INFORMATION COLLECTION SURVEY FOR THE EXPANSION OF THE COMMUNITY-BASED SMALLHOLDER IRRIGATION (COBSI) IN THE SUB-SAHARAN AFRICA

FINAL REPORT

FEBRUARY 2023

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

SANYU CONSULTANTS INC.

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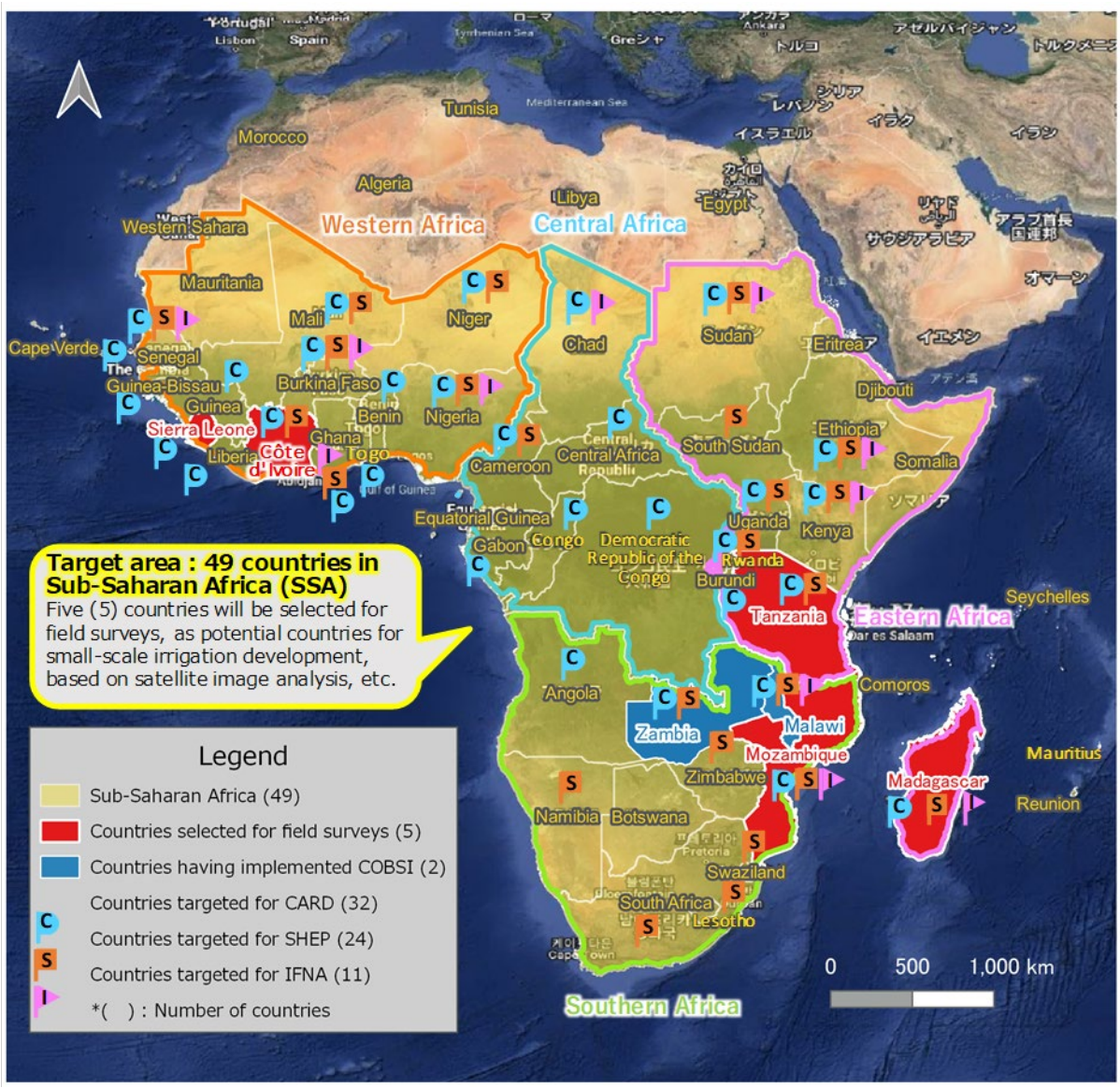
Location Map



Status of Irrigation Development in the Sub-Saharan Africa

Region	Number of countries	Population (in thousands)	Land Area (km^2)	Irrigable areas (thousand ha)	Irrigated areas (thousand ha)	Irrigation rate (%)
Eastern Africa	15	379,525	6,821,501	11,636	4,473	38.4
Central Africa	8	133,711	5,365,960	10,346	80	0.8
Western Africa	16	371,986	6,146,130	9,156	1,219	13.3
Southern Africa	10	176,842	5,967,760	7,989	698	8.7
Total	49	1,062,064	24,301,351	39,127	6,470	16.5

Source : FAO AQUASTAT
(Not including data on irrigable area, irrigated area and irrigation rate for South Africa)

TABLE OF CONTENTS

Note: (1) Rainy year: 1st rainy season sowing, (2) Rainy year: 2nd rainy season sowing,
(3) Drought year: 1st rainy season sowing, (4) Drought year: 2nd rainy season sowing

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND ACRONYM

3PIP	NAP Third Policy Implementation Plan
AE	Accredited Entity
AEW	Annual Evaluation Workshop
AfDB	African Development Bank
BEO	Block Extension Officer
CARD	Coalition for African Rice Development
CEO	Camp Extension Officer
CN	Concept Note
COBSI	Community-based Smallholder Irrigation Development
CSA	Agricultural Service Center
DAE	Direct Access Entity
DACO	District Agriculture Coordinator
DBZ	Development Bank of Zambia
DLI	Disbursement Linked Indicators
EOS	Earth Observing System
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
ESA	European Space Agency
ESIA	Environmental and Social Impact Assessment
EVI	Enhanced Vegetation Index
ESIA	Environmental and Social Impact Assessment
FAO	Food Agriculture Organization
FISP	Farmer Input Support Program
FLDAS	Famine Early Warning Systems Network Land Data Assimilation System
FP	Funding Proposal
FRA	Food Reserve Agency
FY	Fiscal Year
GCF	Green Climate Fund
GDP	Gross Domestic Product
HDI	Human Development Index
HIV	Human Immunodeficiency Virus
IDA	International Development Association
IFNA	The Initiative for Food and Nutrition Security in Africa
IGBP	International Geosphere-Biosphere Program
iTAP	Independent Technical Advisory Panel
JICA	Japan International Cooperation Agency
IUCN	International Union for Conservation of Nature
IWMI	International Water Management Institute
KOT	Kick off Training
LSWI	Land Surface Water Index
MLSWI	Modified Land Surface Water Index
MODIS	Moderate Resolution Imaging Spectroradiometer
MTT	Mid-Term Training
NAP	National Agricultural Policy
NASA	National Aeronautics and Space Administration
NDA	National Designated Authority
NDFI	Normalized Difference Flood Index
NDVI	Normalized Difference Vegetation Index
NERICA	New Rice for Africa
PACO	Provincial Agriculture Coordinator
PAO	Provincial Agriculture Officer
PforR/ P4R	Program for Results

PPF	Project Preparation Facility
REDD＋	Reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries
SAP	Simplified Approval Process
SAO	Senior Agriculture Officer
SCRALA	Strengthening climate resilience of agricultural livelihoods in agro-ecological regions I and II in Zambia
SHEP	Smallholder Horticulture Empowerment & Promotion
SIE	Senior Irrigation Engineer
SRTM	Shuttle Radar Topography Mission
SSA	Sub-Saharan African
TICAD	Tokyo International Conference on African Development
TOT	Training of Trainers
TSB	Technical Service Branch
UNDP	United Nations Development Programme
UN	United Nations
UNEP	United Nations Environment Program
UNESCO	United Nations Educational Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
WB	World Bank
WDPA	World Database on Protected Areas
WFP	World Food Programme
WUA	Water User’s Association
WWF	World Wildlife Fund

ABBREVIATIONS AND ACRONYM（Mozambique）

CSA	Agricultural Service Center
DAE	Direct Access Entity
DNAAF	National Directorate for Farming Family Assistant
DNDAF	National Directorate for Development of Family Agriculture
DPA	Provincial Department of Agriculture
DPAP	Provincial Directorate of Agriculture and Fisheries
DPEA	Provincial Department of Agricultural Extension
EPDA	Pre-viability and Definition of Scope Study
IIAM	Mozambique Institute of Agricultural Research
INIR	National Irrigation Institute
MADER	Ministry of Agriculture and Rural Development
MENU	Multisectoral Enhancement for Nutrition Upgrading
MOLE	Ministry of Land and Environment
MOPHRH	Ministry of Public Works, Housing, and Water Resources
NDWRM	National Directorate of Water Resources Management, ARA-Norte
PEDSA Ⅱ	Strategic Plan for the Agricultural Sector Phase 2
PNI	Programa Nacional de Irrigação
ProAPA	Project for Improvement of Rice Production in Zambezia Province
RPSAN	Provincial Division of Food and Nutritional Security
SER	Simplified Environmental Report
SETSAN	Technical Secretariat for Food Security and Nutrition
SDAE	District Services for Economic Activities

SPAE	Provincial Services for Economic Activities
SUSTENTA	Additional Financing to the Agriculture and Natural Resources Landscapes Management Project
TAC	The Technical Assessment Committee

ABBREVIATIONS AND ACRONYM（Sierra Leone）

ABC	Agricultural Business Center
BES	Block Extension Officer
EPA	Environmental Protection Agency
FBO	Farmer Based Organization
FEW	Front line Extension Worker
HCRC	Horticultural Crops Research Centre
IVS	Inland Valley Swamp
MAF	Ministry of Agriculture and Forestry
MWR	Ministry of Water Resources
NRDS	National Rice Development Strategy
NSADP	Comprehensive Africa Agriculture Development Programme
PEMSD	Planning, Evaluation, Monitoring and Statistics Division
RARC	Rokupr Agricultural Research Centre
SMS	Subject Matter Specialist
SRPP	Sustainable Rice Production Project

ABBREVIATIONS AND ACRONYM（Cote d'Ivoire）

ADR	Agent Rural Development
ANADER	National Agency for Support to Rural Development
ANDE	National Agency for the Environment
DGE	Directorate General of the Environment
DGRE	Director General of Water Resources
MEF	Ministry of Waters and Forests
MINEMINADER	Ministry of Agriculture and Rural Development
MINSEDD	Ministry of the Environment, Hygiene, and Sustainable Development
OCPV	Commodities Marketing Support Board
PNIA	National Agricultural Investment Program
PRORIL	Local Rice Promotion Project
TSCA	Technical Specialist of Annual Crops
TSOPA	Technical Specialist of Professional Agriculture Organization

ABBREVIATIONS AND ACRONYM（Tanzania）

DCD	Crop Development Division
DMI	Agricultural Mechanisation and Irrigation Division
DTER	Agricultural Training, Extension services and Research Division
EMU	Environment Management Unit
FFS	Farmers Field School
LGA	Local Government Authority
MoA	Ministry of Agriculture
NEMC	National Environmental Management Council
NIMP	National Irrigation Master Plan
NIRC	National Irrigation Commission

PoRALG	President’s office, Regional Administration and Local Government
TANSHEP	Project for Strengthening DADP Planning and Implementation capacity through Use of SHEP Approach

ABBREVIATIONS AND ACRONYM（Madagascar）

CDR	Rural Development Advisor
CIRAE	District of Agriculture and Livestock
DAPV	Plant Production Support Directorate
DGA	Directorate-General of Agriculture
DGEau	Directorate General for Water
DGR	Rural Engineering Directorate
DOPAB	Directorate of Support to Producers' Organization and Agro-business
DRAE	Regional Directorate of Agriculture and Livestock
DREDD	Regional Directorate of Environment and Sustainable Development
DRGPF	Director of Reforestation and Landscape and Forest Management
EIE	Initial Environmental Evaluation
FIFATA	Organization for the Development of Farmers
MECIE	The implementation investment compatible with the environment
MEDD	Ministry of Environment and Sustainable Development
MINAE	Ministry of Agriculture and Livestock
ONE	National Office of Environment
ONN	National Office Nutrition
ORN	Regional Office of Nutrition
PAPRIZ	Project for Promotion of Productivity Improvement and Industrialization of the Rice Sector
PASAN	Food and Nutrition Improvement Project
PGE	General state policy
PND	National Development Plan
PREE	Programme d’ Engagement Environnemental
SECRU	Environment, Climate and Emergency Response Department
SRA	Regional Department of Agriculture
SRGR	Regional Department of Rural Engineering
SRSISE	Regional Department of Information System and Monitoring & Evalution

Exchange rate (as of February 2023, JICA designated rate):

- 130.121 YEN/USD
- 141.4670 YEN/EUR
- 2.058870 YEN/MZN (Mozambican Metical: MT)
- 6.920420 YEN/SLE (Sierra Leonean Leone: Le)
- 0.215670 YEN/XOF (West African CFA franc: F.CFA) (Côte d'Ivoire)
- 0.055870 YEN/TZS (Tanzanian shilling: TZS)
- 0.030770 YEN/MGA (Malagasy ariary: Ar)
- 6.866580 YEN/ZMW (Zambian kwacha: K, ZK)

CHAPTER 1 OUTLINE OF THE SURVEY

1.1 Background of the Survey

The major challenge that Sub-Saharan Africa (SSA) faces is that many farmers depend on rainfed agriculture, which results in low and unstable agricultural production. Although sufficient arable land exists, less than 7% is irrigated.[1] In addition, there are many cases where irrigation facilities stopped functioning due to inadequate maintenance and management. To tackle these challenges, the Japan International Cooperation Agency (JICA) started implementing Community-Based Smallholder Irrigation (COBSI) development in Malawi (2002) and Zambia (2009).

COBSI is an irrigation development technological and methodological approach which enables smallholders to construct simple facilities *themselves* using locally available natural resources with a relatively small expenditure. Table 1.1.1 presents the list of COBSI projects implemented by JICA and the achievements of each project.

