PROVINCIAL INVESTMENT PLAN FOR PIPED WATER SUPPLY IN CAMBODIA

Conducted by Investing in Infrastructure Program (3i)
in collaboration with the Ministry of Industry, Science, Technology and Innovation (MISTI) in 2020,
Fully funded by the Australian government

Australian Aid

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DISCLAIMER

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GLOSSARY

Applying for license: the licensing status of a village occupied by a private water supplier that is in the process of applying for a license from MISTI. This ranges from seeking permission to supply piped water from DISTI to obtaining the draft on tariffs for 20-day public announcements.

Coverage status: the status if a certain village is covered by an existing piped water supply or not. Coverage status is regardless of licensing status.

Covered village: a village that is covered by an existing piped water supply, even to some extent.

Licensed: the licensing status of a village occupied by a private water supplier who has already obtained the license from MISTI.

Licensing status: the occupation status of a village indicating if it is in the service area of a certain piped water supplier regulated by a designated ministry. Licensing status is regardless of coverage status.

Non-covered village: a village not yet covered by an existing piped water supply.

Non-occupied: the licensing status of a village not occupied by any water supply from a legal perspective. There is the case that a non-occupied village is covered by piped water supply without seeking legal permission from MISTI or MRD.

Non-pipe solution: village's incompatibility for piped water infrastructure

Pipe solution: village's suitability for a piped water infrastructure without causing conflict over a service area.

System: piped water supply infrastructure.

ACRONYM

ALC	: Appling for License
COM	: Community Piped Water Utility
LC	: Licensed
MISTI	: Ministry of Industry, Science, Technology and Innovation
MOWRAM	: Ministry of Water Resources and Meteorology
MRD	: Ministry of Rural Development
NOC	: Non-Occupied
PIP	: Provincial Investment Plan Study in Piped Water Supply
PUB	: Public Piped Water Utility
TBD	: To Be Determined (suitable for piped treated water supply but was not designed for piped water supply in the study due to potential licensing issues)

01.
INTRODUCTION

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INTRODUCTION

Piped treated water can be ranked at the highest level of clean water access considering its quality, sustainability, price, governance and convenience. However, its high upfront investment cost has prohibited widespread access to the required infrastructure. While many governments in developing countries have difficulties finding public funds to invest in this essential infrastructure, Cambodia has enjoyed strong private sector participation in the provision of clean piped water, with rules and regulation governing commercial piped water supply. This enabling investment climate will prove even more important when the public budget is constrained due to the COVID-19 pandemic. Cambodia's Sustainable Development Goal 6 on Clean Water and Sanitation pledges to reach universal clean water access by 2030. Access to clean piped water will be one of the main approaches to achieve this goal. Clear and coordinated sectoral planning is essential for Cambodia to reach its full potential in bringing clean piped water to households and businesses. This planning requires a thorough understanding regarding current status, potentials and what is needed to fill the gap.

The pandemic has made it even more apparent how access to reliable clean water is essential in controlling transmission through improved sanitation, especially hand washing. Enhanced pandemic response and recovery cannot exclude the consideration of increased access to clean water. This timely study provides essential inputs that set national strategy development and planning to increase coverage to more remote and less commercially viable areas where there are marginalized groups who are more vulnerable to less hygienic environments.

Upon request from the Ministry of Industry, Technology, Science and Innovation (MISTI), Investing in Infrastructure Program (3i), funded by the Australian government, conducted this Provincial Investment Plan Study in Piped Water Supply (PIP) for 22 of Cambodia's 25 provinces as part of its policy support to the Royal Government of Cambodia. The study incorporates social, technical and financial aspects within the current Cambodian context in its design and analysis. It assesses the current coverage status of piped water supply, identifies the potential for the establishment of treated piped water in villages that do not have access to piped treated water yet, estimates required investment costs and identifies the support necessary to stimulate infrastructure investment. A wide range of uses or follow up activities can result from the study in the short- and long-term. Many are expected to be taken on by the 3i program in collaboration with MISTI and potentially other development partners.

The program's own experiences from working directly with private water operators and lessons learned from peer development partners serve as very useful inputs for practicality checks. This allows the program to improve the design of the study wherever possible.

As of 2020, 3i had stimulated a total investment of at least USD 35 million to establish and expand piped treated water infrastructure through investments of more than 80 private water companies by using a Viability Gap Financing approach with the subsidy of 45% of total investment cost.

This investment potentially provides clean water access to more than 1 million Cambodians countrywide.

Service areas of public water utilities were excluded from the infrastructure design and costing under the study because of the potentially large difference in standard, context, and therefore investment cost and potential return on investment. Siem Reap and Prey Veng provinces were also excluded as a similar study was recently conducted in these provinces by the World Bank. Nevertheless, information about coverage and licensing status of each village was collected and combined with previous studies to provide countrywide information.

Despite a strong effort to conduct the PIP study at as detailed a level as possible within the allocated timeframe and resources, each treated piped water system was not designed at full feasibility study level and therefore can only serve as an initial estimate for potential investors and policy makers. Many assumptions and logics behind the study were based on lessons learned from working directly with private water operators and existing and additional studies conducted by the 3i team. A list of major assumptions used in the study can be found in the Annexes. Readers are encouraged to interpret and use the results broadly rather than literally, and with a good understanding of the assumptions and logic behind it.

The PIP study indicates that as of 2020, 47% of all villages in Cambodia's 25 provinces were covered by a piped water network to some extent. These covered villages account for 53% of all households countrywide. This 53% of households live in covered villages, not necessarily connecting to the piped network. 4% of villages in the 22 provinces studied were considered unsuitable for piped water supply.

The total investment cost required to build clean piped water systems in villages not covered by a pipe network, suitable for piped water supply and designed in the study, is estimated to be USD 150 million. This investment cost does not include the budget to fully cover villages covered with piped network to some extent and the cost to upgrade existing infrastructures. On average, estimated public funding equal to 33% of the total investment cost could bring the investment's IRR of designed infrastructures to 15% or a payback period of approximately 8.5 years.

02.

BACKGROUND

OF PIPED WATER SUPPLY SECTOR

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OF PIPED WATER SUPPLY SECTOR

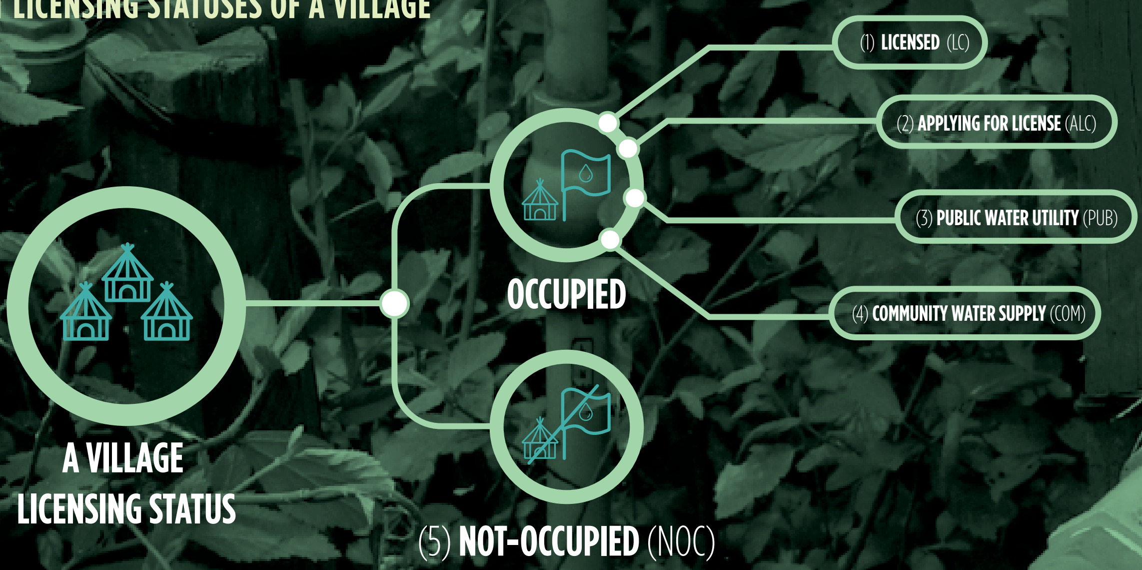
Piped water supply in Cambodia is governed by two ministries – the Ministry of Industry, Science Technology and Innovation (MISTI) and the Ministry of Rural Development (MRD). MISTI governs commercial piped water supply provided by private water operators and public water utilities with relatively clear rules, regulations and standards regarding license, tariff, technical requirements and quality. MRD governs piped water supply under community management, usually with lower technical requirements, lower tariffs, smaller infrastructure size, and high levels of grant.

In this sector, villages in Cambodia can be classified as per the two characteristics below:

2.1 Licensing status:

- whether it is already occupied, i.e., located in the service area of a private water operator who has already received a license from MISTI (marked as Licensed or LC in the study)
- whether it is located in an area under application for a license from MISTI by a private water operator (marked as Applying for License or ALC in the study)
- whether it is located in the service area of one of the public water utilities managed by MISTI (marked as Public Water Utility or PUB in the study)
- whether it is located in the service area of a community water supply system governed by MRD (marked as COM in the study)
- whether it is not occupied, meaning not under the service area of a public, community or private piped water supplier, both who obtained and is applying for a license from MISTI (marked as NOC in the study).

Figure 1:
DIFFERENT LICENSING STATUSES OF A VILLAGE



2.2 Coverage status:

- whether it is covered with a pipe network to some extent (referred to as covered in the study)
- or whether it is not covered with a pipe network to any extent at the time of the study (referred to as non-covered in the study)

The study does not consider the extent of pipe coverage in a covered village given the time limitation of the study in 22 provinces. It is assumed that further expansion will happen in partially covered villages in the near future, although it is possible that some partially covered villages may remain not fully covered in the long-run if water demand is not conducive for commercial operations. An additional study on partially covered villages is needed to estimate the investment cost to ensure full coverage. The licensing status does not necessarily indicate coverage status. For example, villages under the service area of a licensed private operator does not necessarily mean they were covered by a piped water supply. However, not occupied villages may already have pipe network to certain extent. The main reason for this is because a private water operator notifies the village or commune chief about the water supply in their village without yet applying for a proper license at provincial and ministerial levels.

