized into seven types below:

- Electric Utility (UT)
- Public Electric Utility (PUT)
- Wholesale Power Supply (WP)
- Power Purchase Agreement (PPA)
- Support scheme for introducing renewable energy
  Feed-in Tariff [FIT] / Feed-in Premium [FIP] / Renewable Portfolio Standard [RPS], etc.
- Power Production and Sales (PPS) other than PPA or renewable energy support scheme
- On-site Power Generation (OP)

The start of plant operation is between 1914 and 2014, and all plants are still operating as of 2016. Some of them have been refurbished.
The output of plant is 10 MW or less per unit in general, but three projects of greater than 10 MW are included because the definition of small-scale hydropower varies among countries.

Characteristics of the project and primary social aspects in the Good Practices are provided in attached Table 2.2.
As categorized by keyword as shown in attached Fig. 2.4, social aspects in the Good Practices are mostly related to conservation of environment and culture, agriculture, indigenous people and municipality strategy.

3. Specific Measures for Good Practices

3.1 Specific Measures for Economic Sustainability

A list of measures is presented for each of the two categories below. To access more detailed information, click the page number of target article from the linked Good Practice Report (GPR). When there are multiple page numbers, move on pages to get to the corresponding page. In case a reference document is attached, click the corresponding title.
For returning to the Search Page from the GPR or reference document screen, either close the displayed page or switch the displayed file.
The measures common to both (1) and (2) below are displayed in both searches.

(1) Measures for recovering initial investment cost and reducing cost burden

(2) Measures for paying for operation and maintenance cost and gaining appropriate profit

3.2 Specific Measures for Social Sustainability

A list of measures is presented for each of the three categories below. To access more detailed information, click the page number of target article from the linked GPR. When there are multiple page numbers, move on pages to get to the corresponding page. In case a reference document is attached, click the corresponding title.
For returning to the Search Page from the GPR or reference document screen, either close the displayed page or switch the displayed file.
The measures common to two or more of (1) to (3) below are displayed in each of the searches.

(1) Measures for economic benefits to local community

(2) Measures for contribution to local environment

(3) Measures for contribution to local community

4. Factors Improving Project Sustainability

4.1 Success Factors of Measures for Sustainability

The Good Practice Report (GPR) describes “reasons of success” for the measures in each project. From the analysis of these reasons, common factors have been found such as clear vision regarding local contribution, strong local needs for hydropower project, leadership performed by the developers, utilization of partnership, communication with local communities, and support from government policies. Not a few cases can be found reducing construction and maintenance cost with high technological capability. A list of these success factors and corresponding Good Practices are presented in attached Table 4.1.

All Good Practices have more than one success factors. Most common factors among Good Practices are communication with local communities, support from government policies and clear vision regarding local contribution. It is deemed advantageous to implement many of the factors listed in Table 4.1 in order to successfully carry out various measures for sustainability of the project.

4.2 Consideration of Measures for Sustainability in Each Project Stage

Most of the GPRs do not describe clearly the stage in which specific consideration should be given to the possible measures for sustainability. Generally speaking, it is desirable to give such consideration as early as possible, but it may be difficult in some cases unless the project facility design or operational conditions are determined.

In a small-scale hydropower project, the project site, water intake quantity and generation output are determined first in the basic planning stage, and then, assessments of business profitability and environmental impact are conducted. When the results are feasible, the following steps are briefing to the local community, design, official approval procedure, construction and operation.

Therefore, we divided a project into four stages of planning, design, construction and operation and presented the measures for sustainability which should be considered in each stage in attached Table 4.2. This table helps find the possible measures to be specifically considered in each stage and obtain an overview of the measures throughout the project.

Attached tables and figures

Table 2.1: Outline of the Good Practices

(Back)