Table 1.1.1 List of COBSI Projects in Malawi and Zambia and its Achievement

Country	Project name (year of implementation)	No. of COBSI Sites Developed	Irrigated Area (ha)	No. of Participating Farmers
Malawi *1	The Study on the Capacity Building and Development for Smallholder Irrigation Schemes in the Republic of Malawi (2002-2005)	2,535	5,000	56,000
	Development of Smallholder Irrigation Schemes Technical Cooperation Project (2006-2009)			
Zambia	Study for the Capacity Building and Development for Community-based Smallholder Irrigation Scheme in Northern and Luapula Provinces in the Republic of Zambia (COBSI Study, 2009-2011) *2	568	544	6,900
	Technical Cooperation Project on Community-Based Smallholder Irrigation in the Republic of Zambia (T-COBSI, 2014-2017) *3	790	945	12,600
	Technical Cooperation Project on Expansion of Community-Based Smallholder Irrigation in the Republic of Zambia（E-COBSI, 2018-2024) on-going*4	662	1,881	18,440

Source: *1：Cooperation Approach for Sustainable Development of Small-scale Irrigated Agriculture by Human Resource Development in Malawi (KANAMORI Hideyuki. Water, Land and Environmental Engineering. October 2018)
*2：FINAL REPORT, COBSI Study, 2011
*3：FINAL REPORT, T-COBSI, 2017
*4：PROGRESS REPORT No.1, E-COBSI, 2020

COBSI started by constructing “simple weirs” to obtain water for irrigation by stopping the river flow using locally available materials such as wood, bamboo, soil, stones, etc. with the participation of smallholders. Through this simple weir, smallholders could utilize limited water resources as effectively as possible during the dry and also as supplemental irrigation. As a result, farmers could cultivate throughout the year, irrigating with rainwater during the rainy season and river water during the dry season. Not only could smallholders produce during the dry season by constructing simple weirs themselves, but they also learned to maintain and manage the facilities properly even after construction. However, those weirs are simple in structure as their name indicates and get washed away during the

[1] IWMI: International Water Management Institute

rainy season, so farmers' groups have to build new ones every year.

As a next step, “permanent weirs” were constructed to upgrade simple weirs with external inputs of materials such as cement. Smallholders provided labor and other services during the construction—done in the same participatory manner as with simple weirs, logically resulting in a sense of ownership and mastery in terms of operation and maintenance.

A simple weir’s construction cost was USD2-3 per site for an irrigated area of around 1-2 ha and around USD15,000 for a permanent one covering several tens of hectares. Although each site is relatively small, the number of sites developed—as a total—contributes to the country’s irrigation development.

Furthermore, as an entry point to securing water for agriculture during the dry season, COBSI helps increase smallholders’ resilience while, at the same time, strengthening group dynamics by bringing people together to i) construct simple/permanent weirs *themselves*, ii) manage water resources *themselves*, and iii) maintain the weirs *themselves*. In addition to simple weir construction, activities such as promotion of market-oriented agriculture, particularly through the Smallholder Horticulture Empowerment and Promotion (SHEP) approach, were introduced so that smallholders can “grow to sell”. Nutritional awareness was also incorporated to improve smallholders’ nutritional situation. The combination of those activities was known as “COBSI approach” when implemented in Zambia (cf. Section 1.5 for further details). Capitalizing on its unique characteristics, this survey was conducted to identify whether that approach could be applied to other SSA countries.

1.2 Objectives of the Survey

This survey targeted all forty-nine (49) countries in SSA where large areas of irrigable land are available but are not yet developed. Those countries were assessed through satellite image analysis by their natural conditions to identify the potential of available water resources, then further narrowed down to five (5) countries for field surveys by taking into account other aspects. The possibility of expansion of the COBSI approach across SSA was to be surveyed and identified in relation to irrigation potential during the rainy-season—when it would be used supplementarily, during the dry-season, or in periods of drought.

A part from that, JICA technical cooperation project known as E-COBSI, which is under implementation in Zambia, is expected to terminate in the beginning of 2023. Knowing that, JICA is considering handover of support for the COBSI approach, as the Zambian Government is now well capacitated to expand it themselves. Governmental irrigation engineers and agricultural extension workers were trained on and have practiced COBSI through related studies (T-COBSI and E-COBSI) and are capable of using the COBSI approach for irrigation development. Funding is, apparently, the only concern, so this survey offered an opportunity to examine the possibility of utilizing the Green Climate Fund (GCF) as an alternative funding source.

Satellite image analysis also permitted identification of rice cultivation potential in addition to water resources availability for thirty-two (32) SSA countries members of the Coalition for African Rice Development, hereafter referred to as CARD.

1.3 Survey Methodology

This survey on the potential of expanding the COBSI approach was conducted in two stages. In the first stage, all 49 SSA countries were assessed based on wide-area analysis satellite imagery to identify around twenty (20) countries with high COBSI potential. Ten (10) countries were further selected and examined out of them based on online information and existing documents and data such as statistics. Five (5) countries were finally selected for field surveys, as part of the second stage, based on the results of the abovementioned desk survey. A detailed analysis using high-resolution satellite images was carried out for those 5 countries to obtain information on suitable COBSI sites prior to the field surveys. Future cooperation proposals were also examined and put forward based on the results of those field surveys.

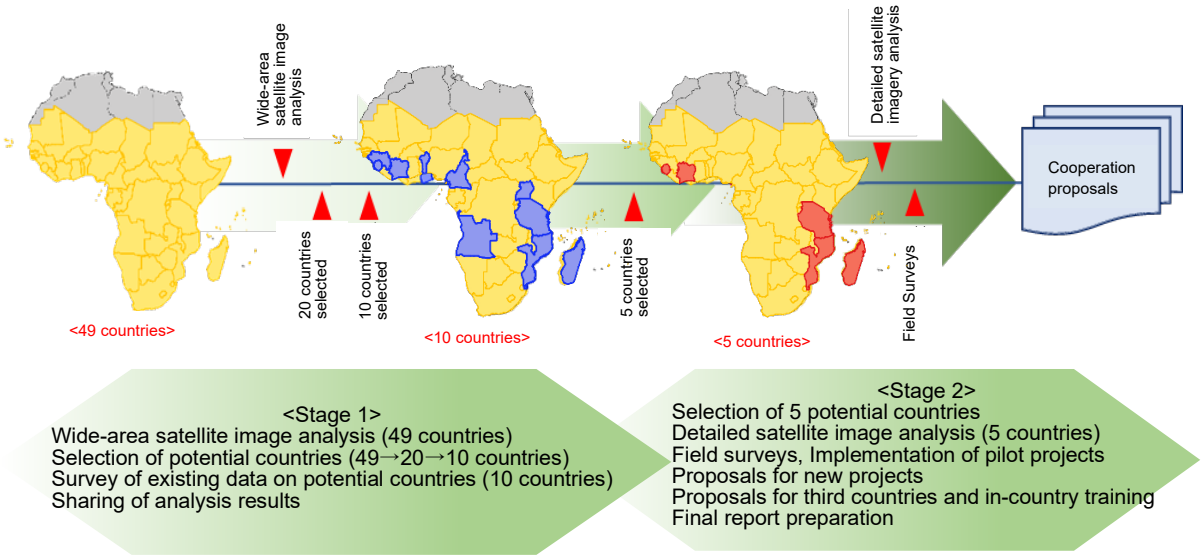


Figure 1.3.1 Priority Countries with Small-scale Irrigation Potential (Cumulative Area by Country for Potential Development)

Source: JICA Survey Team

1.4 Process of the Survey

The original schedule of this survey was from March 2021 to March 2022. However, it has been extended to February 2023 as the research team could not travel to Tanzania and Madagascar during the 2021 dry season due to COVID-19. Besides, rice cultivation mapping was added to the scope of work to analyze rice cultivation potential areas and cultivation risk distribution in SSA.

The 10 countries with high potential were, at first, selected by July 2021 based on wide-area satellite image analysis and Web information, then evaluated in relation to existing data on them. Five countries were then selected in the second stage for field surveys, and an interim report was submitted in August 2021. From October 2021, field surveys were conducted in the said countries and cooperation proposals examined and propounded, then compiled in a final report—to be submitted in February 2023—which includes a survey on the possibility of utilization of the GCF for Post E-COBSI in Zambia and rice cultivation mapping.

Table 1.4.1 Survey Schedule

Year	2021										2022												2023	
Month	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2
First stage (49→10 countries)	■	■	■	■	■																			
Second stage (10→5 countries)					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
Possibility of utilizing GCF for Post E-COBSI in Zambia	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Rice cultivation mapping (additional)					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Report	△					▲																		■

Note: △Inception Report, ▲Interim Report, ■Final Report

Source: JICA Survey Team

1.5 The COBSI Approach

COBSI was developed as an "appropriate technology" for micro/small-scale irrigation in Malawi and Zambia with JICA's assistance, enabling smallholders to secure water for irrigation during the dry season. It is a breakaway from rainfed agriculture and offers the possibility to farm throughout the year. COBSI is also a **comprehensive approach that contributes to increasing smallholders' resilience and adaptive capability** and**,** being an entry point set of intake weir and canal, offers a technology that can be built/rebuilt by smallholders with locally available natural materials (Figure 1.5.1).

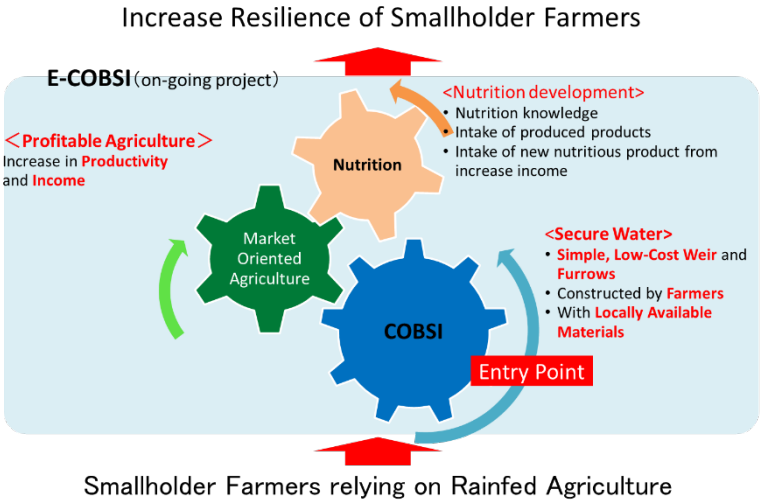


Figure 1.5.1 COBSI Approach (Concept)

Source: JICA Survey Team

(1) Simple Weir and Earthen Canal as an Entry Point to Secure Water

There is a very simple precondition to construct COBSI's simple weir: Water must flow in a stream of 1- to 2-meter width even during the dry season. When this precondition is met, smallholders can i) build one with locally available materials such as wood, grass, soil, etc., (ii) construct and maintain it themselves, (iii) manage irrigated agriculture with a set of intake weir and canal at minimal cost, as (iv) COBSI is an easy-learning technology for such small-scale producers. In addition, simple weirs can be

constructed even on wetlands or places with no firm foundations. Their core concept is to block the water, so there is no fixed technology; it is flexible enough to adapt to any structure by using locally available materials and depending on the river width, depth and riverbed conditions. Zambia, for example, has four (4) different types of simple weir as shown in Figure 1.5.2 below.

Figure 1.5.2 Four Types of Simple Weir (Zambia)

Source: JICA Survey Team

Complementary to the simple weir blocking the water, an earthen canal is constructed to lead the water directly to the field, enabling farmers to irrigate by gravity. Gravity irrigation reduces cost and labor required in pump and bucket irrigation. Moreover, hoes and other common farming tools are used to construct the earthen canals alongside a spirit level, also locally available, needed to ensure proper canal gradient and alignment (Figure 1.5.3).

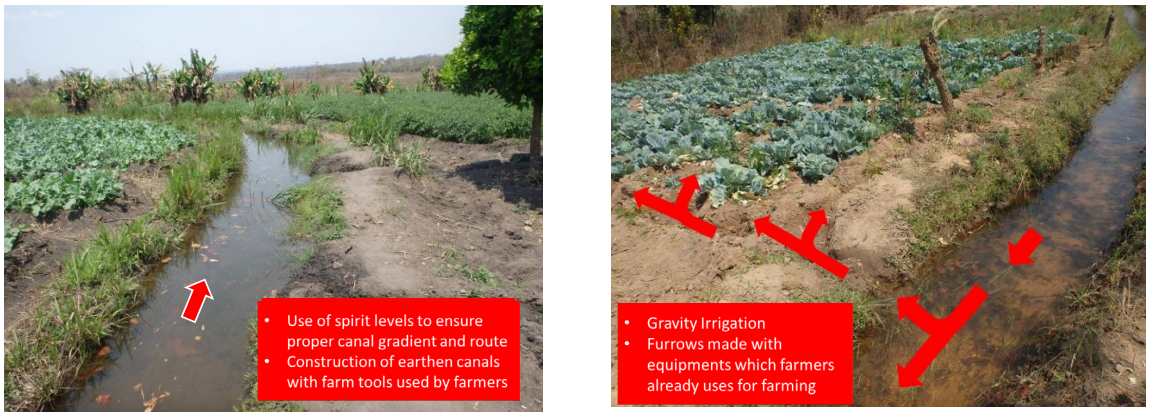


Figure 1.5.3 Earthen Canals (Zambia)

Source: JICA Survey Team

No cost other than that of the spirit level is required, as the simple weir is constructed with locally available materials and the earthen canals using farm tools smallholders; both can, thus, be built at a low cost of USD2-3. With such an amount per site, smallholders can shift to a relatively permanent though

simple irrigation system which enables them to cultivate even during the dry season. Further, they can easily reconstruct COBSI's simple facilities when washed away during the rainy season, as they are "low-skill technology".

(2) Upgrading from Simple to Permanent Weirs

COBSI's simple weirs can be "upgraded" to a permanent ones depending on local conditions. Through this upgrade, smallholders can expand irrigated areas and, as a result, increase crop production, as permanent weirs provide more stable water withdrawal compared to simple ones. Upgrading takes place once farmers have experienced and understood the importance of irrigated agriculture and facilities maintenance techniques using simple weirs.