03.
METHODOLOGY

3.1 DATA COLLECTION

3.2 SYSTEM DESIGN

3.3 LIMITATIONS

03. METHODOLOGY

3.1 Data collection

Data collection, investigation and the design of each piped water infrastructure in the study were conducted for each village and went through multiple layers of peer-review to reduce errors and ensure consistency. A variety of primary and secondary data sources were also used, and verification of information was undertaken to ensure the use of quality and up-to-date data throughout.

Some of the main data sources include:

- Commune database 2017: This was the latest source of socioeconomic data from the Ministry of Planning available at the time of the study. Therefore, new villages established after the 2017 commune database are not included.
- MISTI, their provincial departments, commune chiefs and piped water suppliers: The ministries and their relevant departments are the main sources of information for the licensing status of each village. The information on coverage status is collected from commune chiefs, with validation from piped water suppliers.
- Open Development Cambodia's (ODC) website (www.opendevelopmentcambodia.net) in 2019: The website provides commune, district and provincial boundaries for this study. Note the boundaries in this study are used to help with pipe water infrastructure design for this study only. They cannot be used as official representation of Cambodia's borders.

Once the licensing and coverage status of each village was determined, water engineers began the process of piped water infrastructure design for non-covered villages. The study only looked into investment in infrastructure for non-covered areas and did not look at upgrading existing piped water systems. In addition to this primary data collection, the research team consulted with relevant stakeholders, including the World Bank, GRET, RWST and WaterAid, who have extensive experience in the sector and have previously conducted similar studies. Input from the consultations were used as inputs to fine-tune the study's methodology and improve overall results.

3.2 System design

Information on the distance between each village centre, elevation, house dispersion, nearby water sources, number of households and floating residences, are factors used to determine if a village is suitable for piped water infrastructure. These criteria are also used for village clustering for piped system design.

A non-covered village can be classified into three categories:

- Non-pipe solution, meaning not suitable for piped water supply
- Pipe solution, meaning suitable for piped water supply
- TBD (to be determined), meaning suitable for pipe solution, yet an optimal pipe system design can potentially lead to licensing issues so the study did not conduct any piped system design and costing

For a TBD village, water engineers cannot design an optimal piped water system without leading to potential conflict in license areas of two piped water operators. This normally happens when one village is in the service area of one water operator but that village is far from other villages in her or his service area. However, that village is within close proximity to the service area of another operator where she or he can easily extend the pipe to that village; yet doing so can bring licensing conflict. Therefore, there is no cost estimated for investment on piped treated water infrastructure for TBD areas. Readers should keep this in mind when interpreting investment costs estimated in this study.

Once villages are clustered, water engineers determine the water source, location of water treatment station and draw the main pipe network. Simplified technical and financial models are used to determine size, cost and viability of the designated piped water infrastructure. Prices of major infrastructure facilities, such as treatment plants and pipes, were verified with market prices at the time of study.

Determination of the water source for each system relies on a combination of sources and factors. Nearby surface water sources, historical availability of the water source on Google Earth, catchment area, data on ground water availability, and verification with locals through phone calls and field visit are used to determine if a piped water system can solely rely on a surface water source, wells or ponds, or needs to combine these sources to ensure the system can meet at least the potential clean water demand in the next five years and ensure sustainability of the system.

Quality control processes and information on the commercial viability of a system resulting from the financial model can lead to adjustment of the design or even village cluster to determine an optimal piped water system. A larger pipe system and extension from existing systems are preferred and designed wherever possible.

The study team compared the results from the simplified technical model in the PIP study with the results from 17 full feasibility studies conducted under the program.

The study team compared the results from the simplified technical model in the PIP study with the results from 17 full feasibility studies conducted under the program.

The total investment cost of 17 systems projected by the simplified models in the PIP study is 0.5% higher, with the range from -19% to 16%. The results also show the estimation on electricity consumption in the PIP technical model is also 2% lower on average, with the range from -12% to 16%. Considering the initial level of information aimed for and the scale of the study, the 3i program considers this an acceptable range.

The main assumptions used in the technical and financial models can be found in Annex I and II. This study assumes a tariff of 2,300 KHR per cubic meter. At the time of the study this was the average tariff aimed by MISTI for the systems in Applying for License (ALC) and Not-Occupied (NOC) villages. For the system under licensed private water operator (LC) and community water supply (COM), the study uses the tariff set by MISTI at the consumption range from 4 cubic meters.

3.3 Limitations

The current Cambodian context, including tariff regime, licensing policies, technical requirements, water source development and management, household socio economic status, demand for clean water, coverage status etc, influence the design for what the study deems to be an optimal system. In addition, these factors will change over time. Therefore, the result is not expected to remain valid for several years. Instead, it should be used as useful input for policy development, improvements and long-term sectoral planning.

Unforeseen factors, such as the ability to lay pipe across certain paths, ability of water operators to seek permission to withdraw raw water from a certain source and their actual investment appetite or financial capacity, will affect design of the actual system. Rather than claiming the piped water systems considered as optimal in this study as the best solution, readers are encouraged to use this result as guidance and for their initial investment decision-making process, which needs to be followed by more detailed studies.

The costings of infrastructures designed in the study were verified with current market prices for production and distribution systems. However, the estimated size and costs were made for construction in urban, semi-urban and rural areas where labour cost, ease in pipe installation, technical supervision cost etc, can vary from those in provincial towns or major cities. For this reason, the study does not estimate the cost of piped infrastructure in the service area of public water utilities, although information on licensing status and coverage was collected and reported.

As mentioned above, the study does not investigate the quality of existing water infrastructures. It is expected that a large sum of investment is also needed to upgrade existing facilities so the quality of water supply meets the standard required by relevant ministries; and to respond to the increase in water demand in the future.

04.

FINDINGS & POTENTIAL USES OF PIP RESULTS

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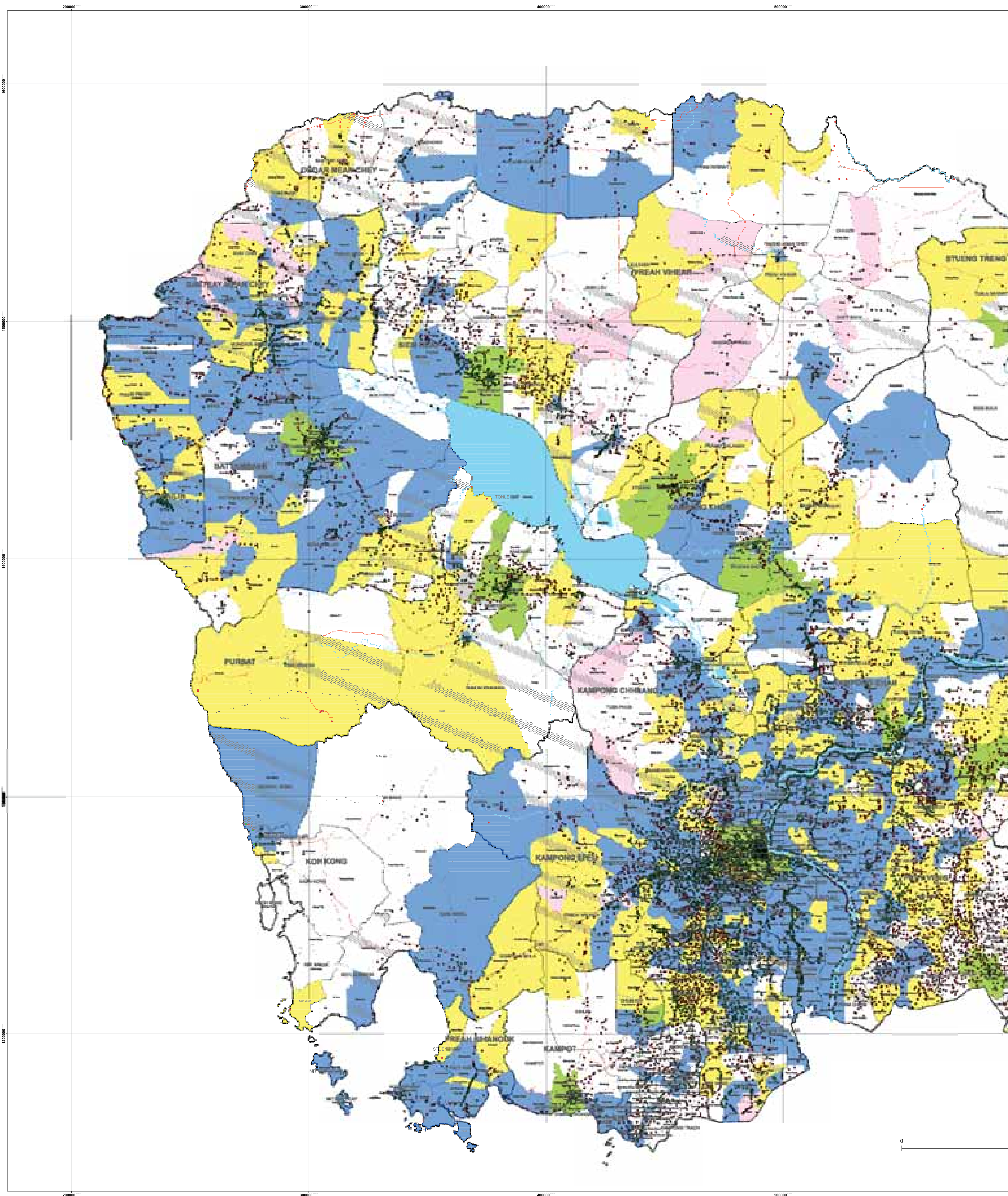
4.1 Sector Overview

