PRE FEASIBILITY STUDY REPORT FOR OMI DAM HYDROPOWER PROJECT , KOGI STATE

PART – I: EXECUTIVE SUMMARY

Bureau of Public Private Partnerships, Kogi State Government requested UNIDO Regional Centre for Small Hydro Power in Africa, Abuja to assess the power potential on using the existing dams at Osara, Okura and Omi which were primarily built for irrigation and other industries and a project on Ofu river for hydro-power generation. The UNIDO team visited the state from 13th March to 16th March 2017 to do a pre-feasibility study. Since the potential in these sites is attractive, UNIDO decided to conduct a detailed study for these sites. The team again visited the site in the first week of December 2017.

Omi Dam Micro hydro project will generate electricity to uplift the economic activities of the region. Many villages near the Omi dam will get connected to the power plant. The royal family of Omi had expressed its willingness to co-operate with this hydro project.

Figure 1 Royal family of Omi community

		UNIT/DETAIL
Project Name	Omi Micro hydro Project	
Location (Village, district , region)	Omi dam, Yagba West LGA of Kogi State, Nigeria	
Developer (Physical address and contact details including telephone contacts)	Kogi State Government	
Position/project layout including GPS coordinates in accordance to the datum and coordinate system : • Dam • Forebay • Surge Tank • Power house • Switch Yard • Interconnection arrangement /delivery point	N8° 12' 28.05” E5° 38' 15.23” Not applicable Not applicable Same as dam – at the toe of the dam Power has to be evacuated to the three villages nearby	
Purpose, objective and scope of the project	To modify the existing dam potential to generate 300 kW to partially meet the requirement of the steel industry.	

Hydrological Features at the Dam site	
Catchment Area	531 km^2
Mean Annual Flow	3.1m^3/s
Normal Average Flow – Wet season	4.8 m^3/s
Normal Average Flow – Dry season	0.6 m^3/s
Design Flow	4.3 m^3/s
Flow (1,000y flood event)	Dam design document not available
Flow (100y flood event)	Dam design document not available
Reservoir	
Reservoir	Yes
Normal Water Level (NWL)	146 masl
Minimum Operating Level Surface area at NWL Live Storage Volume Dead Storage Volume	140 masl 5.6 km^2 23 x $10^6 m^3$ 1 x $10^6 m^3$
Water retention time	6 days
Length of river impounded	6 km
Number of downstream tributaries	None
Useful reservoir life	25 years old, another 50 years life
Present Use of Water	
Water used for irrigation	Less than 1 m^3/s
Water used for drinking purposes	Less than 1 m^3/s

Water used for other settlement/industry purposes (please specify activities)	primarily built for irrigating 4100 hectares. No flow rate figures available.	m^3/s
Dam		
Dam Construction		
Type	Earthen	
Slope		m/m
Crest elevation	150	m
Crest length	1960	m
Maximum height Volume	45 250×10^6	m m^3
Spill way		
Type	Ogee	
Crest Elevation	247	m
Maximum flood level	245	m
Width Discharge	250 3550	m m^3/s
Penstock		
Penstock construction	Existing pipe from the intake tower could be used. But we don't have the details. Assuming new pipe is laid:	
Total length	150 x 2 pipes	m
Horizontal length	150	m
Diameter	1.75 (12mm wall thickness) x 2	m
Power facilities		
Power House type	Dam-toe	
Type of turbine	Francis, Horizontal axis	
Gross head Design discharge	12 10.7	m m^3/s
Length of tailrace channel	10	m
Installed capacity	900	kW
Distribution / Transmission facilities		
Transformer type	A hermetically sealed step up transformer	
Transformer rating	1200 kVA	
Transmission line type	HV, three phase	
Line voltage	33	kV
Line length	10.5	km
Line capacity Proposed conductor size	1.2 6	MVA mm^2

Proposed conductor material	ACSR	
Technical Loss factor along the line	8	Percentage
Power Production		
Total Efficient Capacity	900	kW
Average generation during wet season	900	kW
Average generation during dry season	750	kW
Mean Annual Total Power Production	7.2	GWh
Capacity factor	92	%
Plant factor *(The ratio of the average power load of the plant to its rated capacity)*	92	%
Average Generation for own use	NA	MW
Annual Power Production for own use	NA	GWh
Economics and Financials		
Investment Costs based on detailed underlying assumptions	750000	USD
Annual Operational costs based on detailed underlying assumptions	7500	USD/year
Annual Revenue from Operation	150000	USD/year
Net Present Value (NPV)	180100 (20 year life cycle)	USD
Internal Rate of Return (IRR)	15	%
Pay-Back Period (PBP)	5	Years