Furthermore, ownership is fostered among smallholders as they participate in constructing permanent weirs, which is essential in that weir maintenance and management will be done by themselves. This reduces the risk of permanent weirs not being used or maintained, even though a certain amount of procurement, such as cement, has to be invested. In addition, smallholders can transit smoothly to a larger irrigation scheme, in the future if any, as they would have already been familiar with agricultural irrigation systems and their maintenance.

Construction by farmers, with women participation

Government officials managing construction

Figure 1.5.4 Permanent Weirs (Zambia)

Source: JICA Survey Team

(3) Impact of the COBSI Approach

There are two main aspects of the impact of the COBSI approach. Firstly, it contributes to increasing the resilience and adaptive capacity of smallholders implementing the approach to secure irrigation water during the dry season as an entry point. According to a survey conducted in a project area where T-COBSI was implemented, smallholders who practiced COBSI increased their fields by 1.1 times, crop production value by 1.8 times, production per area by 1.6 times, and farm income by 2.1 times compared with smallholders who relied solely on rainfed farming. In addition, food consumption diversified and showed improvements in relation to weight and wasting, and farmers could utilize the "additional income" generated during the dry season for expenses such as school fees, renewal of household assets, and funds to purchase agricultural inputs for the next growing, rainy season (Figure 1.5.5).

Another positive impact is that COBSI contributes to expanding irrigated areas in the target countries. Although a simple weir irrigates only a few hectares per site, it can be constructed/introduced in a "simple" manner, so the more weirs built the more areas irrigated. For instance, the Zambian Ministry

of Agriculture developed 3,645 ha of irrigated areas from 2014 to 2016 (3 years), 945 ha of which were developed under the T-COBSI project—a significant contribution of about 25%.

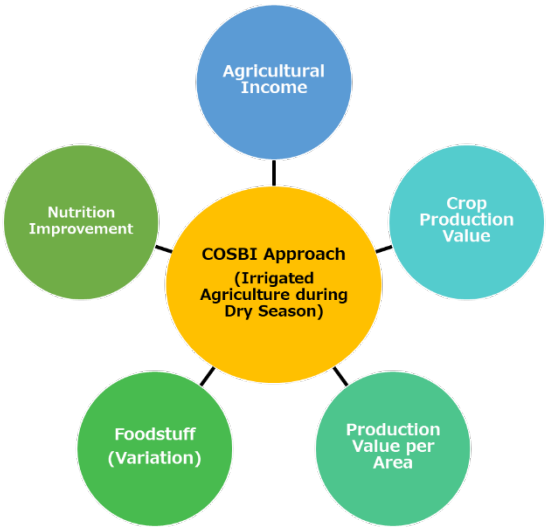


Figure 1.5.5 Impacts of Farmers Practicing the COBSI Approach

Source: JICA Survey Team

CHAPTER 2 SMALL-SCALE IRRIGATION POTENTIAL ANALYSIS BASED ON WIDE-AREA SATELLITE IMAGE ANALYSIS (FIRST SELECTION: 49→20 COUNTRIES)

In the 49 Sub-Saharan African (SSA) countries to be analyzed, many agricultural lands are dependent on rainfed conditions due to a lack of irrigation systems to access water sources. This satellite data analysis aimed to identify areas where small-scale irrigation is possible (small-scale irrigation potential areas).

As described in the previous section, the selection of small-scale irrigation potential areas was carried out following three stages: First, second, and third selections. This analysis was conducted as part of a wide-area satellite data analysis for the first selection. The purpose of the analysis was to select 20 priority countries out of 49 SSA countries as the first selection out of wide-area satellite imagery.

2.1 Satellite Image Analysis Flow

Potential areas for small-scale irrigation were extracted from existing farmlands because the targets are not locations with natural vegetation such as forests, grasslands, etc., but cultivated lands with human intervention as well as compensatory vegetation areas in the vicinity.

Vegetation on cultivated land changes significantly during the growing season from seeding to harvesting, whereas natural vegetation in adjacent areas does so only slowly with the seasons. These vegetation growth differences were detected by tracking phytophenological trends based on vegetation index variations in one (1) hydrological year to discriminate between natural vegetation and cultivated land.

The results were then cross-checked with satellite data products (ground cover classification maps) to determine existing rainfed farmlands from which potential small-scale irrigation areas were identified by setting the following items that could be constraints to development:

Constraints, Content, etc.

Water bodies: Water indices were calculated, areas unsuitable for irrigation excluded, and rivers and lakes extracted from surface cover maps, etc.
Irrigation water sources: Dry areas were excluded based on annual rainfall and predicted runoff records.
Topographical conditions: Mountainous areas or cliffs were excluded based on elevation data.
Unsuitable land for cultivation: Exposed rock areas, chloride soil areas, and nature reserves were excluded based on soil and geological distribution.
Population: Depopulated areas where participation in the project is not expected were excluded.

2.2 Selection of Small-Scale Irrigation Potential Areas and Priority Countries

To determine potential areas for small-scale irrigation, the constraint items were compared with the in-situ condition of the COBSI model site in Zambia. Through this comparison with the Zambia site, the constraints' threshold values were determined, and small-scale irrigation potential areas were selected. For more reliability, the order in which conditions were applied, source and input data, and those threshold values were described in a workflow application and analyzed—as the analysis procedure was complicated and there were concerns about manual input errors.

2.3 List of Priority Countries (Selection of 20 Countries)

Small-scale irrigation potential areas in 49 SSA countries as well as items such lands under cultivation were arranged in descending order (fourth column). A list of priority countries with small-scale irrigation development potential was then prepared (Table 2.3.1).

Table 2.3.1 List of Priority Countries with Small-scale Irrigation Potential

Order	Country	Rainfed farmlands (1,000 ha) (a)	Potential small-scale irrigation areas (1,000 ha) (b)	Potential small-scale irrigation areas/ Rainfed farmlands ((b)/(a))
1	**Nigeria**	36,201	19,096	53%
2	**Ethiopia**	24,261	7,792	32%
3	**Kenya**	7,819	4,041	52%
4	**Benin**	3,419	3,051	89%
5	**Tanzania**	19,640	2,792	14%
6	**Zambia**	7,176	2,700	38%
7	**Angola**	5,236	2,344	45%
8	**Mozambique**	4,275	2,278	53%
9	**Burkina Faso**	10,200	2,163	21%
10	**Ghana**	2,826	2,117	75%
11	**Chad**	4,815	2,110	44%
12	**Malawi**	3,312	2,014	61%
13	**Uganda**	6,427	1,834	29%
14	**Mali**	8,973	1,675	19%
15	**Madagascar**	3,170	1,629	51%
16	**Democratic Republic of the Congo**	3,148	1,604	51%
17	**Togo**	1,729	1,501	87%
18	**Côte d'Ivoire**	1,183	988	84%
19	**Cameroon**	2,545	975	38%
20	**Zimbabwe**	10,474	688	7%
21	**Guinea**	513	423	82%
22	Senegal	4,129	399	10%
23	Burundi	1,513	356	24%
24	**Central African Republic**	328	267	81%
25	South Africa	15,035	100	1%
26	**Guinea-Bissau**	184	99	54%
27	Gambia	403	79	20%
28	Eritrea	740	78	11%
29	South Sudan	444	49	11%
30	Republic of the Congo	180	49	27%
31	Rwanda	1,229	39	3%
32	**Sierra Leone**	65	34	52%
33	Sudan	19,048	26	0%
34	Eswatini	613	26	4%
35	Niger	9,108	3	0%
36	Somalia	1,089	2	0%
37	**Liberia**	2	1	50%
38	Lesotho	365	1	0%
39	Djibouti	2	0	0%
40	Seychelles	0	0	-
41	Comoros	0	0	-
42	Mauritius	0	0	-

Order	Country	Rainfed farmlands (1,000 ha) (a)	Potential small-scale irrigation areas (1,000 ha) (b)	Potential small-scale irrigation areas/ Rainfed farmlands ((b)/(a))
43	Sao Tome and Principe	0	0	-
44	Mauritania	237	0	-
45	Cape Verde	15	0	-
46	Namibia	809	0	-
47	Gabon	2	0	-
48	Equatorial Guinea	0	0	-
49	Botswana	943	0	-
	Total(average)	223,825	65,423	(29%)

Source: JICA Survey Team

In addition to Zambia and Malawi where COBSI projects have been carried out, the top 20 selected countries with the largest cumulative small-scale irrigation potential areas are Mozambique, Angola and Zimbabwe in Southern Africa; Ethiopia, Kenya, Tanzania, Uganda, and Madagascar in Eastern Africa; Chad and the Democratic Republic of the Congo, Cameroon in Central Africa, and Nigeria, Benin, Burkina Faso, Ghana, Mali, Togo, and Côte d'Ivoire in Western Africa (Figure 2.3.1).

Those countries are located in savannah and temperate climates with an annual rainfall of 1,000-1,500 mm and a dry season of 3-6 months, which are common characteristics. Within these regions, the top priority countries are those with particularly vast land mass and large areas of rainfed agricultural land.

On the other hand, some countries are not among the 20 priority ones in terms of cumulative small-scale irrigation potential areas but have a large amount of developable agricultural land compared with rainfed areas. Those countries with high potential for small-scale irrigation development are Guinea, Central Africa, Guinea-Bissau, Sierra Leone, and Liberia.

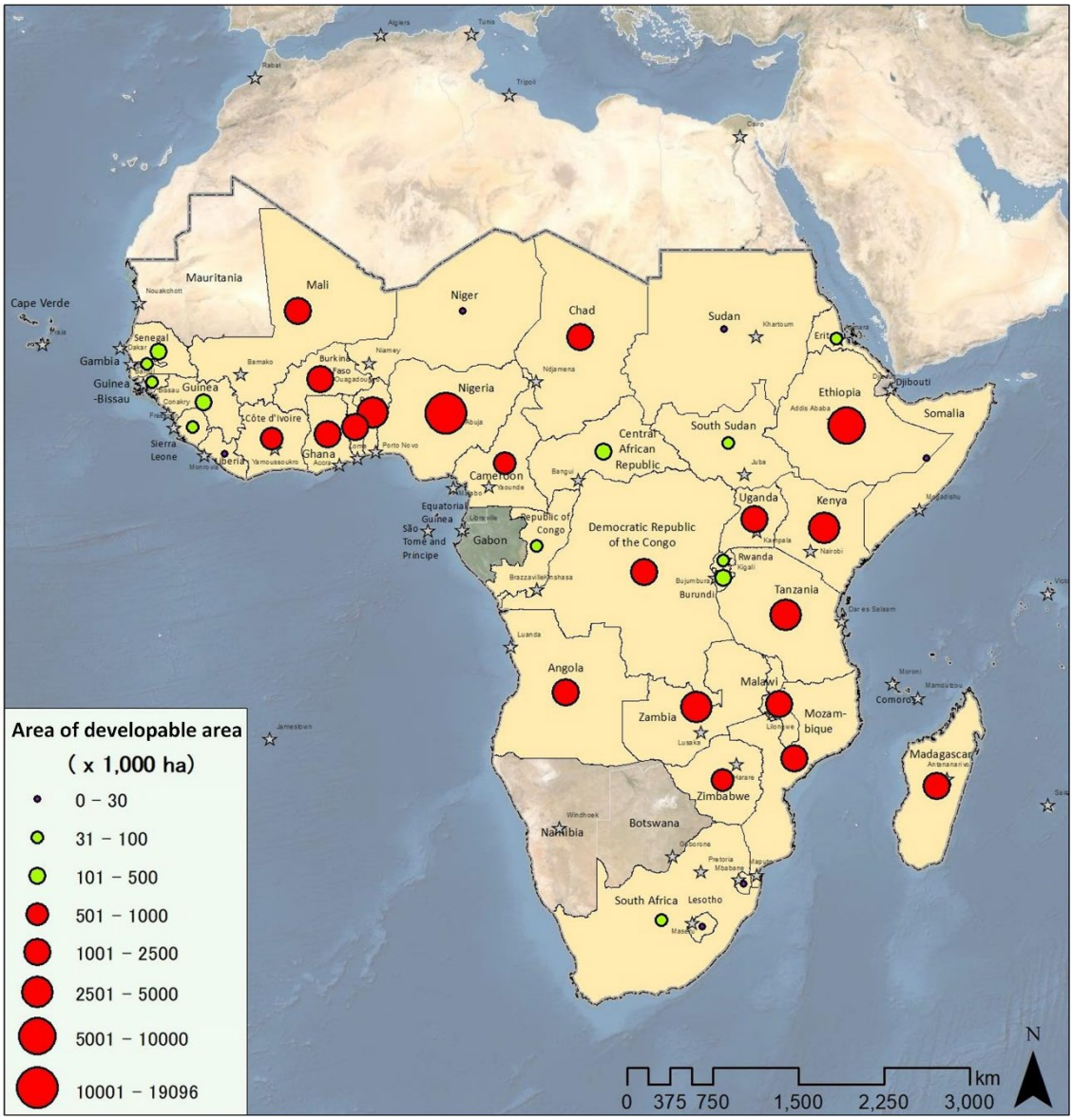


Figure 2.3.1 Priority Countries with Small-scale Irrigation Potential (Cumulative area by country for potential development)

Source: JICA Survey Team

CHAPTER 3 SECOND SELECTION FOR POTENTIAL SURVEY (20→10 COUNTRIES)

3.1 Survey Methodology

In the first selection, the Survey Team prepared a list of priority countries for small-scale irrigation development potential based on natural conditions, using wide-area satellite image analysis. This second selection targeted a total of twenty-two (22) countries—the top twenty (20) countries on the list in addition to Guinea and Sierra Leone—which have a large amount of developable irrigated agricultural land in comparison with their rainfed areas. Then, based on online statistical data (population, GDP, poverty rates, nutritional status, etc.), 10 countries presenting more potential for introducing COBSI out of those 22 were sorted out.