Code	Name of Power Plant	Country	Commis-sioning Year	Ownership Type	Market Type	Installed Capacity (MW)
CA01	McNair Creek	Canada	2004	PP/PC	PPA	9
CA02	Rutherford Creek	Canada	2004	PP/PC	PPA	49
CA03	Atlin	Canada	2009	WP	WP	2.1
CL01	Mallarauco	Chile	2011	WP	WP	3.43
DE01	Prater	Germany	2010	PUT	FIT	2.5
JP01	Kachugawa (3 plants)	Japan	2005	OP/LM	FIT	0.046 in total
JP02	Taio	Japan	2004	OP/LM	FIT	0.066
JP03	Nasunogahara (5 plants)	Japan	1992	OP/LRD	PPA	1.5 in total
JP04	Fujioiro (2 plants)	Japan	1914	OP/LRD	PPA	1.3 in total
JP05	Shin-taishakugawa (2 plants)	Japan	2003	UT	UT	13.4 in total
JP06	Kochi Prefecture Public Corporation Bureau (3 plants)	Japan	1953	WP/LM	WP	39.2 in total
JP07	Ochiairo	Japan	2006	PP/PC	FIT	0.1
NO01	Ljøsåa	Norway	2008	PP/PC	PPS	2.4
NO02	Jorda	Norway	2012	PP/LO	PPS	2.4
NO03	Storfallet (2 plants)	Norway	1990	PP/LO	PPS	7.7 in total
PH01	Ambangal	Philippines	2010	PP/LM	PPA	0.2
PT01	Canedo	Portugal	2008	PP/PC	FIT	10
UK01	Eigg Island (3 plants)	UK	2008	LUT	LUT	0.112 in total
UK02	Torrs	UK	2008	PP/IPS	PPA	0.063
UK03	Abernethy Trust	UK	2010	OP/NPO	FIT	0.089
US01	Power Creek (2 plants)	USA	2002	LUT/EC	LUT	7.25 in total
US02	Delta Creek	USA	1994	PUT/LM	PUT	0.8
ZA01	Brandkop Conduit Hydropower	South Africa	2015	OP/WUT	OP	0.096

PP = Power Producer, PC = Private Company, WP = Wholesale Power Supplier / Supply, UT = Utility

PUT = Public UT, OP = On-site Power Generator / Generation, LM = Local Municipality

LRD = Land Reclamation District, LO = Landowner, LUT = Local UT, IPS = Industrial and Provident Society

NPO = Non-Profit Organization, EC = Electric Cooperative, WUT = Water UT, PPA = Power Purchase Agreement

FIT = Feed-in Tariff, RPS = Renewable Portfolio Standard, PPS = Power Production and Sales

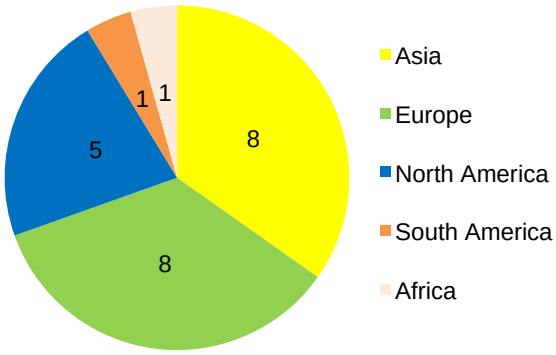

Fig. 2.1: Good Practices by Region

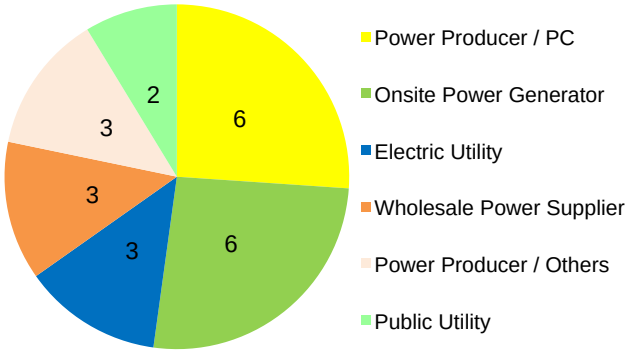

Fig. 2.2: Good Practices by Ownership Type

(PC = Private Company)

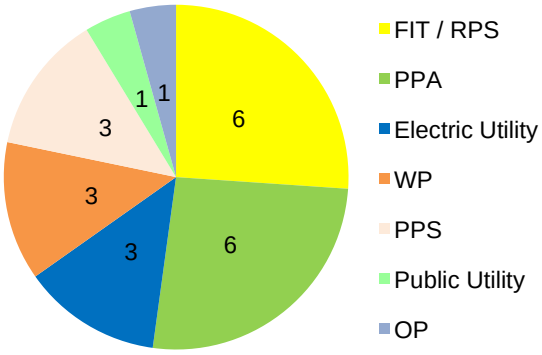

Fig. 2.3: Good Practices by Market Type

（FIT=Feed-in Tariff, RPS=Renewable Portfolio Standard, PPA = Power Purchase Agreement, WP=Wholesale Power Supply, PPS=Power Production and Sales, OP=Onsite Power Generation）

(Back)

Table 2.2: Characteristics of the Project and Primary Social Aspects in the Good Practices