PART II- MAIN REPORT

1 INTRODUCTION

1.1 Background

With a population of over 170 million, Nigeria is the most populous country in Africa and the eighth most populous country in the world. According to the United Nations, one in six Africans is Nigerian. It is a regional power, listed among the "Next Eleven" economies, and a member of the Commonwealth of Nations.[i] But Sadly, on the economic front, the country seems to be stagnant at the best. The main factor that hinders the development as perceived by many is the power sector. Nigeria is ranked 172 out of 187 countries by world Bank on the " ease of getting electricity"[1].

The Energy Commission of Nigeria (ECN) together with the International Atomic Energy Agency (IAEA) projected a demand of 15,730 MW for 2010 and 119,200 MW for 2030 under the reference scenario (7% yearly economic growth)[2]. Many studies indicate that the current gap between supply and demand is already very high (1:3) and that, it will become worse if the same reliance on fossil fuels is continued.

In order to bring a solution to these problems, the Federal Government of Nigeria (FGN), in its Power Sector Reform Roadmap (2013), set ambitious targets to increase installed hydro to 5,690 MW, thermal to over 20,000 MW and renewable 1000 MW capacities by 2020[3] . The targets also aim at diversifying Nigeria's energy mix to reduce its natural gas dependence.

Federal Government of Nigeria through the Federal Ministry of Power and Federal Ministry of Water Resources (FMWR) are undertaking studies of irrigation dams in the country to identify their potential for SHP integration and development.

Bureau of Public Private Partnerships, Kogi State Government requested UNIDO Regional Centre for Small Hydro Power in Africa, Abuja to assess the power potential on using the existing dams at Osara, Okura and Omi which were primarily built for irrigation and other industries and a project on Ofu river for hydro-power generation. The UNIDO team visited the state from 13th March to 16th March 2017 to do a pre-feasibility study. Since the potential in these sites is attractive, UNIDO decided to conduct a detailed study for these sites.

1.2 Project Objective

Omi Dam hydro power project will use the natural resource, the Kampe river water, a perennial river in the state to generate electricity to meet the energy demands of the three nearby villages and to power the water treatment plant at Omi. Kogi state is , as the rest of the country, facing a severe shortage of power supply options and this project will take care of these few communities and thereby improving the local economy through small agricultural processing industries .

The overall objective of this project is to provide power for the base-loads of the iron ore company with captive power generation. The project outcomes will include the following:

---

[1] www.doingbusiness.org/data/exploretopics/getting-electricity

[2] A. S. Sambo, 2008, Matching Electricity Supply with Demand in Nigeria, Fourth Quarter, International Association for Energy Economic, p. 33

[3] The Presidency of the Federal Republic of Nigeria, August 2013, Roadmap for Power Sector Reform, Revision1, p. 24-25