Items to be taken into account in the second selection are shown in Table 3.1.1. When proposing new projects in this survey, it was important to consider collaboration with JICA's three agricultural and rural development cluster (CARD, SHEP and IFNA[1]). Therefore, the implementation status of that cluster was also identified. Moreover, country-specific risk information, availability of JICA overseas offices, project priorities of JICA overseas offices and regional balance of the target countries were also considered. Based on the results of all those parameters and in consultation with JICA Headquarters, 10 countries were later selected for the third selection.

Table 3.1.1 Secondary Selection Considerations

Items	Descriptions
Natural conditions (determination of countries for secondary selection)	Small-scale irrigation potential areas; importance of small-scale irrigation development
Poverty situation	Percentage below the international poverty line ($1.9/day)
GDP and agricultural sector workers	GDP per capita; ratio of the agricultural sector to GDP; ratio of agricultural sector workers
Nutritional status	Malnutrition status of children under five (5) years
Country-specific risk information	Determining the level of travel risks
JICA overseas offices	Availability of JICA overseas offices/branches
Status of cluster (CARD, SHEP, IFNA) implementation	Target countries and implemented/on-going projects
Area classification	Consideration of expansion into Western and Central Africa
Identification of project priorities for JICA overseas offices	Priority of JICA overseas offices for COBSI project implementation

Source: JICA Survey Team

3.2 Survey Results

3.2.1 Natural Conditions

Natural conditions were obtained from satellite image analysis. As mentioned above, a list of priority countries was prepared for all 49 SSA countries in order of sizes of areas available for COBSI development. The top 20 countries were selected for secondary selection. Countries with a large proportion of developable rainfed agricultural land, other than those 20, were evaluated as eligible for COBSI and considered for the secondary selection. Those with JICA overseas offices and branches were given higher priority for proposing new projects, namely Guinea and Sierra Leone. They were, therefore, added to the top 20 priority countries, making a total of 22 countries sorted out for secondary selection

[1] Initiative for Food and Nutrition security in Africa

(Table 3.2.1). Although Zambia and Malawi are COBSI-implementing countries, they were still included but for reference purposes only.

Table 3.2.1 22 Selected Countries for Secondary Selection

Nigeria, Ethiopia, Kenya, Benin, Tanzania, Zambia, Angola, Mozambique, Burkina Faso, Ghana, Chad, Malawi, Uganda, Mali, Madagascar, Democratic Republic of the Congo, Togo, Ivory Coast, Cameroon, Zimbabwe, Guinea and Sierra Leone.

Source: JICA Survey Team

3.2.2 Poverty Situation

Poverty conditions were assessed in relation to the international poverty line (USD1.9 per person per day) set by the World Bank (WB) in October 2015. As of 2018, the average poverty rate across SSA was 40.4%; the 20 selected countries were ranked by their poverty levels as shown in Table 3.2.2 below. SSA Countries with higher-than-average poverty rates are Angola, Benin, Burkina Faso, the Democratic Republic of the Congo, Madagascar, Malawi, Mali, Mozambique, Sierra Leone, Tanzania, Togo, Uganda and Zambia. Those thirteen (13) countries were identified as high-priority in terms of poverty.

Table 3.2.2 Percentage of Poverty[2]

Country*1	Ratio of the poor (%)	Poverty level ranking (out of 20 countries)
1. Nigeria	39.09	14
2. Ethiopia	30.80	17
3. Kenya	37.08	16
4. Benin	49.61	9
5. Tanzania	49.37	10
6. Zambia	58.75	5
7. Angola	49.91	8
8. Mozambique	63.68	4
9. Burkina Faso	43.84	11
10. Ghana	12.66	20
11. Chad	38.08	15
12. Malawi	69.21	3
13. Uganda	41.35	12
14. Mali	50.29	7
15. Madagascar	78.84	1
16. Democratic Republic of the Congo	77.15	2
17. Togo	51.14	6
18. Côte d'Ivoire	29.83	18
19. Cameroon	25.97	19
20. Zimbabwe	39.53	13
21. Guinea	36.09	-
32. Sierra Leone	42.99	-

*1: These countries are ranked in order of size of areas available for small-scale irrigation, with Nigeria being the largest.

3.2.3 GDP per Capita and Human Resources in the Agricultural Sector

GDP per capita and the percentage of people employed in the agricultural sector are shown in Table 3.2.3. In Madagascar, Malawi, Mozambique, and Sierra Leone, GDP per capita is around USD400-500, which is low in comparison to other target countries. On the other hand, the agricultural sector's

[2] World Development Indicators (WB), http://iresearch.worldbank.org/PovcalNet/povOnDemand.aspx

contribution to GDP is less than 10% in mineral-rich countries like Angola, Zambia and Zimbabwe where mining is an important industry. In Zambia, nearly half the population (49.6%) are engaged in the agricultural sector, suggesting that although this sector's human resources percentage is high, its profitability is very low compared to other industries. Here, countries with low GDP and a large number of people engaged in the agricultural sector—namely Burkina Faso, the Democratic Republic of the Congo, Madagascar, Malawi, Mozambique, and Sierra Leone—were identified as high-priority.

Table 3.2.3 GDP per Capita and Percentage of People Employed in the Agricultural Sector

Country*1	GDP per capita (USD)[3]	Agriculture sector contribution to GDP (%)[4]	Agricultural sector workers Percentage (%)[5]
1. Nigeria	2,230	21.9	35.0
2. Ethiopia	856	33.5	66.6
3. Kenya	1,817	34.1	54.3
4. Benin	1,219	26.9	38.3
5. Tanzania	1,122	28.7	65.1
6. Zambia	1,305	2.9	49.6
7. Angola	2,791	6.7	50.7
8. Mozambique	504	26.0	70.2
9. Burkina Faso	787	20.2	26.2
10. Ghana	2,202	17.3	29.8
11. Chad	710	42.6	75.1
12. Malawi	412	25.5	76.4
13. Uganda	794	23.1	72.1
14. Mali	879	37.3	62.4
15. Madagascar	523	23.3	64.1
16. Democratic Republic of the Congo	581	20.0	64.3
17. Togo	679	22.5	32.4
18. Côte d'Ivoire	2,276	20.7	40.2
19. Cameroon	1,507	14.5	43.5
20. Zimbabwe	1,464	8.3	66.2
21. Guinea	963	23.6	60.7
32. Sierra Leone	528	54.3	54.5

1*: These countries are ranked in order of size of areas available for small-scale irrigation, with Nigeria being the largest.

3.2.4 Nutritional Situation

Existing COBSI projects show that introduction of this approach, harmoniously with JICA's agricultural and rural development cluster food and nutrition component (IFNA), can improve nutrition through year-round agricultural production. As nutrition improvement is a pressing issue in the African region, nutritional situation was added as an indicator to identify priorities for COBSI development.

Three indicators, also applicable here, are often used to compare the nutritional situation of countries: Stunting, wasting and overweight rates in children under five (5) years old. UNICEF's stunting,

[3] "GDP per capita (current US$)", World Development Indicators (WB)
http://iresearch.worldbank.org/PovcalNet/povOnDemand.aspx
[4] "Agriculture, forestry and fishing, value added (% of GDP)", World Development Indicators (WB),
https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS
[5] "Employment in agriculture (% of total employment) (modeled ILD estimate)",
https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS

wasting, and overweight thresholds are as follows, with “Very high” indicating significant problems in each indicator.[6]

Table 3.2.4 Proportion Thresholds for Undernourished Children Under 5

Category	Stunting (%) (Stature for age)	Wasting (%) (Weight for height)	Overweight (%) (Overweight)
Very low	<2.5	<2.5	<2.5
Low	2.5 - <10	2.5 - <5	2.5 - <5
Medium	10 - <20	5 - <10	5 - <10
High	20 - <30	10 - <15	10 - <15
Very high	≥30	≥15	≥15

The nutritional situation of children under 5 in each country is shown in Table 3.2.5. Based on the above thresholds, stunting is classified as 'High' or 'Very high', and high rates of stunting is observed in most of the 22 selected SSA countries, while only two (2) have high percentages of wasting and overweight. Generally, the surveyed countries tended to have a high proportion of stunting, but low wasting and overweight. Consequently, 16 countries with a “Very high” percentage of stunting only, especially in rural areas, were prioritized.

Table 3.2.5 Percentage of Undernourished Children under 5 in Each Country[7]

Country*1	Stunting (%)		Wasting (%)		Overweight (%)	
	Urban	Rural	Urban	Rural	Urban	Rural
1. Nigeria	26.8	44.8	5.34	7.93	2.0	2.1
2. Ethiopia	25.6	40.6	5.70	7.70	1.7	2.2
3. Kenya	20.0	29.2	3.46	4.53	5.5	3.5
4. Benin	27.5	35.2	5.11	4.87	1.8	1.9
5. Tanzania	24.8	37.8	3.78	4.75	4.1	3.6
6. Zambia	32.1	35.9	4.95	3.85	5.7	5.0
7. Angola	31.8	45.7	4.58	5.39	4.0	2.6
8. Mozambique	34.4	45.1	3.53	4.73	8.8	6.3
9. Burkina Faso	21.4	37.4	14.66	15.69	3.7	2.6
10. Ghana	13.9	20.3	7.05	6.64	1.5	1.3
11. Chad	29.9	39.3	16.31	13.50	2.3	2.3
12. Malawi	25.1	35.7	8.05	4.39	11.1	2.3
13. Uganda	23.5	30.2	2.88	3.61	2.8	4.0
14. Mali	16.9	29.4	7.74	9.31	2.7	1.8
15. Madagascar	37.7	42.6	5.85	6.59	1.6	1.4
16. Democratic Republic of the Congo	28.9	50.1	5.39	7.09	3.7	3.9
17. Togo	14.2	29.7	5.52	5.84	1.2	1.7
18. Côte d'Ivoire	12.6	27.4	5.74	6.25	1.4	1.5
19. Cameroon	19.8	36.2	3.63	4.84	10.3	11.5
20. Zimbabwe	18.5	25.6	3.00	2.82	2.4	2.6
21. Guinea	21.7	33.8	9.86	8.94	6.6	5.2
32. Sierra Leone	24.5	32.0	6.33	4.88	5.5	4.1

1*: The countries are ranked in order of size of areas available for small-scale irrigation, with Nigeria being the largest.

Stunting is an indicator of long-term chronic malnutrition and wasting an indicator of short-term and acute nutritional situations involving significant loss of body fat and muscle. Considering the above table, many of the surveyed candidate countries were judged to be in a situation of chronic malnutrition. It should be noted that even in fertile granary areas usually not affected by food scarcity, there are cases of high rates of stunting and low wasting in children. This is presumed to be due to parents being too busy with farm work to adequately care for their children as well as lack of quality and frequency of weaning. Therefore, it is deemed necessary to raise awareness about nutrition improvement in parallel

[6] "Malnutrition" (UNICEF), https://data.unicef.org/topic/nutrition/malnutrition/
[7] "Malnutrition" (UNICEF), https://data.unicef.org/topic/nutrition/malnutrition/

with the introduction of the COBSI approach when implementing COBSI projects.

3.2.5 Country-specific Risk Information

In order to conduct field surveys in 5 countries during the period of this survey, the current travel advisories of the Ministry of Foreign Affairs of Japan (as of June 2021) were referred to for current travel possibilities. In Burkina Faso, Chad, the Democratic Republic of the Congo, Mali, and Nigeria, the travel advisories indicated that many areas were at level 2 ("Do not travel urgently") to level 3 ("Travel suspension advisory"), while some other areas were even issued a level 4 ("Evacuation advisory"). Judged unsafe, travel and field surveys to those five countries were, therefore, given a low priority.

3.2.6 Availability of JICA Overseas Offices/Branches

Countries with JICA offices/branches were identified, as new projects are more likely to be implemented in them. Among the 22 selected countries, three (3)—Chad, Mali, and Togo—did not establish any JICA overseas offices and were excluded from the third selection. Four countries—Benin, Guinea, Sierra Leone, and Zimbabwe—have JICA branch offices, Guinea's being considered as a "field office". In all other candidate countries, JICA offices have been established.

3.2.7 Implementation Status of the JICA Cluster (CARD, SHEP, IFNA)

JICA is currently implementing CARD, SHEP, and IFNA as a cluster for agriculture and rural development in African countries. The implementation status of those three cluster components is shown in Table 3.2.6 (●: Implemented, ○: Under implementation/Planning). Light purple highlights indicate the cluster component(s) relevant to each target country.

Table 3.2.6 Implementation Status of CARD, SHEP, and IFNA

Country*1 / Cluster	CARD	SHEP	IFNA
1. Nigeria	●	–	–
2. Ethiopia	●	○	–
3. Kenya	●○	●○	–
4. Benin	–	–	–
5. Tanzania	●	●	–
6. Zambia	●○	○	–
7. Angola	●	–	–
8. Mozambique	●○	○	○
9. Burkina Faso	●○	–	–
10. Ghana	●	●	–
11. Chad	–	–	–
12. Malawi	○	○	–
13. Uganda	●○	●	–
14. Mali	–	—	–
15. Madagascar	●○	●○	○
16. Democratic Republic of the Congo	–	–	–
17. Togo	–	–	–
18. Côte d'Ivoire	●	–	–
19. Cameroon	●○	–	–
20. Zimbabwe	–	–	–
21. Guinea	●	–	–
32. Sierra Leone	●○	–	–

1*: The countries are ranked in order of size of areas available for small-scale irrigation, with Nigeria being the largest.

Source: JICA Survey Team.

CARD projects have already been implemented or are under implementation/planning in seventeen (17) out of 22 countries other than Benin, Chad, Mali, Togo, and Zimbabwe. Regarding the possibility of collaboration with CARD, it would be relatively easy to implement COBSI in countries with CARD experiences. Priority is, therefore, given to the 17 countries having experienced CARD projects implementation.