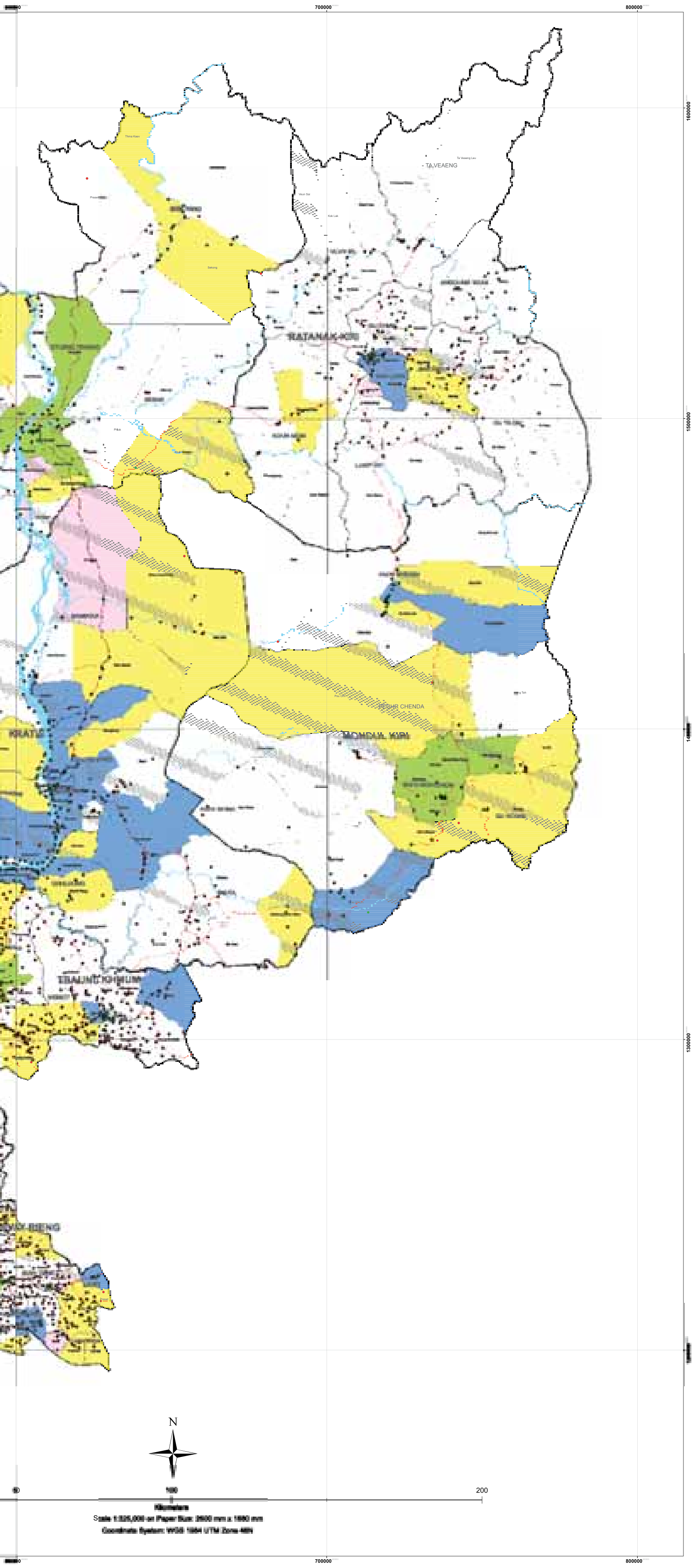
Combined the data from World Bank's similar study in Prey Veng and Siem Reap provinces and the data in Phnom Penh from General Department of Potable Water, as of 2020, 47% of all villages in the 25 provinces were covered by piped water networks in full or to some extent. These covered villages consist of 53% of all households in 25 provinces. These 53% of households live in covered villages, not necessarily connected to the pipe network. Figure 2 shows a countrywide map of villages that have access to piped water even to some extent.

Figure 3 indicates that 61% of all households in the 25 provinces are living in villages that are licensed (LC) or being applied for licenses (ALC) by private water operators to supply clean piped water. 16% and 2% of total households are living in villages that are licensed to public water suppliers (PUB) and under management of community water suppliers (COM) respectively. The remaining 21% of total households are living in villages that are not occupied (NOC) by anyone yet.

Figure 2:

MAP SHOWING VILLAGES WITH AND WITHOUT PIPED WATER





Ministry of Industry, Science, Technology & Innovation

Australian Aid

Piped Water Supply Map in Cambodia in 2020

Legend:

- Commune in which all villages are under feasibility study: 282 communes
- Commune in which more than 50% of total villages are under feasibility study: 81 communes
- Commune in which all villages are community water supply: 15 communes
- Commune in which more than 50% of total villages are community water supply: 21 communes
- Commune in which all villages obtained license from MISTI: 475 communes
- Commune in which more than 50% of total villages obtained license from MISTI: 132 communes
- Commune in which all villages are not occupied by any operator: 323 communes
- Commune in which more than 50% of total villages are not occupied by any operator: 91 communes
- Commune in which all villages are occupied by public water operator: 203 communes
- Commune in which more than 50% of total villages are occupied by public water operator: 15 communes
- Commune which has many types of water operators and each type accounts for less than 50% of total villages: 8 communes
- Villages covered by piped water, supported by 3i: 1,101 villages
- Villages covered by piped water: 5,648 villages
- Villages not covered by piped water: 7,689 villages
- Road
- Main River
- Tonle Sap Lake
- Province Boundary
- District Boundary

Province Code	Province	Number of Districts	Number of Communes	Number of Villages	Number of Covered Villages	Coverage Rate
1	Banteay Meanchey	9	65	670	392	59%
2	Battambang	14	102	809	306	38%
3	Kampong Cham	10	109	917	648	71%
4	Kampong Chhnang	8	70	571	215	38%
5	Kampong Speu	8	87	1,380	869	63%
6	Kampong Thom	8	81	767	221	29%
7	Kampot	8	93	488	186	38%
8	Kandal	11	127	1,010	821	81%
9	Koh Kong	7	29	120	37	31%
10	Kratie	6	47	258	139	54%
11	Mondul Kiri	5	21	92	33	36%
12	Phnom Penh	12	105	953	803	84%
13	Preah Vihear	8	51	232	45	19%
14	Prey Veng	13	116	1,149	363	32%
15	Pursat	6	49	511	185	36%
16	Ratanak Kiri	9	50	243	44	18%
17	Siem Reap	12	100	936	298	32%
18	Preah Sihanouk	4	29	111	66	59%
19	Stung Treng	5	34	128	21	16%
20	Svay Rieng	8	80	690	74	11%
21	Takeo	10	100	1,119	656	59%
22	Oddar Meanchey	5	24	304	55	18%
23	Kep	2	5	18	15	83%
24	Pailin	2	8	90	55	61%
25	Tbaung Khmum	7	64	872	202	23%
	Total	**197**	**1,646**	**14,438**	**6,749**	**47%**

Data Source: Commune Database 2017

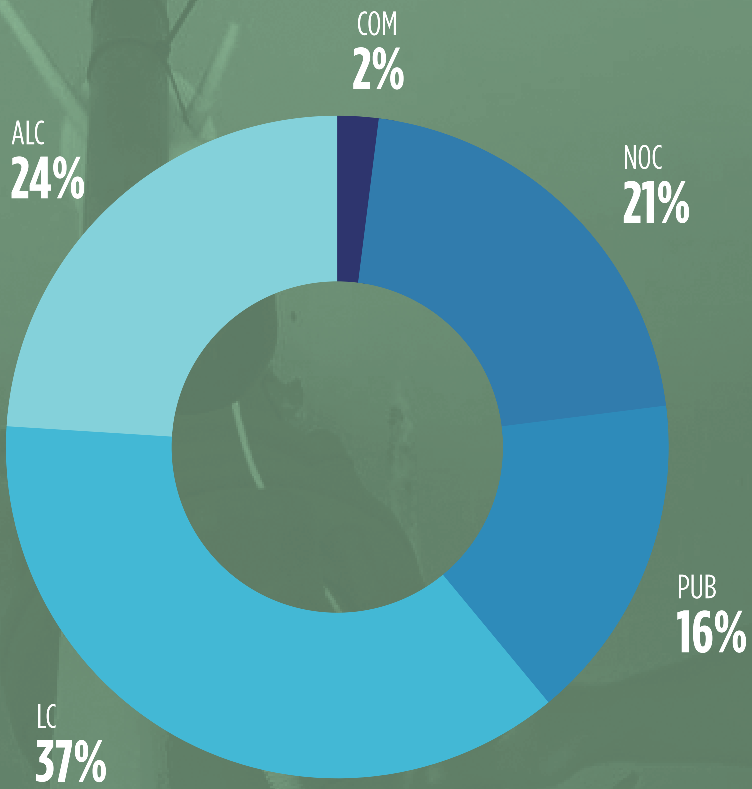
Note: This boundary is for piped water supply purpose only, not for official administrative purpose.