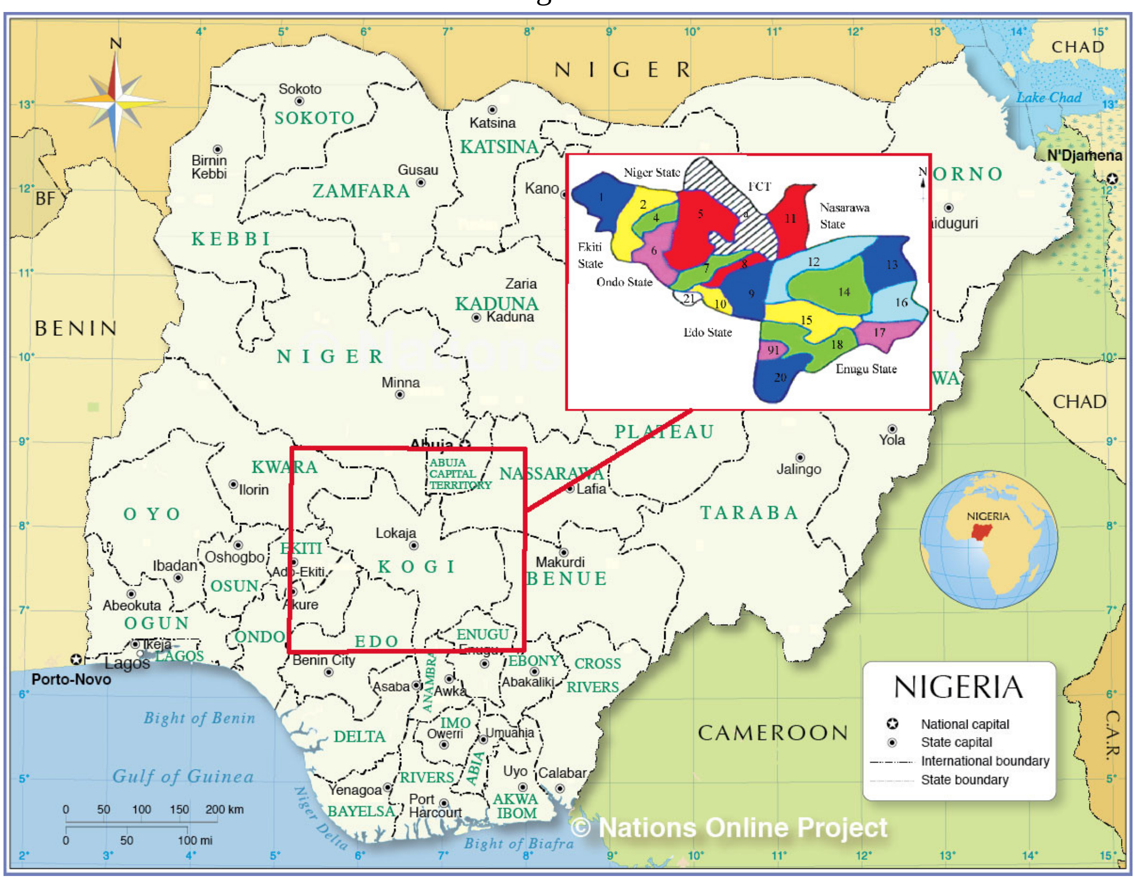
- Supply of reliable, affordable electricity
- Supply safe drinking water to the communities – by powering the water treatment plant which is not functional now because of shortage of power.
- Increased Value addition and other small industries for the rural areas
- Reduced pollution – both indoor and outdoor
- Increased facilities to health services

1.3 Pre-Feasibility Study Objective

UNIDO sent a technical team to assess the potential and to provide broad guidelines to design and implement the hydro-power project in the Omi dam area. The objective is also to ascertain the technical and economical viability of the proposed project. The PFS will provide topographical data, hydrological data, analysis of historical rainfall data using flow duration curve, as well as assess the environmental and social impact that might arise from developing these sites.

2 DESCRIPTION OF PROJECT AREA

Kogi is a state in the central region of Nigeria. It is also popularly called as the Confluence State because the confluence of River Niger and River Benue is at its capital, Lokoja. The State has twenty one (21) local government areas and is located in the middle belt or what is historically referred to as the North Central area of Nigeria.



The state experiences two major seasons, dry and wet seasons which favours the growth of varieties of food and cash crops. The major economic activities of the people are farming, fishing, services and government employees. The major crops grown are yam, cassava, and rice while the cash crops include cashew, oil palm, and Neem tree. Kogi State is also abundantly endowed with Iron Ore, Limestone and coal.

2.1 Project location with coordinates and relevant site maps

Omi Dam on Kampe river is situated in Yagba West Local Government Area (LGA). Omi dam lies in the derived savanna ecological zone of Kogi state with about 7 months of dry season.

Kampe river originates at about 25 km at the southern tipf od the catchment east of Ikole in Ekiti state over an elevation of 638m to join Niger river at elevation 53m.

It was primarily built for irrigating 4100 hectares of land. The project was first conceived in 1979 and the construction started in 1983. It was completed and commissioned on May 12, 1999 by Lower Niger River Basin Development Authority (LNRBDA). The total length of the canal is 39km. The gradient of the canal is low and it can carry a maximum of 40 m3/s.

2.1.1 Physical & Salient features of the project site

Multiple streams feed into the Omi reservoir as can be seen from the catchment area shown below. The catchment area is about 1650 km^2. The inflow of water into Kampe river depends to a large extent on the contribution of various tributaries like Oyi, Erigi and sub-tributaries like Aiyewa, Ele and Omo which are seasonal.

The estimated area of the reservoir is 25.7 km^2 with a storage volume of 250 x 10^6 m^3.

The sedimentation load has not been recorded.

There is grid line already in the region but not functional due to defective transformers. With minimal cost, this transmission network can be connected to the Omi power scheme.

Figure 2 Transmission network & transformer at Omi village

Figure 3 Omi Dam and Canal

2.1.2 Load profile and electricity demand

There are three villages nearby. The largest village is called Omi.