SHEP has been or is being implemented in 5 countries and is under implementation/planning in four (4) other countries out of 22. Five countries have been designated as SHEP target countries but have not yet implemented the project. In view of integrating SHEP into the COBSI approach, it is preferable to select countries with experiences in its implementation—namely Ethiopia, Ghana, Kenya, Madagascar, Malawi, Mozambique, Tanzania, Zambia, and Uganda—as it takes time for partner governments to understand its concept.

3.2.8 Area Classification

As the objective of this survey is expansion of COBSI to SSA, not only Southern and Eastern Africa where COBSI-implementing Zambia and Malawi are located, but also Western and Central Africa should be considered. Regional balance was, thus, also taken into account in this second selection as shown in Table 3.2.7 below according to the regional classification defined by JICA.

Table 3.2.7 Regional Classification of Countries for Second Selection

Southern Africa	Eastern Africa	Western Africa	Central Africa
Zambia, Angola, Mozambique, Malawi, Madagascar, and Zimbabwe.	Ethiopia, Kenya, Tanzania, and Uganda	Nigeria, Benin, Burkina Faso, Ghana, Mali, Togo, Côte d'Ivoire, Guinea, and Sierra Leone.	Chad, Democratic Republic of the Congo, and Cameroon.

Source: JICA Survey Team

3.2.9 Identification of COBSI Project Priorities for JICA Overseas Offices

Project priorities of JICA overseas offices are also important in terms of planning COBSI projects. An online seminar was held on June 11th, 2021 to introduce COBSI to JICA SSA offices. The PowerPoint material used in this seminar is shown in Annex 1.

After the seminar, project priorities were identified for a total of fourteen (14) JICA overseas offices, excluding the following out of the 22 targeted for the second selection: 1) Five (5) countries judged to be risky for travel; 2) Three (3) countries with no JICA overseas office (with overlaps), and 3) Zambia and Malawi where COBSI was already implemented. Seven (7) overseas offices showed interest in implementing COBSI projects, three (3) were interested, but unable to implement them anytime soon, and four (4) expressed no interest at all. The results of the project priorities of JICA overseas offices are shown in Table 3.2.8.

Those results show that countries with high poverty rates, low GDP and high malnutrition prevalence in rural areas were more likely to be “interested in implementing COBSI projects”, while countries in opposite situations were more likely to show “no interest in implementing COBSI projects”. Those results match COBSI’s main strength of enabling low-income farmers to benefit from simple-technology and low-cost irrigation facilities.

Table 3.2.8 Project Priority Results for JICA Overseas Offices

Interested in implementing COBSI projects: 7 countries	Interested but unable to implement COBSI projects soon: 3 countries	No interest in implementing COBSI projects: 4 countries
Tanzania, Angola, Mozambique, Madagascar, Côte d'Ivoire, Cameroon and Sierra Leone.	Benin, Uganda, and Guinea.	Ethiopia, Kenya, Ghana, and Zimbabwe.

Source: JICA Survey Team

3.3 Results of the Second Selection

Ten (10) countries were selected as a result of the second selection described above and shown in Table 3.3.1. Those 10 countries sorted out for the third selection (field surveys) are Angola, Benin, Cameroon, Côte d'Ivoire, Guinea, Madagascar, Mozambique, Sierra Leone, Tanzania, and Uganda. Among those countries, Benin, Guinea (light blue), and Uganda were not selected, because they responded "interested but unable to implement COBSI projects anytime soon". Angola, Cameroon, Cote d'Ivoire, Madagascar, Mozambique, Sierra Leone (green), and Tanzania were candidate third selection countries and only five (5) of them will be selected for field surveys. Countries "not interested in implementing COBSI projects" are shown in white; the 5 countries classified as risky and the 3 with no JICA overseas offices are shown in gray, whereas Zambia and Malawi—COBSI implementing countries—are shown in yellow.

Table 3.3.1 Second Selection List (22 → 10 Countries)

Country	First Selection		GDP		Agricultural sector workers Percentage (%)	(1) High priority on poverty reduction	(2) High priority on nutrition improvement for children in rural areas	(3) Travel risks due to deteriorating security	(4) Availability of local JICA office*	(5) JICA cluster implementation status			(6) Area Classification	(7) COBSI Project Priorities for JICA Overseas offices.	Evaluation *** (to 3rd selection)	
	No.	Potential irrigable areas (1,000 ha)	GDP per Capita (US$)	Agricultural sector contribution to GDP (%)						CARD	SHEP	IFNA				
1. Nigeria	1	19 096	2 230	21,9	35,0		◎	×	✓	✓●	✓	✓	Western		Travel risk	
2. Ethiopia	2	7 792	856	33,5	66,6		◎		✓	✓●	✓○	✓	Eastern	No interest	No interest	
3. Kenya	3	4 041	1 817	34,1	54,3				✓	✓●○	✓●○	✓	Eastern	No interest	No interest	
4. Benin	4	3 051	1 219	26,9	38,3	◎	◎		△	✓	–	–	Western	Interested but unable soon	★	9
5. Tanzania	5	2 792	1 122	28,7	65,1	◎	◎		✓	✓●	✓●	–	Eastern	Interested	☆	1
6. Zambia	6	2 700	1 305	2,9	49,6	◎	◎		✓	✓●○	✓○	–	Southern		Implemented	
7. Angola	7	2 344	2 791	6,7	50,7	◎	◎		✓	✓●	–	–	Eastern	Interested	☆	2
8. Mozambique	8	2 278	504	26,0	70,2	◎	◎		✓	✓●○	✓○	✓○	Eastern	Interested	☆	3
9. Burkina Faso	9	2 163	787	20,2	26,2	◎	◎	×	✓	✓●○	✓	✓	Western		Travel risk	
10. Ghana	10	2 117	2 202	17,3	29,8				✓	✓●	✓●	✓	Western	No interest	No interest	
11. Chad	11	2 110	710	42,6	75,1		◎	×	No	✓	–	✓	Central		Travel risk/No JICA office	
12. Malawi	12	2 014	412	25,5	76,4	◎	◎		✓	✓○	✓○	✓	Southern		Implemented	
13. Uganda	13	1 834	794	23,1	72,1	◎	◎		✓	✓●○	✓●	–	Eastern	Interested but unable soon	★	8
14. Mali	14	1 675	879	37,3	62,4	◎		×	No	✓	–	–	Western		No JICA office	
15. Madagascar	15	1 629	523	23,3	64,1	◎	◎		✓	✓●○	✓●○	✓○	Eastern	Interested	☆	4
16. Democratic Republic of the Congo	16	1 604	581	20,0	64,3	◎	◎	×	✓	✓	–	–	Central		Travel risk	
17. Togo	17	1 501	679	22,5	32,4	◎			No	✓	–	–	Western		No JICA office	
18. Côte d'Ivoire	18	988	2 276	20,7	40,2				✓	✓●	✓	–	Western	Interested	☆	7
19. Cameroon	19	975	1 507	14,5	43,5		◎		✓	✓●○	✓	–	Central	Interested	☆	5
20. Zimbabwe	20	688	1 464	8,3	66,2				△	–	✓	–	Southern	No interest	No interest	
21. Guinea	21	423	963	23,6	60,7		◎		△	✓●	–	–	Western	Interested but unable soon	★	10
22. Sierra Leone	22	34	528	54,3	54,5	◎	◎		△	✓●○	–	–	Western	Interested	☆	6

*(4) Availability of local JICA office, ✓: JICA offices, △: JICA branch offices (There is JICA field office in Guinea)

**(5) JICA Cluster implementation status, ✓: Target Countries, ●: Implemented, ○: Under implementation/planning (SHEP project in Malawi and Madagascar is under planning)

***Evaluation, ☆: Countries considered for field surveys, ★: Countries not considered for field surveys

Source: JICA survey Team

In the third selection, five (5) countries will be selected for field surveys out of Angola, Cameroon, Côte d'Ivoire, Madagascar, Mozambique, Sierra Leone, and Tanzania. Those seven (7) countries include three

(3) countries located in Western and Central Africa, namely Cameroon, Cote d'Ivoire, and Sierra Leone. This selection is, therefore, regionally dispersed and balanced across SSA. The Survey Team did not conduct any field surveys in Benin, Guinea, and Uganda, but will collect information on those countries, since they are strong candidates for future COBSI expansion.

CHAPTER 4 EXISTING DATA SURVEYS AND THIRD SELECTION

4.1 Survey Methodology

In the third selection, the Survey Team conducted a more detailed survey on the ten (10) countries sorted out of second selection as shown in Table 4.1.1 using existing data published by international organizations and national governments. These existing data surveys were carried out with a focus on 1) the possibility of implementing related technical cooperation projects in the future, 2) the suitability of the COBSI approach, and 3) regional balance across SSA. The survey items and points of concern are itemized in Table 4.1.2.

Table 4.1.1 Ten (10) Countries Surveyed in Relation to Existing Data (Third Selection)

Countries considered for field surveys: Seven (7)	Countries not considered for field surveys: Three (3)
Angola, Cameroon, Côte d'Ivoire, Madagascar, Mozambique, Sierra Leone, and Tanzania	Benin, Guinea, and Uganda

Source: JICA Survey Team

Table 4.1.2 Existing Data Survey Items and Points of Concerns

Item		Point of concern
1) Possibility of implementing related technical cooperation projects in the future	National development plans and policies	・ Whether small-scale irrigation development is aligned with national development plans for the agriculture and irrigation sectors, irrigation development plans, etc.
	Assistance policies of Japan	・ Is it aligned with the country's assistance policy? ・ Is the country targeted by CARD, SHEP, or IFNA?
	Safety considerations, entry and travel conditions	・ Collation of small-scale irrigation potential areas and country-specific risk information (Ministry of Foreign Affairs of Japan) ・ Possible travel areas and conditions (JICA)
2) Suitability of the COBSI approach	Natural conditions (weather, terrain).	・ Annual rainfall (>1,000 mm) and rainfall patterns during the rainy season ・ Small-scale irrigation potential areas
	Socio-economic conditions	・ Population, economic trends, smallholder farmers' proportion, poverty rates, etc. ・ Nutritional condition of children under 5 years old (stunting, wasting, overweight)
	Agricultural conditions	・ Status of rainfed and irrigated agriculture, irrigated areas ・ Potential contribution to improved livelihoods of smallholder farmers, etc.
	Agricultural extension system	・ Existing agricultural extension systems, number of extension agents ・ Existence of farmers' organizations, possibility of establishing water users' associations, etc.
3) Regional balance across SSA	Regional characteristics, project priorities	・ Expansion of the COBSI approach to Western and Central Africa ・ Project priorities of JICA overseas offices

Source: JICA Survey Team

(1) Natural Conditions

Monthly graphs for representative areas in each country were obtained from FAO's CLIMWAT for CROPWAT to identify detailed regional annual rainfall as well as dry and rainy season precipitation distribution which are difficult to obtain from satellite images and numerical modeling. Since COBSI is highly adaptable to gently hilly areas, topography was also analyzed. Additionally, potential areas for small-scale irrigation were referenced based on the results of the first selection satellite image analysis.

(2) Socio-economic Conditions

In order to have a socio-economic overview of the target countries, the Survey Team reviewed their

populations, economic trends (GDP per capita, contribution of the agricultural sector, etc.), poverty situations (urban/rural poverty rates), development and educational levels, and nutritional conditions (stunting, wasting, and obesity among children under 5). World Bank and USAID publications were particularly studied for that purpose.

(3) Agricultural Conditions

The survey team identified main agricultural products, situation of rainfed and irrigated agriculture, areas available for irrigation as well as areas under irrigation to draw up an overview of the agricultural sector in the target countries. The potential contribution of the COBSI approach to improving the livelihoods of smallholder farmers was also identified, especially through information sourced from FAO AQUASTAT documents.

(4) Alignment with National Development Plans and Policies

The Survey Team identified agricultural development, poverty reduction, and irrigation development in national development plans prepared by target countries' governments. The directions and specific goals of the latest agricultural and irrigation development schemes were also examined in consistency with the COBSI approach.

(5) Assistance Policies of Japan

Japan's assistance policies and project expansion plans were surveyed from the Ministry of Foreign Affairs of Japan's website to verify the COBSI approach's alignment with them.

(6) Agricultural Extension System

In the COBSI approach, farmers are responsible for the construction, operation, and maintenance of small-scale irrigation facilities, so there must be sufficient extension agents or officers to instruct them. For the implementation system of agricultural extension and water management, the Global Forum for Rural Advisory Services (GFRAS) "World Wide Extension Study" was used as reference. Information related to farmers' organizations was also taken from the same document.

(7) Safety Considerations and Entry/Travel Conditions

Potential areas identified in the first selection were set against country-specific risk information provided by the Ministry of Foreign Affairs of Japan to ascertain safety of travel for conducting field surveys. Furthermore, JICA's restrictions and conditions of travel to the areas, besides quarantine for COVID-19 and requirement of an official passport for entry, were also researched and taken into account.

(8) Regional Characteristics and Project Priorities

Surveying the possibility of implementing the COBSI approach into Western and Central Africa was key to understanding the potential of its expansion in the future, taking into consideration the official language(s)—French being the most widely used lingua franca in many Western and Central African countries—as well as the regional characteristics. JICA overseas offices' priorities could not be ignored either, given their importance when implementing COBSI projects.

4.2 Summary of Survey Results

Existing data surveys were conducted on the 10 aforementioned countries, whose results—sorted by country—are shown in Appendix 4. In addition, the main points of evaluation for the third selection in each item are indicated as follows.

4.2.1 Natural Conditions

(1) Annual precipitation

Annual precipitation exceeds 1,000 mm in most of Southern and Eastern Africa (Angola, Madagascar, Mozambique, Tanzania, and Uganda) and 2,000 mm in some areas of Madagascar and Uganda. Cameroon, located in Central Africa, has a long north-south stretch with rainfall ranging from about 400 mm in the north to more than 2,000 mm in southwestern coastal areas. In Western Africa, namely Benin and Côte d'Ivoire, precipitation falls below 1,000 mm in parts of the north but increases toward the south to about 1,500 mm. Guinea and Sierra Leone have very high annual rainfall, ranging from about 1,000 mm to 3,000 mm (northern part of Guinea) and 4,000 mm in coastal areas.