Produced by

General Department of Potable Water and **Investing in Infrastructure Programme (3i)**

December 2020

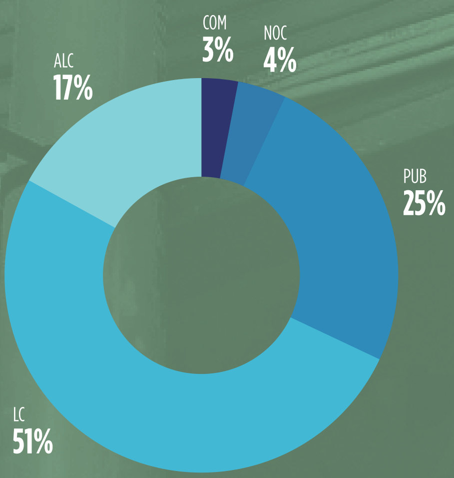
Figure 3:
LICENSING STATUS IN 25 PROVINCES
3,446,069 Total Households



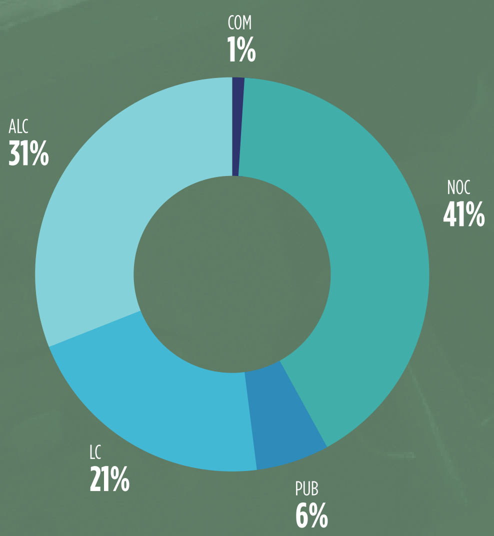
Among households living in villages that have access to piped treated water, most of them (68%) are in the service areas of private water suppliers (LC and ALC villages). Refer to Figure 4. In addition, 52% of total households living in non-covered villages are in the service area of private piped water suppliers (LC and ALC villages). This statistic highlights the significant role of the private sector in the supply of piped clean water in Cambodia. The sector has strong potential to leverage private water investment further and reduce the burden of public investment or funding.

Figure 4:
DISTRIBUTION OF HOUSEHOLDS BY LICENSING STATUS IN COVERED AND NON-COVERED VILLAGES

Distribution of households in covered villages
1,835,137 Households in Covered Villages



distribution of households in non-covered villages
1,610,932 Households in Non-Covered Villages



In 2020, there were 13 public water utilities and 418 private operators who had already obtained licenses or were applying for licenses to supply clean piped water in the 25 provinces. The number of community piped water supply systems in the 22 provinces studied by 3i is 135.

The size of the service areas of public water utilities ranges between 19 and 976 villages, covering 4,000 to 315,000 households per utility. The service areas of private water operators range from 1 to 227 villages, covering from less than 500 to 82,300 households per operator. The average size of the service areas of a private water operator is 21 villages or approximately 5000 households. This statistic provides an indication that although there is very strong private participation in the piped water sector in Cambodia, it is fragmented and many private piped water suppliers operate smaller scale systems compared to those of public water utilities.

While 53% of all households were living in villages with access to piped water to some extent, only 47% of all villages had pipe coverage to some extent.

Table 1 provides a further break-down of information about the average number of households per village by licensing status. This figure implies that villages that have received investment so far have a higher number of households per village.

Table 1 also indicates that the service area of public water utilities has the highest number of households per village, followed by service areas of licensed private water operators, the community piped water supplier, and the private operators who are applying for licenses. Non-occupied areas stand at the lowest. This somewhat implies lower commercial viability or less commercial attractiveness of non-occupied areas in attracting private investment.

Table 1:

AVERAGE NUMBER OF HOUSEHOLDS PER VILLAGE IN EACH LICENSING STATUS IN 25 PROVINCES

DATA IN THE 25 PROVINCES	LC	ALC	PUB	COM	NOC	TOTAL
Average number of households per village in all villages	256	214	311	225	204	239
Average number of households per village in covered villages	271	218	354	227	220	272
Average Number of HHs per village in non-covered villages	222	212	203	219	203	210

4.2 Designs of clean piped water infrastructure in non-covered villages

The results shown in this section is for the 22 provinces. All villages not covered by piped water supply and not located in the service areas of public water utilities were investigated if suitable for piped water supply. As mentioned above, after the investigation, non-covered villages can be classified into three types: (1) villages not suitable for piped water supply marked as non-pipe solution villages, (2) to be determined villages marked as TBD villages that are suitable for piped water supply, but its optimal design would cause licensing conflict, so there was no system designed, and (3) villages suitable for piped water supply and piped water infrastructure design were made and costed in the study, marked as pipe solution villages.

Table 2 shows the number of all villages in the 22 provinces with different licensing status. 464 or 4% of the total villages were considered as not suitable for piped water supply. 124 villages in the service areas of private operators who have obtained licenses and who are applying for licenses are not suitable for piped water supply and 11 villages in those of community piped water supply. Combined with the World Bank study for Siem Reap and Prey Veng provinces, the number of villages not suitable for piped water supply will decrease from 4% to 3% of villages across the 25 provinces.

The presence of villages not suitable for piped water supply in occupied villages can impose more challenges, in addition to financing, to achieve full coverage throughout service areas. The organization providing alternative solutions for clean water access can find it harder to reach these villages in service areas of private water operators, although the operators themselves maybe willing to release villages not suitable for piped solutions from their piped treated water service areas. The potential revision of licensing areas should be warranted if MISTI wants to achieve full piped water supply coverage in the service area.

Table 2 also shows that 318 villages not occupied by any operators are not suitable for pipe water solution. Another important measure to avoid the potential need for license area revision is ensuring new licenses for piped clean water supply does not include villages not suitable for piped water supply despite being located in the same commune.

Considering the expertise of MISTI in commercial piped water supply and MRD in both piped and alternative clean water access, villages suitable and not suitable for piped water supply can be one of the criteria to increase clarity on roles and responsibilities and improve coordination between MISTI and MRD in clean water access.

Table 2:
NUMBER OF VILLAGES IN DIFFERENT TYPES OF LICENSING STATUS IN THE 22 PROVINCES AS OF 2020

22 Provinces	ALC	COM	LC	NOC	PUB	Grand Total
Total Villages	3,076	259	4,364	2,916	785	11,400
Covered Villages	1,325	206	3,079	258	417	5,285
Non-Covered Villages	1,751	53	1,285	2,658	368	6,115
Non-Covered Villages, yet Non-Pipe Solution	82	11	42	318	11	464
Non-Covered Villages, yet Pipe Solution	1646	42	1204	2073	340	5305
Non-Covered Villages, yet TBD	23		39	267	17	346
% of Non-Covered Villages, yet Non-Pipe Solution	1%	0%	0%	3%	0%	4%

4.3 Cost of investment required and support needed

The study designed and costed piped treated water infrastructures for non-covered villages suitable for pipe solutions, except those in the service areas of public water utilities.

> **782 piped water systems were designed for 4,966 villages covering 1.06 million households at an estimated cost of USD 150.20 million.**

Refer to Table 3 for more detailed information. It is worth noting this estimated investment cost is for non-covered villages suitable for pipe solution in LC, ALC, COM and NOC villages in 22 provinces only. To ensure universal access to clean water supply in these 22 provinces, further investment cost is needed for non-covered villages in the service area of public water supplies, TBD villages and non-pipe solution villages. Additional investment is also necessary for full expansion of piped water supply in covered villages.

Table 3:

THE INVESTMENT COST OF PIPED WATER SYSTEMS DESIGN BY LICENSE STATUS IN THE 22 PROVINCES

22 PROVINCES	Number of Non-Covered Villages yet Pipe Solution	Number of Households in Non-Covered Villages yet Pipe Solution	Number of Designed System	Total Investment (million USD)
ALC	1,586	335, 780	227	45.83
COM	48	11, 624	16	1.78
LC	1,265	274,553	166	42.24
NOC	2,067	443,421	373	60.35
PUB	399	75,929	NA	NA
TOTAL FOR LC, ALC, COM, AND NOC	4,966	1,065,378	782	150.20

The average investment cost per household in this study is approximately USD 141.

Readers should be reminded that the standard of piped water infrastructure, including requirements on water quality, treatment system, pipe quality and potential commercial tariff etc, set by MISTI have been used as inputs to determine the design of the piped water infrastructures, calculation of investment costs and potential return on investment. Should the system standard be lowered to a simple distribution system without standard treatment process, for example, investment costs and return on investment can be interpreted differently from this study, specifically for villages in the service areas of community piped water supply.

16 of 782 systems designed are in community water supply areas, covering 48 villages or 11,624 households with a required investment cost of USD 1.78 million. The absolute value of the total investment cost estimated can be lowered if the infrastructure standard and quality is based on the current standard required by MRD, rather than the technical standard used by MISTI – which was used in the study to undertake the cost estimations. Public subsidy for community water supply should consider lower investment cost if lower technical standard is adopted.

The program used its experiences with the Viability Gap Financing approach to stimulate private investments in piped water supply in areas where the commercial viability is not strong enough to make the private sector invest by themselves to calculate the financial support needed. The grant estimation applies only for the non-occupied systems (NOC) and private water supply systems both LC and AL. Systems in community piped water supply are not included in this analysis as 3i has not had experiences stimulating the community investment. A high proportion of subsidy is provided for the establishment of piped water infrastructures under community management.

For LC, ALC and NOC systems, 766 piped water systems were designed with a total investment cost of approximately USD 148.42 million. Refer to Table 4.

At the current cost of infrastructure, tariff regime, and current level of assumptions detailed in Annexe I and II, 33% or approximately USD 48.80 million will be needed as grant subsidy to leverage private water investment of around USD 100 million to invest in the 4,918 villages.

The grant is calculated to bring the IRR of the designed systems to 15% over five years, or the payback period to approximately 8.5 years.