(Back)

Code	Characteristics of the Project	Primary Social Aspects
CA01	Development in first nation's traditional area	Employment, Environmental conservation
CA02	Development in first nation's traditional area	Employment, Recreational use of tailrace
CA03	First nation's initiative in off-grid area	Education, training and employment
CL01	Collaboration of PC and irrigation union	Maintenance of facilities and cost reduction
DE01	Underground SHP in urban area by PUT	Municipality carbon strategy, Urban landscape
JP01	Public participation on-site SHP by municipality	Municipality environmental / regional strategy
JP02	On-site SHP using existing dam by municipality	Regional exchange, Tourism, Forest protection
JP03	On-site SHP using irrigation channel by LRD	Maintenance of facilities and cost reduction
JP04	On-site SHP using irrigation channel by LRD	Maintenance of facilities and cost reduction
JP05	Redevelopment of aged power plant by UT	Natural park, Tourism in dam reservoir
JP06	Wholesale power supply by public corporation	Improvement of environment around the dam, Forest conservation
JP07	Regeneration of decommissioned SHP by PC	River environment for tourism and fishery
NO01	Collaboration of PC and landowner	Agriculture promotion, Unused hydro potential
NO02	Collaboration of PC and landowner	Agriculture promotion, Unused hydro potential
NO03	Development by a landowner company	Agriculture promotion, Unused hydro potential
PH01	Public participation granted SHP by NGO	Conservation of historical rice terrace & culture
PT01	Reservoir type SHP by PC	Plant operation for irrigation and fish farm
UK01	Micro grid system in off-grid island	Stable power supply by demand management
UK02	Social contribution oriented SHP by IPS	Community support, Environmental education
UK03	On-site SHP by non-profit charity organization	Outdoor education program for young people, Dissemination of SHP
US01	Micro grid system in off-grid area by EC	Enterprise attraction, Support for first nation's renewable energy development
US02	Micro grid system in off-grid area by PUT	Stabilization of electricity fee in remote first nation's area
ZA01	On-site conduit SHP by water utility	Reduction of GHG from water supply plant, Excess power supply to electricity-deficit area

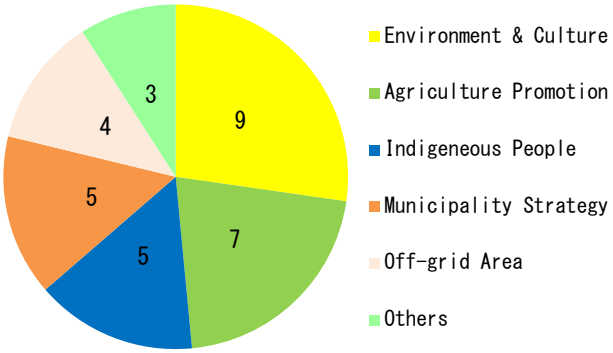

Fig. 2.4: Good Practices by Keyword for Social Aspects (some cases overlapped between keywords)

(Back)

Table 4.1: Factors Common to Successful Measures and Corresponding Good Practices

(Back)

Factors Common to Successful Measures	Number of Corresponding Good Practices
Communication with local communities	16
Support from government policies	15
Clear vision regarding local contribution	14
Strong local needs for hydropower project	10
Leadership performed by the developers	10
Utilization of partnership	10
High technological capability	6

Table 4.1.1: Good Practices Corresponding to “Communication with Local Communities”

(Back)

Outline of the Success Factor	Code of Good Practices
Community consultation on local contribution in the early stage of the project	CA01, CA02
Community consultation on power plant construction in the early stage of the project	PH01
Community consultation on various issues from planning to commissioning	PT01
Understanding and cooperation with the project in local community	CA03, CL01, UK02, UK03
Understanding and cooperation with the project in local agricultural community	JP03, JP04
Understanding and cooperation with the project in local off-grid island community	UK01
Redevelopment considering needs of local community and environmental conservation	JP05
Redevelopment of abolished power plant considering needs of local stakeholders	JP07
Community-participating development project promoted by local municipality	JP01
Promotion of local communication by improving local environment	JP06
Development of mutual relationship with local indigenous community	US01

Table 4.1.2: Good Practices Corresponding to “Support from Government Policies”

(Back)

Outline of the Success Factor	Code of Good Practices
Utilization of subsidies and grants	JP01-JP05, JP07, UK01 UK02, US01, US02
Utilization of FIT scheme	DE01, JP07, UK03
Utilization of support scheme for introduction of renewable energy by indigenous community	CA03
Utilization of environmental performance certification programme for products and services	CA01, CA02