The rainy season is from October to April in Southern and Eastern African countries and from April to November in Western and Central Africa, as those regions are mainly located in the Northern Hemisphere. Since it was important to identify water sources during the dry season, it should be noted that field surveys had to be conducted during that particular season.

(2) Terrain

Gentle topography was dominant in many of the ten (10) third selection countries. However, Madagascar is the only island country with a clear division between the central highlands and coastal areas, with steep slopes in the east and gentle terrain in the west.

(3) Potential Areas for Small-Scale Irrigation

Small-scale irrigable potential areas were calculated from wide-area satellite imagery analysis in the first selection (cf. Table 4.2.1). Although Sierra Leone is a small country and such areas are small compared to those of other countries, their percentage in relation to rainfed agricultural lands is fairly high (52%), making the country highly important for small-scale irrigation development.

Table 4.2.1 Potential Areas for Small-Scale Irrigation and Ranking (10 countries)

Countries considered for field surveys: Seven (7)			Countries not considered for field survey: Three (3)		
Country	Small irrigable areas (Thousand ha)	Rank*.	Country	Small irrigable areas (Thousand ha)	Rank*
Tanzania	2,792	2	Benin	3,051	1
Angola	2,344	3	Uganda	1,834	5
Mozambique	2,278	4	Guinea	423	9
Madagascar	1,629	6			
Côte d'Ivoire	988	7			
Cameroon	975	8			
Sierra Leone	34	10			

*Indicates ranking among 10 countries

Source: JICA Survey Team

4.2.2 Socio-Economic Conditions

(1) Economic Trends (GDP per Capita and Others)

Côte d'Ivoire has the highest GDP per capita among all 10 countries, at USD2,326. This country produces and exports especially large quantities of cocoa and coffee beans as well as palm oil, and its economy is greatly affected by international price fluctuations and climatic conditions. On the other hand, GDP per capita in Madagascar, Mozambique, and Sierra Leone was extremely low, around USD500. Contribution of the agricultural sector to GDP was less than 30% in nine (9) countries,

excluding Sierra Leone (61.3%). In addition, the agricultural sector labor force participation rate exceeds 50% in 7 countries, indicating a high dependence on that sector in most.

Table 4.2.2 GDP per Capita and Percentage of Working Population in the Agricultural Sector (10 countries)

Country	GDP per capita (USD)[1]	Agricultural sector contribution to GDP (%)[2]	Agricultural sector workers Percentage (%)[3]
Countries considered for field surveys: Seven (7)			
Tanzania	1,076	26.7	65.1
Angola	1,896	9.4	50.7
Mozambique	449	26.0	70.2
Madagascar	495	24.1	64.1
Côte d'Ivoire	2,326	20.7	40.2
Cameroon	1,499	15.2	43.5
Sierra Leone	485	61.3	54.5
Countries not considered for field surveys: Three (3)			
Benin	1,291	27.1	38.3
Uganda	817	24.0	72.1
Guinea	1,194	23.7	60.7

(2) Poverty situation

Seven countries—Angola, Benin, Guinea, Madagascar, Mozambique, Sierra Leone, and Uganda—are classified as "Least Developed Countries (LDCs)"[4]. Of the ten (10) countries, Madagascar showed the highest percentage of poverty level at 78.8%, up from 63.9% in 1999. Mozambique indicated a similarly high level at 63.7%, but this was down from 80.0% in 1996. Cameroon, on the other hand, had the lowest poverty level of them all at 26.0%—thanks to its stable economy—compared to an average of 41.0% for the other SSA countries.[5]

Table 4.2.3 Percentage of the Poor (10 countries)[6]

Countries considered for field surveys: Seven (7)		Countries not considered for field surveys: Three (3)	
Country	Percentage of the poor (%)	Country	Percentage of the poor (%)
Tanzania	49.4	Benin	49.6
Angola	49.9	Uganda	41.3
Mozambique	63.7	Guinea	36.1
Madagascar	78.8		
Côte d'Ivoire	29.8		
Cameroon	26.0		
Sierra Leone	43.0		

(3) Nutritional status

Stunting in children under 5 years old was higher in rural areas in all 10 countries surveyed, exceeding 40% in Angola, Madagascar, and Mozambique. Similarly, wasting was also high in rural areas, ranging from 6% to 8% in Côte d'Ivoire, Guinea, and Madagascar. Regarding overweight, the percentage was higher in urban areas than in rural communities in most countries except in Cameroon where the rate

[1] "GDP per capita (current USD)," World Development Indicators (WB)
[2] "Agriculture, forestry and fishing, value added (% of GDP)," World Development Indicators (WB)
[3] "Employment in agriculture (% of total employment)," World Development Indicators (WB)
[4] List of Least Developed Countries (2021, UNCTAD): https://unctad.org/topic/least-developed-countries/list
[5] Poverty headcount ratio at 1.9 USD a day (% of population), (WB): https://data.worldbank.org/indicator/SI.POV.DDAY?end=2018&locations=ZG&start=2018&view=bar
[6] Poverty headcount ratio at $1.90 a day (2011 PPP) (% of the population), World Development Indicator (WB)

was particularly high, exceeding 10% in both urban and rural areas.

Table 4.2.4 Percentage of Undernourished Children under 5 (10 countries)[7]

Country	Stunting (%)		Wasting (%)		Overweight (%)	
	Urban areas	Rural Areas	Urban areas	Rural Areas	Urban areas	Rural Areas
Countries considered for field surveys: Seven (7)						
Tanzania	24.8	37.8	3.78	4.75	4.1	3.6
Angola	31.8	45.7	4.58	5.39	4.0	2.6
Mozambique	34.4	45.1	3.53	4.73	8.8	6.3
Madagascar	37.7	42.6	5.85	6.59	1.6	1.4
Côte d'Ivoire	12.6	27.4	5.74	6.25	1.4	1.5
Cameroon	19.8	36.2	3.63	4.84	10.3	11.5
Sierra Leone	24.5	32.0	6.33	4.88	5.5	4.1
Countries not considered for field surveys: Three (3)						
Benin	27.5	35.2	5.11	4.87	1.8	1.9
Uganda	23.5	30.2	2.88	3.61	2.8	4.0
Guinea	21.7	33.8	9.86	8.94	6.6	5.2

4.2.3 Agricultural Conditions

In Angola, Benin, Cameroon, Mozambique, and Sierra Leone, actual irrigated areas relative to irrigable areas is less than 10%, indicating very large expansion potential. Further, agricultural production in many countries is dominated by smallholder farmers engaged mostly in rainfed agriculture. Development of small-scale irrigation can, therefore, be achieved in a short period of time and its expansion can significantly contribute to increasing smallholder agricultural production. Madagascar, on the other hand, has a high irrigation (i.e. irrigated area/irrigable area) rate, so irrigated agriculture is considered more widespread than in other countries. However, there is still plenty of potential for irrigation development, especially small-scale which is considered feasible through COBSI.

Table 4.2.5 Irrigable and Irrigated Areas (10 countries)

Countries considered for field surveys: Seven (7)				Countries not considered for field surveys: Three (3)			
Country	Irrigable areas (thousand ha)	Irrigated areas (thousand ha)	irrigation rate (%)	Country	Irrigable areas (thousand ha)	Irrigated areas (thousand ha)	irrigation rate (%)
Tanzania	2,132	364	17	Benin	322	23	7
Angola	3,700	86	2	Uganda	90	11	12
Mozambique	3,072	118	4	Guinea	520	95	18
Madagascar	1,517	905	60				
Côte d'Ivoire	475	73	15				
Cameroon	290	26	9				
Sierra Leone	807	29	4				

Source: FAO AQUASTAT Database

4.2.4 Alignment with National Development Plans and Policies

In all 10 countries surveyed, agricultural promotion is mentioned in national development plans and policies, and the support provided by COBSI is in alignment with such plans for the agricultural and irrigation sectors.

For example, Tanzania plans to increase its irrigated areas to one (1) million hectares by 2020 to promote irrigated agriculture. In Uganda, irrigation water is to be efficiently used and secured to improve food

[7] Malnutrition (2021, UNICEF): https://data.unicef.org/topic/nutrition/malnutrition/

security, crop productivity and profitability as well as sustainability of water for irrigation. In Angola, in order to break away from oil trade dependency, the Ministry of Agriculture is working to strengthen rice production under the National Development Plan which includes industrial diversification through promotion of agriculture and manufacturing. In Guinea, the national program includes modernizing irrigation facilities, improving market access, strengthening value chains, and enhancing food security and nutrition for vulnerable groups.

4.2.5 Assistance Policies of Japan

(1) Assistance Policies

Japan has assistance policies in the agricultural sector for all 10 countries surveyed, and the Survey Team confirmed alignment of the assistance provided by COBSI with its country-specific assistance strategy.

(2) JICA Agricultural and Rural Development Cluster (CARD, SHEP, IFNA)

The target countries and implementation status of the JICA Agricultural and Rural Development Cluster were identified in the second selection (cf. Table 4.2.6).

All ten (10) countries are CARD targets, and 9 countries other than Angola have been targeted since Phase 1. CARD-related projects have also been implemented in countries other than Benin. Regarding SHEP, six (6) countries (Cameroon, Côte d'Ivoire, Madagascar, Mozambique, Tanzania, and Uganda) were targeted and four (4) of them (Madagascar, Mozambique, Tanzania, and Uganda) have already implemented SHEP projects. As for IFNA, implementation is ongoing in two countries, namely Madagascar and Mozambique.

Table 4.2.6 Cluster Countries/Implementation Status (10 countries)

Countries considered for field surveys: Seven (7)				Countries not considered for field surveys: Three (3)			
Country	CARD	SHEP	IFNA	Country	CARD	SHEP	IFNA
Tanzania	✓●	✓●	―	Benin	✓	―	―
Angola	✓●	―	―	Uganda	✓●○	✓●	―
Mozambique	✓●○	✓○	✓○	Guinea	✓●	―	―
Madagascar	✓●○	✓●○	✓○				
Côte d'Ivoire	✓●	✓	―				
Cameroon	✓●○	✓	―				
Sierra Leone	✓●○	―	―				

*Cluster countries/implementation status: ✓: Target countries, ● : Implemented, ○ : Under implementation/planning (Project under planning for Madagascar)

Source: JICA Survey Team

4.2.6 Agricultural Extension System

(1) Agricultural Extension Systems and Officers

In 9 out of the 10 countries surveyed, except for Madagascar, agricultural extension is carried out by government agencies related to agriculture. The number of extension officers and farmers in each country as well as of farmers per extensionist (number of farmers/extension officer) are shown in Table 4.2.7. In Benin and Uganda, the number of farm households per extensionist—1,500 and 1,800 respectively —is relatively small. In Guinea, however, the number of farmers per officer is more than

10,000, which means that the extensionist's workload is extremely heavy. This raised concern that technology transfer through extension officers would be insufficient to provide technical support to farmers.

In Madagascar, the provision of public agricultural extension services was discontinued in the 1990s, and agricultural extension is now mainly provided by donor-supported projects and other means. Existing in one hundred and seven (107) rural counties throughout the country, Agricultural Service Centers (*"Centres de service agricole – CSA"*), which are NGOs funded by the Ministry of Agriculture, have been established to support farmers' production activities.

Table 4.2.7 Number of Extension Officers and Farmers (10 countries)[8]

Countries considered for field surveys: Seven (7)				Countries not considered for field surveys: Three (3)			
Country	Number of extension officers (persons)	Number of farmers (ten thousand farmers)	Number of farmers/ extension officers	Country	Number of extension officers (persons)	Number of farmers (ten thousand farmers)	Number of farmers/ extension officers
Tanzania[9]	8,756	1,825	2,080	Benin	1,211	189	1,560
Angola	909	674	7,400	Uganda[10]	3,854	N/A	1,800
Mozambique[11]	1,304	935	7,170	Guinea[12]	N/A	N/A	>10,000
Madagascar[13]	-	-	-				
Côte d'Ivoire[14]	1,500	720	4,800				
Cameroon	1,651	499	3,030				
Sierra Leone	702	148	2,100				

Note: Regarding the number of farmers in 7 countries except for Côte d'Ivoire, Guinea, and Madagascar, the figure is the total working population multiplied by the proportion of farmers.[15]

(2) Farmers' Organizations and Water Users' Associations

There are farmers' organizations in all 10 countries surveyed, and agricultural technology dissemination and marketing advice are provided through them. In Tanzania, they encourage farmers to save money and obtain loans from banks, though there are challenges in managing such organizations. Guinea also has farmers organized in groups, unions, federations, etc., but reports indicate that farmers' organizations are not very familiar with how the private sector operates due to past market control and economically isolated conditions. In Mozambique, only 6.5% of smallholder farmers belong to farmers' organizations, which is extremely low.

[8] Global Forum for Rural Advisory Services (GFRAS), https://www.g-fras.org/en/world-wide-extension-study.html (number of extension workers)
[9] "Tanzania Country National Irrigation Master Plan Revision Project (Final Report)" (July 2018, JICA);
[10] "BMAU Briefing Paper 25/19, May 2019 ", Ministry of Finance, Uganda, https://www.finance.go.ug/sites/default/files/Publications/BMAU%20Policy%20Brief%2025-19-Performance%20of%20Agricultural%20Extension%20Services%20-%20What%20are%20the%20emerging%20challenges.pdf
[11] Desk Study of Extension and Advisory Services (Mozambique), (2018, USAID)
[12] "Guinea: Desk Study of Extension and Advisory Services" (2017, USAID)
[13] "Report of the Survey on the Collection and Confirmation of Basic Information on the Agricultural Sector in Madagascar" (JICA, 2014)
[14] "Climate-Smart Agriculture Investment, Côte d'Ivoire's" (WB, 2019)
[15] https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS and https://data.worldbank.org/indicator/SL.TLF.TOTL.IN (WB)

4.2.7 Safety Considerations and Entry/Travel Conditions

(1) Safety considerations

Considering the next step(s) of the field surveys, the Survey Team checked small-scale irrigation potential areas against country-specific risk maps published by the Ministry of Foreign Affairs of Japan and identified relevant safety aspects as of July 2021. In many countries, the majority of the areas were largely below Level 1 ("Travel with caution"), and there were no problems with field survey activities in small-scale irrigated potential areas. However, some survey targets in Benin, Côte d'Ivoire, Guinea, and Mozambique were placed at Level 2 ("Do not travel urgently") and Level 3 ("Travel suspension advisory"). In Angola, Level 2 areas covered much of the country, though about half of the irrigable areas were at Level 1. In Cameroon, most of the small-scale irrigated potential areas were located in the northern and western parts of the country and concerned by Levels 2, 3, and 4 ("Evacuation advisory"), with few irrigable areas within Level 1. Neighboring Central Africa, Chad, and Nigeria were also under Levels 3 and 4.