Table 4:
GRANT NEEDED FOR LC, ALC AND NOC SYSTEMS

22 PROVINCES	Number of Non-Covered Villages yet Pipe Solution	Number of Households in Non-Covered Villages yet Pipe Solution	Number of Designed System	Total Investment (million USD)	Grant for IRR 15% (million USD)	Average Percentage of Grant
ALC	1,586	335, 780	227	45.83	14.44	32%
LC	1,265	274,553	166	42.24	13.01	31%
NOC	2,067	443,421	373	60.35	21.35	35%
Total for LC, ALC and NOC	4,918	1,053,754	766	148.42	48.80	33%

Table 5:
INVESTMENT COST AND GRANT REQUIRED BY PROVINCE FOR SYSTEMS DESIGNED IN LC, ALC AND NOC AREAS IN THE 22 PROVINCES

PROVINCE	Number of Systems	Number of villages to be covered	Number of households to be covered	Total Investment Cost (million USD)	Investment cost per households (USD)	Grant (million USD)	Percentage of grant
Koh Kong	22	58	11,070	2.08	188	0.93	45%
Stung Treng	33	58	15,673	2.31	147	0.95	41%
Ratanak Kiri	35	124	22,148	3.51	158	1.44	41%
Preah Vihear	63	162	39,273	7.52	192	3.06	41%
Mondul Kiri	7	20	4,566	0.65	143	0.26	40%
Banteay Meanchey	45	233	55,286	9.01	163	3.31	37%
Otdar Meanchey	36	219	40,676	6.95	171	2.55	37%
Tboung Khmum	68	494	105,926	10.89	103	3.83	35%
Kracheh	37	94	32,009	3.90	122	1.37	35%
Kampong Cham	35	230	59,171	6.84	116	2.35	34%
Pursat	29	223	49,799	7.21	145	2.43	34%
Pailin	5	29	5,788	0.90	156	0.29	33%
Kampong Thom	53	402	81,277	12.06	148	3.90	32%
Svay Rieng	34	525	101,298	10.49	104	3.38	32%
Kampong Chhnang	44	332	69,171	9.23	133	2.93	32%
Kampong Speu	62	472	59,434	9.06	152	2.86	32%
Kandal	17	154	30,996	4.99	161	1.53	31%
Battambang	67	405	123,488	19.56	158	5.74	29%
Preah Sihanouk	8	36	10,006	1.42	142	0.41	29%
Takeo	42	403	66,603	10.05	151	2.72	27%
Kampot	22	242	69,164	9.72	141	2.55	26%
Kep	2	3	932	0.07	69	0.01	13%
GRAND TOTAL	766	4,918	1,053,754	148.42	141	48.80	33%

Table 5 details the investment cost and grant required to stimulate the piped water infrastructure investment for LC, ALC and NOC systems by province. The figures in Table 5 are arranged in order of percentage of grant required, from the largest to the smallest. The top five provinces requiring the highest percentage of grant to stimulate private investment are Koh Kong (45%), Stung Treng (41%), Ratanak Kiri (41%), Preah Vihear (41%) and Mondul Kiri (40%). In principle, the study would cluster as many villages into one large system wherever possible. However, a few factors, such as household density, elevation differences and distance between the villages, do not always allow an optitmal piped water system with large scale. The sector as a whole already has 418 private operators who obtained the license or are applying for a license from MISTI. This does not include the number of public and community water utilities. Should the existing investment model in the water sector continue, there is likely to be more fragmentation in the sector to cover additional villages suitable for piped water supply. This can bring increased pressure on governance capacity.

While it is quite challenging to consolidate the management of existing private water supplies for improved efficiency, consolidating management of non-occupied systems could be a policy option to minimize fragmentation in the sector. Table 6 shows that among 373 non-occupied systems designed, 200 systems have less than or equal to 800 households per system, yet they cover only 19% of all households in the 373 systems.

Table 6:

INVESTMENT COST AND GRANT REQUIRED FOR NOC SYSTEMS IN THE 22 PROVINCES BY NUMBER OF HOUSEHOLDS PER SYSTEM

22 Provinces (NOC only)	Number of Systems	Number of villages to be covered	Number of households to be covered	Household Distribution	Total Investment Cost (million USD)	Grant (million USD)	Percentage of Grant	Investment Cost per Household (USD)
<=800 HH	200	437	83,770	19%	14.31	6.60	46%	171
801-1500 HH	72	337	76,484	17%	10.68	4.29	40%	140
1501-3000 HH	71	678	144,330	33%	18.49	5.81	31%	128
3001-5000 HH	21	350	77,614	18%	9.61	3.09	32%	124
>5000 HH	9	265	61,223	14%	7.26	1.56	21%	119
Total	373	2,067	443,421	100%	60.35	21.35	35%	136

Table 6 also shows that smaller systems generally have lower commercial viability compared to larger systems, largely explained by economies of scale. Smaller systems tend to be located in more remote areas and small islands that are flooded for many months of the year. Stimulating private investment in these smaller systems is more difficult not only because they need more public support but because of their sheer size. This makes them less attractive for private and standard infrastructure investment. Consolidating small systems under the management of one water operator is an idea that has been mooted for a while, although it has not yet been widely put into practice but is worthwhile trying.

4.4 Water source and investment in piped treated water infrastructure

To ensure sustainability of the systems designed, ponds were added as additional or sometimes a sole water source. Without including the cost of land, the cost of pond digging accounts for 14% of total investment cost in the 766 systems in LC, ALC and NOC villages suitable for piped water supply. Not surprisingly, the higher the cost of pond digging for a system - caused by the longer period a system needs to rely on raw water from the pond - the lower the commercial viability of the system, and the higher the grant needed to attract private investors. Refer to Table 7 for more details.

Table 7:

INVESTMENT COST AND GRANT BY WATER SOURCE IN THE 22 PROVINCES FOR LC, ALC AND NOC SYSTEMS

22 Provinces (LC, ALC and NOC)	Number of Systems	Number of villages to be covered	Number of households to be covered	Household Distribution	Total Investment Cost (million USD)	Grant (million USD)	Percentage of Grant	Investment Cost per Household (USD)	Investment for Pond (million USD)	Percentage of Investment for Pond
No Pond	443	2,954	632,753	60%	78.65	24.37	31%	124	-	0%
Pond 1-3 months	70	521	98,290	9%	13.39	4.13	31%	136	2.29	17%
Pond 4-6 months	140	889	196,829	19%	32.49	11.33	35%	165	8.38	26%
Pond 7-9 months	113	554	125,882	12%	23.89	8.97	38%	190	9.38	39%
Total	766	4,918	1,053,754	100%	148.42	48.80	33%	141	20.05	14%

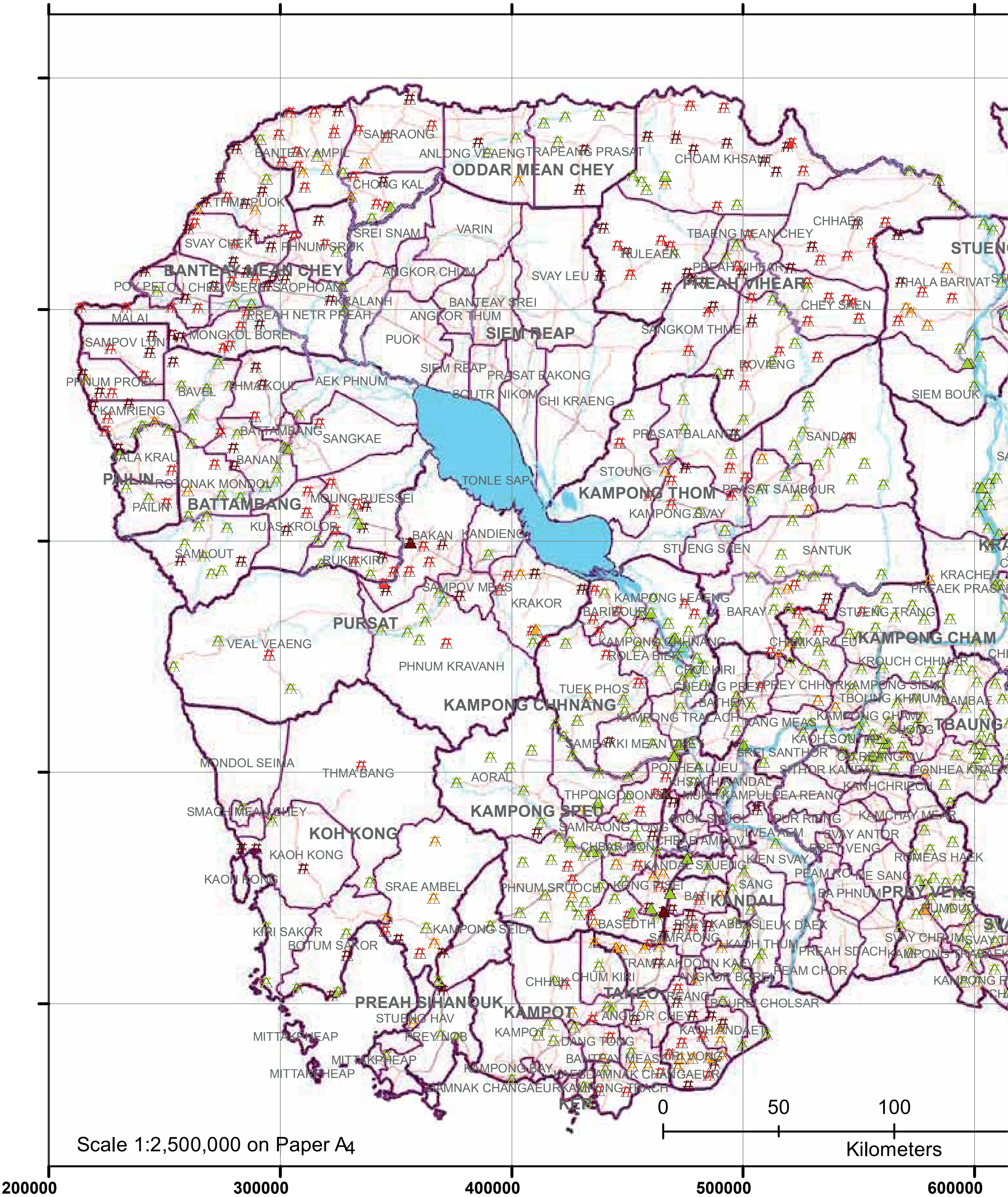
Integrated water resource management in Cambodia has not been widely practiced. Planning for investment in water resources, which is under governance of Ministry of Water Resources and Meteorology (MOWRAM), for irrigation canals or reservoirs has not so far systematically integrated potential demand for domestic water supply through piped networks.