Table 4.1.3: Good Practices Corresponding to “Clear Vision regarding Local Contribution”

(Back)

Outline of the Success Factor	Code of Good Practices
Activation of local economy through hydropower development by indigenous community	CA03
Activation of local economy through hydropower development in rural area	NO01, NO02
Promotion of agriculture by hydropower development using irrigation water	JP03, JP04
Tourism development and forest conservation using water power resources	JP02
Establishment of power self supply system using renewable energy in off-grid area	UK01, US01, US02
Hydropower project contributing to local environmental sustainability	UK02
Returning profit from municipal public bureau’s business to local welfare	JP06
Utilization of project profit by local municipality for conservation of World Heritage rice terrace	PH01
Contribution to municipal CO2 reduction policy by introducing renewable energy	DE01
Community-participating local development by raising public awareness for small-scale hydropower development	JP01

Table 4.1.4: Good Practices Corresponding to “Strong Local Needs for Hydropower Project”

(Back)

Outline of the Success Factor	Code of Good Practices
Improvement of energy security in off-grid area	CA03, UK01, US01, US02
Activation of local economy in de-popularizing rural area	NO01, NO03
Improvement of local environmental sustainability	UK02
CO2 reduction policy of local municipality by introducing renewable energy	DE01
Restoration of suspended hydropower project because of tight situation of power supply and demand	CL01

Table 4.1.5: Good Practices Corresponding to “Leadership Performed by the Developers”

(Back)

Outline of the Success Factor	Code of Good Practices
Leadership by local indigenous community’s company	CA03
Leadership by local municipality or public bureau	DE01, JP01, JP02, JP06
Leadership by land reclamation district	JP03, JP04
Leadership by family managed company of land owner	NO03
Leadership by social association in the United Kingdom	UK02
Leadership by electricity cooperative in the United States	US01
Leadership by water supply utility	ZA01

Table 4.1.6: Good Practices Corresponding to “Utilization of Partnership”

(Back)

Outline of the Success Factor	Code of Good Practices
Joint project of private hydropower developer and irrigation management association	CL01
Joint project of private hydropower developer and land and water right owners	NO01, NO02
Joint project of municipal bureau and environmental protection organization	DE01
Joint project of land reclamation district and national government	JP03
Joint project of residents in remote island, local municipality and environmental NGO	UK01
Cooperation of international NPO with municipal project	PH01
Support by local municipality and businesses for social association project in the United Kingdom	UK02
Partnership contract between plant owner and manufacturer	UK03
Joint development of conduit power generation system by water supply utility and university	ZA01

Table 4.1.7: Good Practices Corresponding to “High Technological Capability”

(Back)

Outline of the Success Factor	Code of Good Practices
Cost reduction by using new technologies for intake and penstock	CA01, CA02
Cost reduction by using new technologies for intake weir and turbine generator	JP07
Application of latest technologies of wind power generation to underground hydropower plant	DE01
Implementation of maintenance work for aged dam and redevelopment of power plant	JP05
Development of conduit power generation system in water purification plant	ZA01

Table 4.2: Topics Considered Regarding Project Sustainability in Each Stage

(Back)

Project Stage	Topics Regarding Economic Sustainability	Topics Regarding Social Sustainability
Planning	Financial procurement (subsidy, etc.) Market type (PPA, FIT, etc.) Joint investment	Income for local municipality (tax, etc.) Promotion of agriculture / forestry Development of local energy resources Local employment (indigenous people, etc.) Power supply for rural / off-grid areas Contribution to state and other policies
Design	New technologies (CE and EM facilities)* Use of existing facilities (dam, etc.) Rationalized design (simplified facility) Optimization of reservoir operation	Promotion of tourism and recreation Improving plant environment (roads, etc.) Improving disaster prevention function (emergency power supply, fireproof, etc.) Natural environment/ecosystem conservation Conservation of landscape, history and culture
Construction	Contract method (EPC, equipment lease, etc.) Local procurement of materials Resident participation in construction	Use of construction site (soil disposal site, temporary yard, etc.) Greening and tree planting Support for local municipality (compensation for construction, etc.)
Operation	Integrated maintenance of multiple plants Remote monitoring system Volunteer maintenance	Support for local community projects Reducing charges on irrigation beneficiaries Income from land / water right ownerships Enhancing inter-regional exchange (education, tourism, etc.)

* CE=civil engineering, EM=electrical and mechanical