(2) Domestic Travel and Entry Conditions

Since JICA provided information on the areas and conditions of domestic travel in each country, the Survey Team estimated the extent to allow field survey trips. Travel to all parts of the country was possible only in Uganda as opposed to within 1.5 to 8 hours by vehicle from the capital or a major city in other countries. Regarding entry requirements, Angola and Madagascar required official passports, and the application process took about a month until reception. Furthermore, Madagascar had only one flight per week as of July 2021.

4.2.8 Regional Characteristics and COBSI Project Priorities

(1) Regional Characteristics

Table 4.2.8 shows the regional characteristics of the 10 surveyed countries in Africa. Considering broader expansion and dissemination of COBSI to the rest of SSA in the future, at least two (2) out of five (5) countries targeted for field surveys should be selected from Western and Central Africa. In view of this future prospect for COBSI, it is desirable to also select French-speaking countries, since French is the official language in many Western and Central African countries, which is the case of four nations other than Sierra Leone.

Table 4.2.8 Regional Classification (10 countries)

Items	Southern Africa	Eastern Africa	Western Africa	Central Africa
Countries considered for field surveys: Seven (7)	Angola and Mozambique	Tanzania and Madagascar	Côte d'Ivoire and Sierra Leone	Cameroon
Not included in the field study: Three (3)	-	Uganda	Benin and Guinea	-

Source: JICA Survey Team

(2) COBSI Project Priorities

All of the seven (7) countries targeted for field surveys showed a high level of interest in the COBSI project. Benin, Guinea, and Uganda were excluded from the list because their JICA overseas offices/branches responded "interested, but unable to implement COBSI projects anytime soon".

4.3 Results of Third Selection (Sharing Analysis Results)

The third selection was based on existing data surveys on ten (10) countries—needed to identify key evaluation points for each item—whose results are tabulated under Appendix 4-11. In this table, each item was scored on a four-point scale from A to D (very high, high, some, or low effectiveness of the COBSI approach), and an overall evaluation was made. After consulting JICA headquarters, five (5) countries were selected for field surveys, namely Côte d'Ivoire, Madagascar, Mozambique, Sierra Leone and Tanzania. The third selection results and a related location map are respectively shown in Table 4.3.1 and Figure 4.3.1.

Table 4.3.1 Results of the Third selection

Countries selected for field surveys: Five (5)	Countries not selected for field surveys: Two (2)	Countries not considered for field surveys: Three (3)
Tanzania, Mozambique, Madagascar, Côte d'Ivoire, and Sierra Leone.	Angola and Cameroon	Benin, Uganda, and Guinea

Source: JICA Survey Team

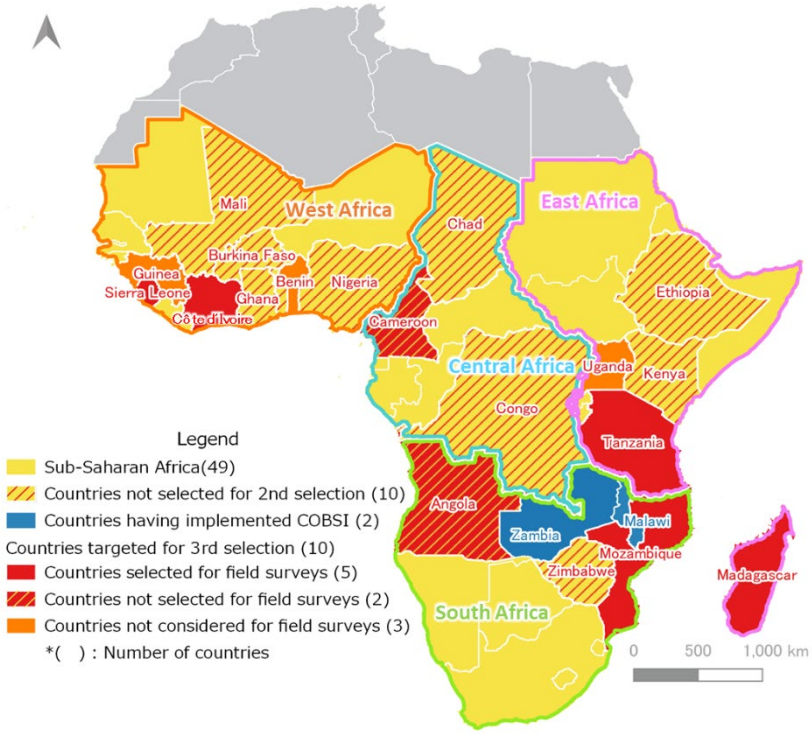


Figure 4.3.1 Location Map of Third Selection Results

Source: JICA Survey Team

CHAPTER 5 DETAILED SATELLITE IMAGERY ANALYSIS (5 COUNTRIES FOR FIELD SURVEY)

Detailed satellite image analysis was performed on five (5) countries for the third selection. Using high-resolution satellite data, water resources availability and small-scale irrigation potential were evaluated for the said countries, and the evaluation's analytical method (wide-area analysis) was the same as for the first selection.

5.1 Satellite Image Data

10 m resolution Sentinel-2 multispectral sensor data was used as high-resolution optical sensor images, and 30 m resolution (15 m for panchromatic) Landsat-8 data was applied to supplement cloud-covered areas.

Additionally, processed products generated from publicly available satellite data were used as comparison data for verification and correction of the analysis results.

5.2 Area of Intent for the Analysis

To ensure accuracy and improve work efficiency, the analysis coverage or the area of intent—defined as the region, state, and province for each analysis object—was adjusted according to the purpose of the survey.

5.3 Distribution of Small-Scale Irrigation Potential

A distribution map for small-scale irrigation potential was prepared based on rainfall, surface runoff, hydrological balance, topographical features, soil types, population, land use, distance to water sources, and surrounding villages' location (Figures 5.3.1 to 5.3.5).

The selection of plots in potential areas for small-scale irrigation was based on existing cultivated fields which were not only identified by tracking time-series changes in vegetation and water indices, but also modified through comparison with several other processed satellite products (Sentinel-2, Landsat-8, and PROBA-V data).

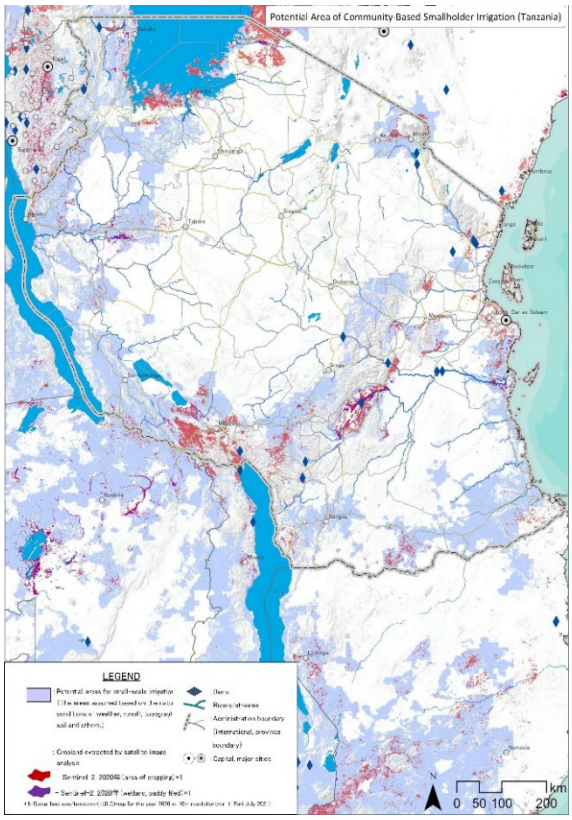


Figure 5.3.1 Potential Areas for Community-Based Smallholder Irrigation in Tanzania

Source: JICA Survey Team

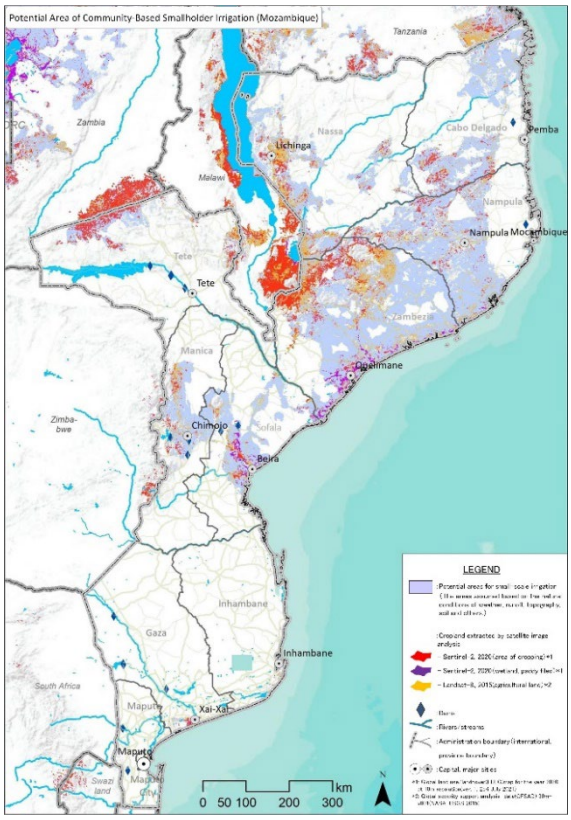


Figure 5.3.2 Potential areas for Community-Based Smallholder Irrigation in Mozambique

Source: JICA Survey Team

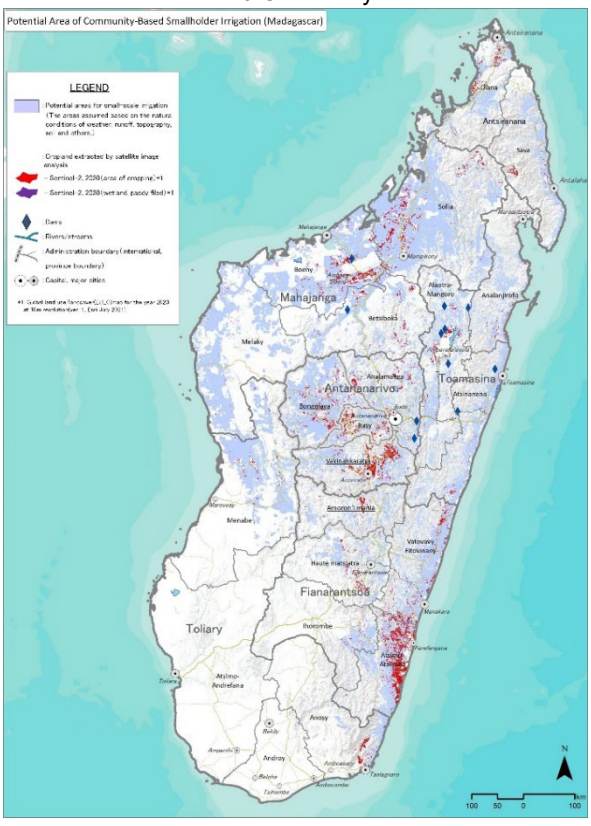


Figure 5.3.3 Potential areas for Community-Based Smallholder Irrigation in Madagascar

Source: JICA Survey Team

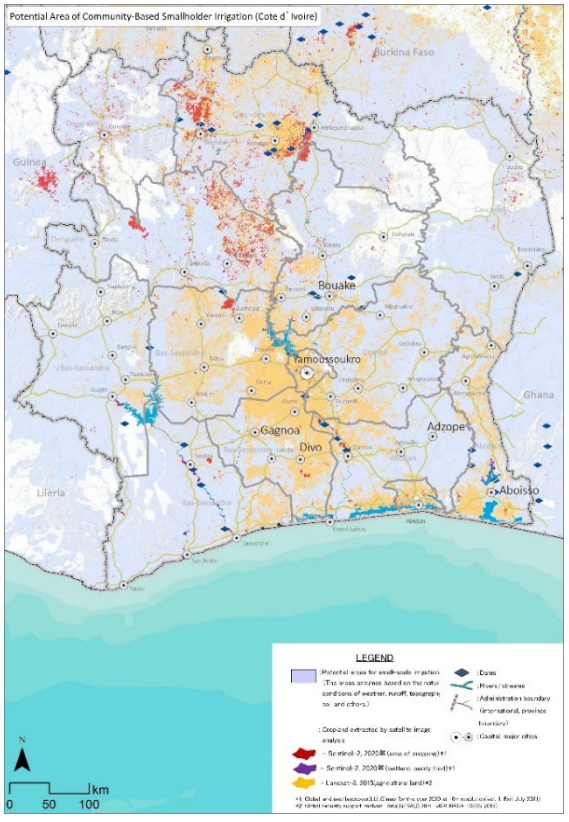


Figure 5.3.4 Potential areas for Community-Based Smallholder Irrigation in Côte d'Ivoire

Source: JICA Survey Team

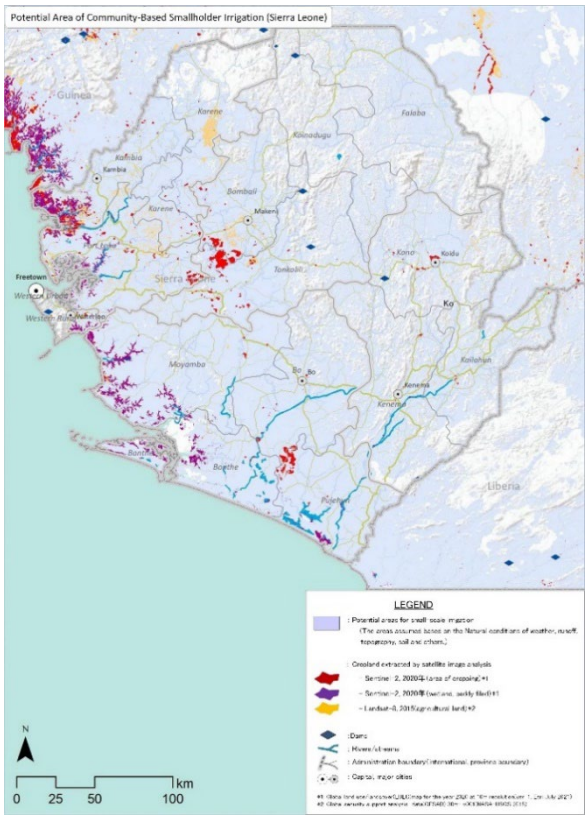


Figure 5.3.5 Potential areas for Community-Based Smallholder Irrigation in Sierra Leone
Source: JICA Survey Team

5.4 Use of Analysis Results

Of the analytical results, useful information for developing small-scale irrigation projects has been arranged in GIS data which consist of:

(1) Potential areas (areas available for small-scale irrigation, lands under cultivation, wetlands);

(2) Weather information (rainfall, temperature, drought, etc.);

(3) Hydrological information (water source volume, effective rainfall, evaporation, river inflow, etc.);

(4) Topographical information (elevation, specific height, slope, etc.);

(5) Surface cover information (soil, surface geology, etc.);

(6) Protected area information (nature reserves, national parks, etc.), and

(7) Land use information (irrigation facility rate, surrounding population, surrounding villages, location of existing water sources, etc.).