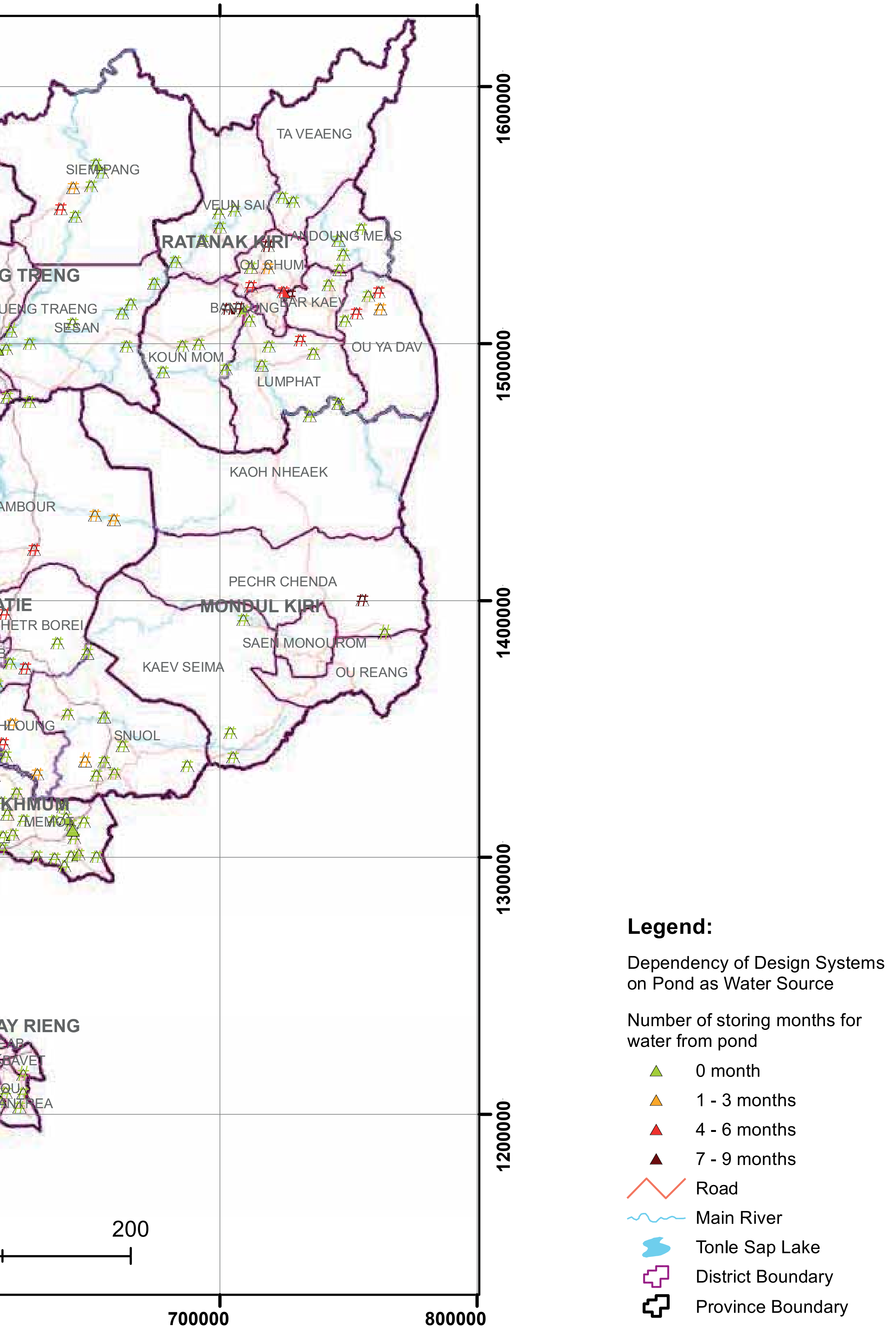
Water extraction for commercial water supply does not have a formal fee charging system and requires permission from different local or provincial authorities without clear processes in place to date. As there is no formal fee charged for raw water extraction, the tariff calculation does not take this factor into account. The current non-systemic process of water extraction request can put the piped water business in a vulnerable position when there is competition for water.

By mapping out the potential areas for piped water supply and the water source in each system, this study can be used to pinpoint locations where piped water supply would benefit significantly from the availability of sustainable surface water for investment. Figure 5 provides the location of 782 designed systems in LC, ALC, COM and NOC villages in 22 provinces and the duration that the designed systems rely on ponds as a water source.

Figure 5:

MAP SHOWING THE DURATION THAT THE DESIGNED SYSTEMS RELY ON POND AS WATER SOURCE IN 22 PROVINCES FOR LC, ALC, COM AND NOC SYSTEMS




TA VEAENG
SIEMPANG
VEUN SAI
RATANAK KIRI
ANDOUNG MEAS
OU CHUM
G TRENG
UENG TRAENG
SESAN
BAR KAEV
KOUN MOM
OU YA DAV
LUMPHAT
KAOH NHEAEK
AMBOUR
PECHR CHENDA
ATIE
MONDUL KIRI
HETR BOREI
SAEN MONOUROM
KAEV SEIMA
OU REANG
SNUOL
KHMUM
MEMOT
AY RIENG
200
700000
800000
1600000
1500000
1400000
1300000
1200000
Legend:
Dependency of Design Systems on Pond as Water Source
Number of storing months for water from pond
0 month
1 - 3 months
4 - 6 months
7 - 9 months
Road
Main River
Tonle Sap Lake
District Boundary
Province Boundary

This map can serve as a valuable input for integrated water resource planning that integrates demand for domestic piped water supply. In addition, it can be used as a tool to identify locations for potential investment opportunities in bulk water systems, which bring water from a sustainable source for several retail piped water systems, especially for covered and non-covered areas challenged by access to sustainable water sources. As one of its follow-on activities, the 3i program will conduct an initial assessment to map out potential areas for bulk water supply as part of its efforts to demonstrate bulk water supply business models.

4.5 Simulation

In addition to providing information about the status quo and potential in the piped water sector, the results of the study can be used to simulate the effects of different policy changes on the sector's development to aid policymakers to test how different policy set up would affect return on investments.

MISTI's current tariff regime charges different tariffs for varying levels of consumption. 3i's study of 60,000 users in 37 different piped water schemes was used to determine the levels of consumption of users in a scheme in wet and dry seasons. Annex II provides brief findings about the study.

As the basic assumption, the study uses current charging tariff for licensed systems and assumes a tariff of 2,300 KHR per cubic meter for all consumption levels for designed systems that are being applied for license or non-occupied to determine commercial viability and grants needed to stimulate private investments.

In this section, the study simulates two different tariff scenarios for LC, ALC and NOC designed systems to see the effect on the grant needed to stimulate private investment. By keeping the tariff of the LC designed systems the same, scenario 1 changes the tariff structure of ALC and NOC designed systems by assuming the tariff of 2100, 2300, and 2500 KHR per cubic meter for the consumption tier of 0-3 m^3, 4-9m^3 and 10 m^3 and above respectively. The simple average tariff remains the same, yet this tariff structure would lead to the reduction of grant requirement by 4% from USD 48.80 million to USD 46.76 million (Table 8).

Scenario 2 uses the same tariff structure for ALC and NOC designed systems in scenario 1 but changing the tariff structure in LC designed systems by (1) reducing 100 KHR/m^3 for consumption between 0-3 m^3, (2) reducing 100 KHR/m^3 for consumption between 4-9m^3 and (3) increasing 200 KHR/m^3 for consumption from 10 m^3 and above, the total grant requirement is reduced by 6% from USD 48.80 million to USD 46.00 million. Other policy measures, such as revenue from connection charges and water maintenance fees, can be similarly used for the simulation.

Table 8:

THE CHANGE OF GRANT GIVEN CHANGE OF TARIFF FOR LC, ALC AND NOC DESIGNED SYSTEMS IN 22 PROVINCES

22 Provinces	Number of villages to be covered	Number of households to be covered	Number of Systems	Total Investment Cost (million USD)	"Grant for IRR 15% (million USD) Basic Tariff Assumption"	"Grant for IRR 15% (million USD) Tariff Scenario 1"	"Grant for IRR 15% (million USD) Tariff Scenario 2"
ALC	1,586	335,780	227	45.83	14.44	13.55	13.55
LC	1,265	274,553	166	42.24	13.01	13.01	12.25
NOC	2,067	443,421	373	60.35	21.35	20.20	20.20
Total for LC, ALC and NOC	4,918	1,053,754	766	148.42	48.80	46.76	46.00
						-4%	-6%

05.
3i'S FOLLOW ON ACTIVITIES

05.

3i'S FOLLOW ON ACTIVITIES

Optimal village cluster

Efficiency in overall investment on potential piped treated water infrastructure in non-covered village can be achieved when the development takes both technical and financial aspects of the infrastructure into consideration. Villages clustered for optimal infrastructure designed by experienced water engineers with multiple layers of peer-review and quality control should be one of the inputs that provincial and ministerial officials use as a basis to provide new licenses or determine new service areas for piped water supply. 3i will work with the relevant ministries, including MISTI and MRD, to raise awareness and train relevant officials to use the PIP data to incorporate optimal village clusters in to future service areas.

Investment guidance

For existing or new investors who seek new areas to invest in piped treated water infrastructure, access to important information, such as location of a potential system, number of households in the potential service areas, water sources, estimated investment cost, and nearby existing infrastructure, can be valuable. Ready access to this information can lower cost of entry into the market and speed up the investment decision process. 3i will develop an interactive map that provides public access to such information.

More coordination between MISTI and MRD

Sharing the same goal, MISTI and MRD have different strengths that can complement each other to maximize access to piped treated water supply in remaining villages suitable for this type of infrastructure. As presented in the tables and figures above, systems designed for the remaining areas have a wide range of characteristics in terms of size of systems, commercial viability, level of grant needed, remoteness etc. This information for all systems can serve as additional criteria, instead of just rural or urban areas, for discussion between MISTI and MRD to determine clearer areas of focus to ensure efficiency and achieve coordinated sectoral development. This is essential for efficient public budget planning. 3i will avail the information and provide analysis to support the dialogue.

Diversification of business models to attract more investment

As indicated through the data above, new business models, such as bulk water supply arrangements and bundling of small-scale systems for one investment, have potential to stimulate more investment in the sector by lowering challenges on access to sustainable water sources or increasing the attractiveness of the investment for private investors. The program will collaborate with MISTI to test these models in the sector as a demonstration and increase confidence for private investment. Necessary regulatory changes, such as more compatible licensing procedures for these new business models, can be also be part of the collaboration.

Water Development Fund

Despite better sectoral coordination, a better enabling environment and diversification of investment model, it is unlikely that all or many of the not-covered villages suitable for piped water supply will have access to piped treated water anytime soon if left to the public or private sector alone, especially in the aftermath of the pandemic. With 80 piped water companies that are, and will be, providing clean piped water to more than 1 million Cambodians with viability gap financing supported by 3i, 3i has shown the public sector in Cambodia does not have to invest in the full system cost. It can spend less than half of the cost of investment to attract another two-thirds from the private sector to invest in sustainable clean piped water supply. At the request of MISTI, 3i will develop a framework for Cambodia Water Development Fund to provide the necessary public support to stimulate investment in sustainable piped water supply infrastructure. The fund can serve as a platform for coordinated public support from government and development partners on areas identified as priority for development.

06.
CONCLUSION

ANNEX I: MAIN ASSUMPTIONS USED IN THE TECHNICAL AND FINANCIAL MODELS

ANNEX II: SUMMARY OF RESEARCH ON PIPED WATER CONSUMPTION BEHAVIOUR OF HOUSEHOLDS IN CAMBODIA

06. CONCLUSION

Despite coming a long way, there is still an enormous task ahead for Cambodia to reach its ultimate target to provide clean piped water to the entire population. Well-coordinated policy changes on multiple ends that are based on experiences, evidence and concrete data are essential for efficient and rapid expansion of the much-needed and sustainable piped water infrastructure. As the data highlights, the Royal Government of Cambodia has strong potential to continue to leverage private resources for piped water infrastructure development, with strengthening of regulatory governance to increase access to affordable clean piped water infrastructures, especially when the public budget is under constraint in the aftermath of the pandemic.

The report's data is rich and can be used flexibly for a wide variety of analysis, simulation, and planning. The program will work closely with MISTI and any interested ministries and development partners to assist them in using the study's results to its full potential.

Annex I:
MAIN ASSUMPTIONS USED IN THE TECHNICAL AND FINANCIAL MODELS

1: Assumptions on consumption & connection speed
(connections are assumed to grow over 15 years, but production capacity is sized for 5 years)

Characteristic of Site:	Alternative Water Source for HH	Dry Season (m^3/HH/ month)	Avg.cons (m^3/HH/ month)	Assumed Conection Speed														
				Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
If there is district centre, or factory, or whole-day market	Good ground water	9	7.5	7%	15%	30%	40%	50%	55%	60%	65%	70%	75%	80%	90%	90%	90%	90%
If there is district centre, or factory, or whole-day market	other than good groundwater	9.5	8	20%	35%	50%	65%	70%	72%	74%	76%	78%	80%	82%	84%	86%	88%	90%
If no district centre, nor factory, nor whole-day market	Good ground water	7	6	7%	15%	30%	40%	50%	55%	60%	65%	70%	75%	80%	85%	90%	90%	90%
If no district centre, nor factory, nor whole-day market	Other than good groundwater	8	7	20%	35%	50%	65%	70%	72%	74%	76%	78%	80%	82%	84%	86%	88%	90%

1: Assumptions on consumption & connection speed
(connections are assumed to grow over 15 years, but production capacity is sized for 5 years)
contiued

Characteristic of Site:	Alternative Water Source for HH	Dry Season (m^3/HH/month)	Avg.cons (m^3/HH/month)	0-3 m^3				3-9 m^3				>=9 m^3			
				Tier 1-dry		Tier 1-Wet		Tier 2-dry		Tier 2-wet		Tier 3-dry		Tier 3-wet	
				Percent-age	Con-sumption (m^3/HH/month)	Percent-age	Con-sumption (m^3/HH/month)	Percent-age	Con-sumption (m^3/HH/month)	Percent-age	Con-sumption (m^3/HH/month)	Percent-age	Con-sumption (m^3/HH/month)	Percent-age	Con-sumption (m^3/HH/month)
If there is district centre, or factory, or whole-day market	Good ground water	9	7.5	20%	0.9	30%	0.91	30%	4.92	35%	4.14	50%	14.67	35%	12.65
If there is district centre, or factory, or whole-day market	other than good groundwater	9.5	8	25%	0.9	35%	0.73	30%	5.49	30%	4.53	45%	16.91	35%	14.03
If no district centre, nor factory, nor whole-day market	Good ground water	7	6	25%	1.2	35%	0.93	30%	4.47	30%	3.78	45%	11.90	35%	10.54
If no district centre, nor factory, nor whole-day market	Other than good groundwater	8	7	25%	1.4	40%	1.37	35%	5.27	35%	5.34	40%	14.53	25%	15.01

2: Assumptions on consumption and population growth

	Water consumption growth rate Population growth rate in each province	1%
N.	**Province Name**	**Population growth rate [2008-2019]**
1	Banteay Meanchey	2.2%
2	Battambang	-0.3%
3	Kampong Cham	-0.2%
4	Kampong Chhnang	1.0%
5	Kampong Speu	1.8%
6	Kampong Thom	0.6%
7	Kampot	0.1%
8	Kandal	0.8%
9	Koh Kong	0.5%
10	Kracheh	1.4%
11	Mondul Kiri	3.4%
12	Phnom Penh	3.2%
13	Preah Vihear	3.5%
14	Prey Veng	1.0%
15	Pursat	0.3%
16	Ratanak Kiri	2.8%
17	Siem Reap	1.1%
18	Preah Sihanouk	2.8%
19	Stung Treng	3.2%
20	Svay Rieng	0.8%
21	Takeo	0.6%
22	Otdar Meanchey	3.1%
23	Kep	1.4%
24	Pailin	0.1%
25	Tboung Khmum	0.2%

Source: Provisional Population Census Report 2019. The Ministry of Planning

3: Assumptions on investment items

The table below explains the investment items taken into consideration for each project type
Y: Include. N: Not include

Items	Existing WTP.	No Existing WTP. HH>=500 HHs	No Existing WTP. HH<500 HHs
TYPE	A	B	C
Pumping Station	Y	Y	Y
Water Treatment Plant	Y	Y	Y
Water Storage Tank	Y	Y	Y
HDPE Pipes	Y	Y	Y
Raw water pumps	Y	Y	Y
Booster pumps	Y	Y	Y
Test Kits	Y	Y	Y
Design Cost	Y	Y	Y
Electricity connection	N	Y	Y
Office building	N	Y	N
Warehouse	N	Y	N
Motorbike	N	Y	N
Computer	N	Y	N
Printer	N	Y	N
Office desk & chairs	N	Y	N
Other investments	N	Y	N

Note: System A refers to the system having an existing WTP already.
System B refers to the system does not have an existing WTP and will cover at least 500 HHs
System C refers to the system does not have an existing WTP and will cover below 500 HHs

4: Number of staff working in each system

This is for the system that does not have an existing WTP

Lower Limit (HH)	Upper Limit (HH)	Number of staffs
0	500	1
501	1999	3
2000	3999	4
4000	5999	5
6000	7999	6
8000	infinite	7

This is for the system that has an existing WTP

Lower Limit (HH)	Upper Limit (HH)	Number of staffs
0	1999	1
2000	3999	2
4000	5999	3
6000	7999	4
8000	infinite	5

5: Costing Assumptions

a. Water Source

Drilled Well	5,000	USD/ 1 unit of well
Pond Excavation	0.8	USD/1 cubic meter of pond

b. Water treatment plant

Capacity (m^3/h)	Cost (USD)
5	13,139
10	17,524
15	21,792
20	25,943
25	29,978
30	33,897
35	37,699
40	41,385
45	44,954
50	48,407
55	51,744
60	54,964
65	58,067
70	61,054
75	63,925
80	66,679
85	69,317
90	71,838
95	74,243
100	76,531

Capacity (m^3/h)	Cost (USD)
105	78,703
110	80,759
115	82,698
120	84,520
125	86,226
130	87,816
135	89,289
140	90,646
145	91,886
150	93,010
155	94,017
160	94,908
165	95,683
170	96,341
175	96,882
180	97,308
185	97,616
190	97,809
195	97,884
200	97,844