Items necessary for field surveys were selected, and field survey materials were prepared in advance based on the natural conditions of the area of intent. The following section describes examples of the use of this information in Mozambique: (1) Potential areas, (3) Hydrological information (water source volume), and (7) Land use information (irrigation facility rate).

5.4.1 Potential Areas in the Survey Coverage (Mozambique)

Small-scale irrigation potential in Mozambique was tabulated at each administrative division (Level 3 administrative posts; Figure 5.4.1) to help identify priority areas for the survey. Potential areas are distributed in the northeastern region where Niassa and Zambezia provinces are located, and administrative posts with a maximum area of over 100,000 ha were identified.

With less than 5%, irrigation rate in the region is, however, lower than that of neighboring Malawi and South Africa (Figure 5.4.2), assuming that most of the water sources in potential areas are dependent on rainwater.

A (first) field survey was conducted in 2021 in Niassa Province which was also identified as an area with high small-scale irrigation potential based on preliminary satellite data analysis.

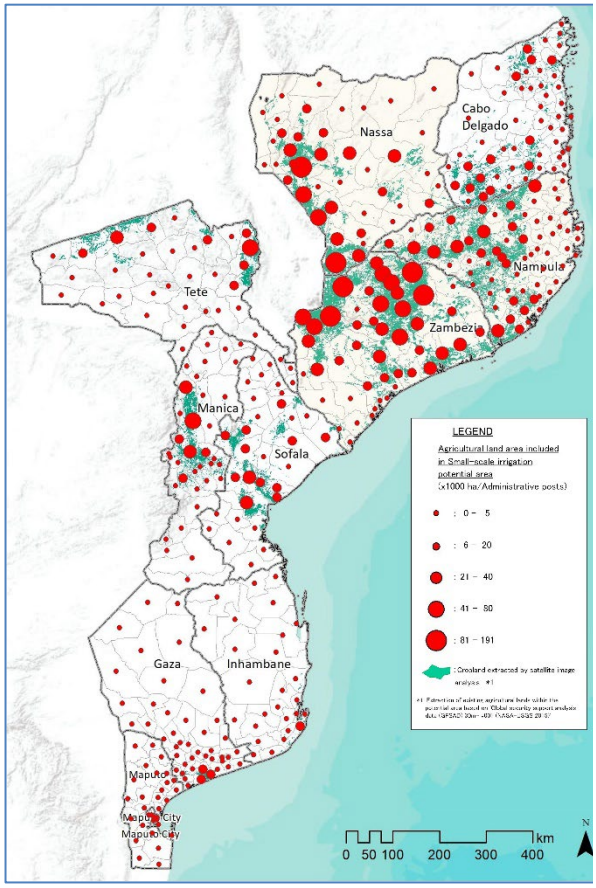


Figure 5.4.1 Small-scale Irrigation Potential Areas (Mozambique)
Source: JICA Survey Team

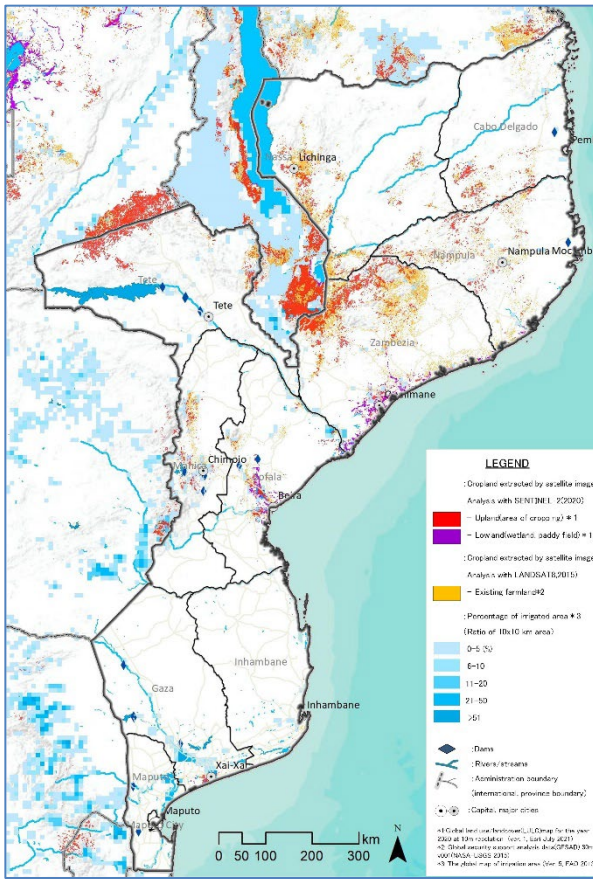


Figure 5.4.2 Percentage of Irrigation Areas (Mozambique)
Source: JICA Survey Team

5.4.2 Irrigation Water Sources (Mozambique)

A second field survey was conducted in the southern region where the average annual rainfall (Gaza, Inhambane, and Maputo Provinces) is less than 1,000 mm and exposed to high evapotranspiration, so rivers on small watersheds usually dry up by the end of the dry season. Therefore, only few regional districts could be extracted as "small-scale irrigation potential areas" based on the Zambia model site flow regime (i.e., where irrigation water is available even at the end of the dry season), and dry-season water sources are thus available only in coastal areas, large watersheds, and spring-fed areas in the hinterland.

In order to find more stable water sources in the regions, river inflow (mainly baseflow) during the first half of the dry season (three months after the rainy season) was calculated (Figure 5.4.3) and used as preliminary data for the second field survey.

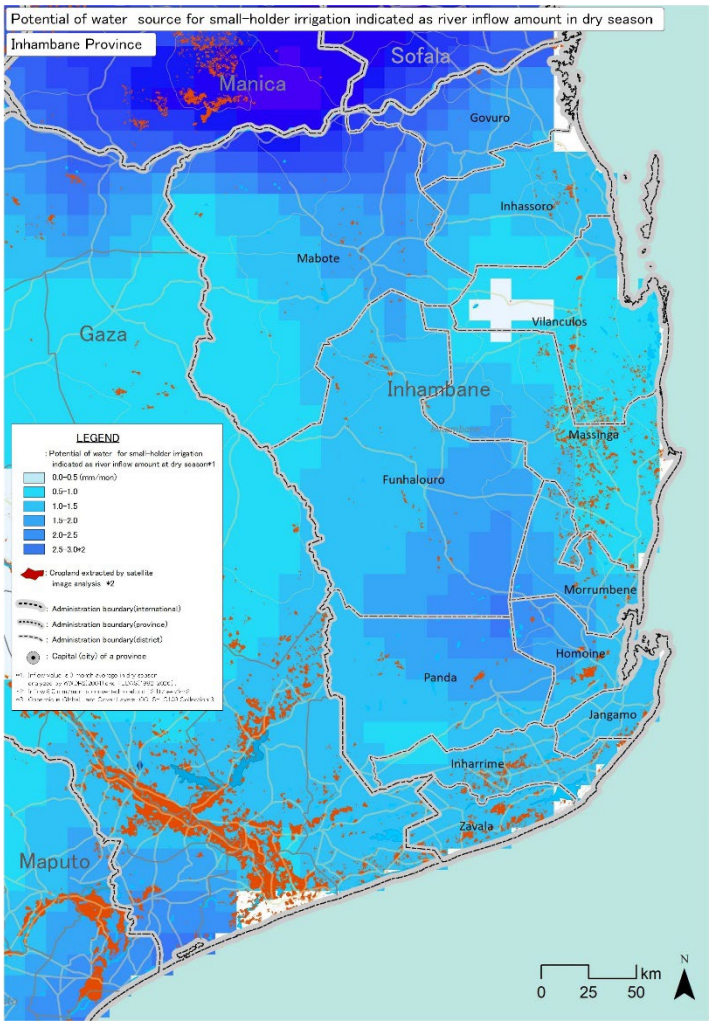


Figure 5.4.3 Potential water sources for smallholder irrigation (Inhambane ~ Maputo Provinces, Mozambique)

Source: JICA Survey Team

5.4.3 Field-Based Preliminary Map (Mozambique)

Proximity of target plots to water sources (streams and rivers) and degree of difficulty of access were items of consideration in the development of the project. In order to survey the relationship between those fields and water sources, a preliminary map was prepared by overlaying the distribution of fields extracted from satellite data, water system network and land use information obtained from topographical and preliminary field survey information.

The preliminary maps used for the first field survey (Zambezia boundary areas, Niassa Province) and the second one (nearby Xai-Xai City areas, Gaza Province) are shown in Figures 5.4.4 and 5.4.5.

Niassa Province—target of the first field survey—is located in the highlands on a high plateau composed of basement rocks, and its topography is characterized by an open and resinous water system. Its annual rainfall exceeds 1,000 mm, and many rivers and streams maintain their flow even at the end of the dry season. Its high river density provides good water source-to-field access, so the area is considered to

have high development potential.

The suburbs of Xai-Xai City, covered by the second field survey are—on the other hand—located in an alluvial, low-lying area at the mouth of the Limpopo River where rainfall is about 1,000 mm/year in coastal areas and the monsoon has a strong influence, while inland areas receive less rainfall and become drier. Rivers in small catchment areas are, thus, expected to dry up at the end of the dry season when, alternatively, both rainwater and subsoil water from the Limpopo River can be used as irrigation water sources, though fluctuation is large and water sources access conditions could not be determined from imagery information.

The results of satellite image analysis shown in Figures 5.4.3 to 5.4.5 were used as preliminary information for the five target countries.

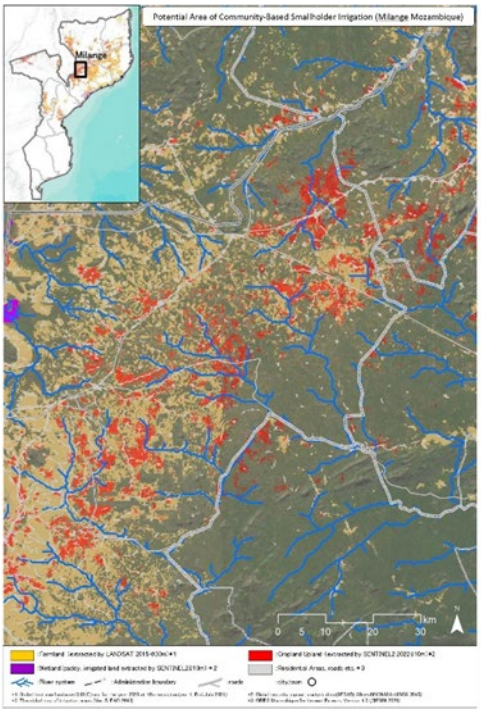


Figure 5.4.5　Preliminary map for 1st field survey
(Niassa～Zambezia Provinces, Mozambique)
Source: JICA Survey Team

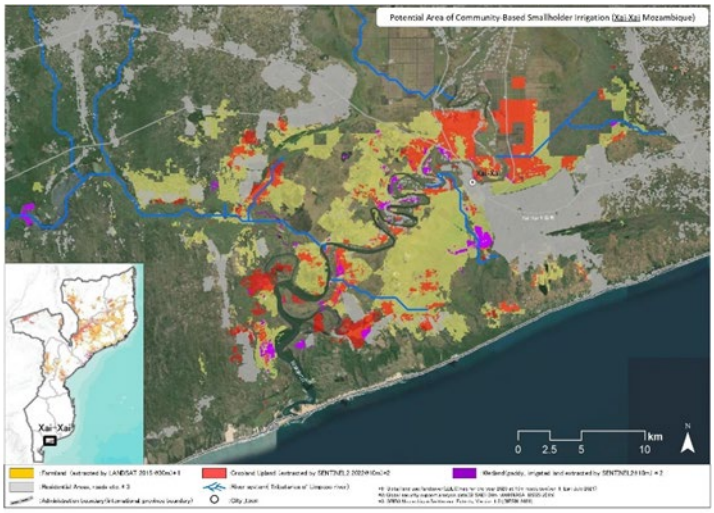


Figure 5.4.5　Preliminary map for 2nd field survey
(Xai-Xai, Maputo Province, Mozambique)
Source: JICA Survey Team