C. Storage tank

Capacity (m³)	Cost (USD)	Capacity (m³)	Cost (USD)
-	-	840	42,406
40	5,772	880	43,643
80	8,142	920	44,823
120	10,456	960	45,946
160	12,712	1,000	47,013
200	14,912	1,040	48,023
240	17,056	1,080	48,976
280	19,143	1,120	49,873
320	21,173	1,160	50,713
360	23,146	1,200	51,496
400	25,063	1,240	52,223
440	26,923	1,280	52,893
480	28,726	1,320	53,506
520	30,473	1,360	54,063
560	32,163	1,400	54,563
600	33,796	1,440	55,006
640	35,373	1,480	55,392
680	36,893	1,520	55,722
720	38,356	1,560	55,996
760	39,763	1,600	56,212
800	41,113		

d. HDPE Pipe

Pipe diameter (mm)	PN	Unit Price (USD/m)
32	10	1.3
40	10	1.65
50	10	2.19
63	10	2.9
75	10	3.76
90	8	4.42
110	8	6.06
125	8	7.81
140	8	10.39
160	8	13.22
180	8	15.61
200	8	19.24
225	8	24.78
250	8	29.95
280	8	37.71
315	8	46.25

Note: The price includes the price of pipe, installment cost, and accessories. The unit is USD per m.

e. Raw water pump

Capacity (kW)	Cost (USD)	Capacity (kW)	Cost (USD)
0.5	1,030	11	7,423
0.75	1,134	15	10,114
1	1,240	18.5	12,142
1.5	1,453	22	15,112
1.8	1,580	30	18,512
2.2	1,750	37	21,487
3	2,333	45	24,887
3.7	2,630	55	29,137
4	3,025	75	37,637
5.5	3,663	90	44,012
7.5	4,984	110	52,512
9.2	6,335	132	61,862

Note: The price is for 2 units of pumps

f. Booster Pumps

Capacity (kW)	Cost (USD)	Capacity (kW)	Cost (USD)
0.5	2,250	11	16,245
0.75	2,497	15	22,128
1	2,744	18.5	26,510
1.5	3,238	22	32,911
1.8	3,534	30	40,811
2.2	3,929	37	47,723
3	5,179	45	55,623
3.7	5,871	55	65,498
4	6,665	75	85,248
5.5	8,146	90	100,061
7.5	10,121	110	119,811
9.2	13,915	132	141,536

Note: The price is for 3 units of pumps, 1 unit of inverter, and 1 unit of control panel

d. Additional Investment Cost

Items	Unit	Price (USD)
Electricity connection	63A	1,686
Pumping station	1 unit	1,500
Office building	1 unit	4,000
Warehouse	1 unit	4,000
Test Kits	1 unit	700
Motorbike	1 unit	1,000
Computer	1 unit	1,000
Printer	1 unit	250
Office desk & chairs	lump sum	250
Other investments	lump sum	1,614

Note: Other investments include a lump sum investment on items as: safe, toilet, phone, weilding machine, heating machine, AC, etc. (as per guideline on feasbility study of the MIH)

h. Design cost

Design Cost	4% of CAPEX and maximum 15000 USD

Note: This includes the feasibility study cost and construction supervision cost.

6: Assumptions operational cost

Chemicals	0.024120	USD/m³
Billing & collection	100	KHR/connection
Salary	250	USD/month
supplies & communications	50	USD/month
Price of elelectrity	790	KHR/kWh
Exchange rate	4,000	KHR/USD
Water loss	15%	
Connection cost	250,000	KHR
Inflation	3.0%	
Connection fee	290,000	KHR/connection
Maintenance	1.5%	of total investment cost (USD/year)
Water maintenance fee	1,000	KHR/connection

Annex II:
SUMMARY OF RESEARCH ON PIPED WATER CONSUMPTION BEHAVIOUR OF HOUSEHOLDS IN CAMBODIA

1: Research Objective and Methodology

The research was conducted in 2020 to understand the piped water consumption behavior of households in rural areas of Cambodia. That is, how much piped water is consumed by a household per month in the dry and wet seasons? Also, the study aims to classify the consumption tier of households. This can be used as reference for the estimation of household consumption in the "Provincial Investment Plan" study.

Given that private piped water operators have been using Ms. Excel, E-water, and BanhJi to keep records of the monthly consumption for each consumer and to issue invoices, the study asked the operators to share this data. 32 operators from 45 communes in 15 provinces agreed. As a result, the study collected monthly consumption data from 59,619 connections. It is worth noting that a connection represents a household. The data ranges from 2015 until 2020. For one month of water consumption, a household generates one datapoint. That is, for a year, a household should generate 12 datapoints. However, households connected at different times and also started consuming piped water from different times. Some started in January 2015, while others started in December 2019, for example. Nevertheless, in total, the study collected 1.52 million monthly consumption datapoints, 56% of which are for consumption in dry season.

2. Key Results

The consumption data is classified into three tiers as follows:

- Tier 1: monthly consumption is between 0 and 3 m^3 per month
- Tier 2: monthly consumption is between 3 and 9 m^3 per month
- Tier 3: monthly consumption equals to and is above 9 m^3 per month

Table 1 reports the percentage and average consumption of each tier during dry season, wet season and a year.

Table 1:
AVERAGE CONSUMPTION PER CONSUMPTION TIER (M^3/MONTH)

	Dry		Wet		Year	
Data Range	Pct (%)	Avg.Cons (m^3/month)	Pct (%)	Avg.Cons (m^3/month)	Pct (%)	Avg.Cons (m^3/month)
Tier 1 [0-3]	22%	1.33	35%	1.29	28%	1.31
Tier 2 [3-9]	30%	6.41	31%	6.18	30%	6.31
Tier 3 [>=9]	48%	21.51	34%	21.13	42%	21.37
ALL	100%	12.54	100%	9.56	100%	11.25

On average, a household consumes 12.54 m^3/month in dry season, 9.56 m^3/month in wet season, and 11.25 m^3/month within a year. The consumption tier can be interpreted as the following: for example, in dry season 22% of households consume between 0 and 3 m^3 per month, with the average consumption of 1.33 m^3/month for this group. In wet season, this increases to 35% of households, with average consumption of 1.29 m^3/month among the group.

In addition, the study disaggregated the above results with respect to different site characteristics. The sites are classified into two principles as follows:

- Level of development:

- High level: refers to areas where there are some markets and hotels.

- Low level: Otherwise

- Good underground water:

- Good groundwater: refers to areas where the majority of the households use wells

- Bad groundwater: Otherwise

As a result, in combination of the two principles, the sites can be classified as:

Table 2:
SITE CHARACTERISTICS

	Good Groundwater	Bad Groundwater
High level of development	**HG**	**HB**
Low level of development	**LG**	**LB**

Upon the disaggregates of the site characteristics, the average consumption per consumption tier is disaggregated as the following:

Table 3:

AVERAGE CONSUMPTION PER CONSUMPTION TIER WITH RESPECT TO SITE CHARACTERISTICS

		Dry		Wet		Year	
Site Characteristics	Data Range	pct	Avg.Cons (m³/month)	pct	Avg.Cons (m³/month)	pct	Avg.Cons (m³/month)
HG							
	Tier 1 [0-3]	19%	1.18	29%	1.36	24%	1.28
	Tier 2 [3-9]	28%	6.51	32%	6.23	30%	6.37
	Tier 3 [>=9]	53%	22.17	39%	21.81	47%	22.04
	ALL	100%	13.87	100%	10.82	100%	12.53
HB							
	Tier 1 [0-3]	22%	1.08	34%	1.01	27%	1.05
	Tier 2 [3-9]	26%	6.45	28%	6.25	27%	6.36
	Tier 3 [>=9]	52%	22.68	38%	22.15	46%	22.49
	ALL	100%	13.71	100%	10.59	100%	12.38
LG							
	Tier 1 [0-3]	17%	1.69	39%	1.48	27%	1.55
	Tier 2 [3-9]	39%	6.41	38%	6.02	38%	6.23
	Tier 3 [>=9]	44%	18.94	24%	18.64	35%	18.85
	ALL	100%	11.11	100%	7.23	100%	9.33
LB							
	Tier 1 [0-3]	24%	1.65	38%	1.57	30%	1.61
	Tier 2 [3-9]	35%	6.33	34%	6.11	35%	6.24
	Tier 3 [>=9]	41%	19.45	28%	19.17	35%	19.35
	ALL	100%	10.58	100%	8.02	100%	9.46

The table shows that the group of high development areas consume piped water more than that of the low development areas. The magnitude of difference is around 3 m^3/month in both dry and wet seasons. However, when the study further disaggregates the development areas into areas with good and underground water, the magnitude of difference is not significant within each group.

3. The PIP Study

Table 2 is the benchmark reference for the estimation of household consumption and the percentage of each consumption tier. However, one should note that observations in the data are collected from a large number of households, some of whom have been consuming piped water for a very long time while some others have just connected.

PIP is to design the water infrastructure where there is no pipe. Hence, the consumption is scaled down with triangulation from working experiences from 80 water projects of 3i. Also, the percentage of each consumption tier is rounded for simplicity. As a result, the PIP uses the following table.

Table 4:

THE ASSUMPTION OF PIP ON CONSUMPTION

				Dry		Wet	
Site Characteristics	Peak cons in dry season (m^3/month)	Yearly Avg.cons (m^3/month)	Data Range	pct	Avg.Cons (m^3/month)	pct	Avg.Cons (m^3/month)
			Tier 1 [0-3]	20%	0.89	30%	0.91
HG	9	7.5	Tier 2 [3-9]	30%	4.92	35%	4.14
			Tier 3 [>=9]	50%	14.67	35%	12.65
			Tier 1 [0-3]	25%		47%	22.04
HB	9.5	8	0.92	35%	0.73	100%	12.53
			Tier 2 [3-9]	30%	5.49	30%	4.53
			Tier 1 [0-3]	25%	1.18	35%	0.93
LG	7	6	Tier 2 [3-9]	30%	4.47	30%	3.78
			Tier 3 [>=9]	45%	11.90	35%	10.54
			Tier 1 [0-3]	25%	1.37	40%	1.37
LB	8	7	Tier 2 [3-9]	35%	5.27	35%	5.34
			Tier 3 [>=9]	40%	14.53	25%	15.01

- The peak consumption in dry season is used for technical calculation of water infrastructure.
- The consumption in each tier is used for financial projection and tariff simulation.

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