2.1.3 Demographic and Socio-economic parameters

3 TOPOGRAPHICAL SURVEYS

A team led by Engineer Rufai prepared the topographic maps for the dam. A maximum head of 12 m is available at the site.

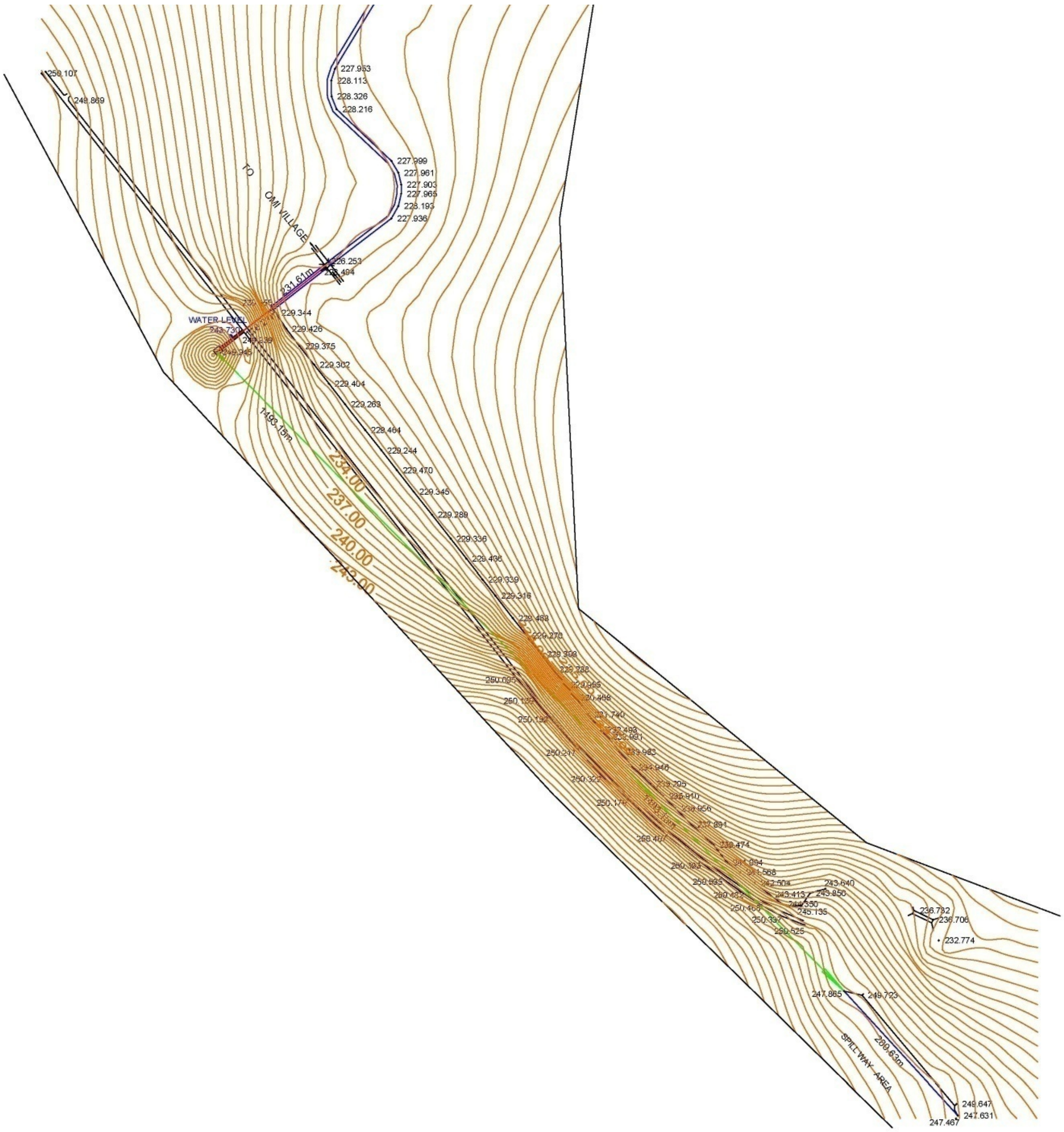


Figure 4 Topographic survey map the project area

The existing dam's crest level is at 150 m asl. This will give a gross head of 12 m for the power generation. The usable water level is 147m asl. At the time of visit, the eavel was at 143m asl giving a height difference of 14m. Allowing for reduced inflow during dry periods, the effective design head is fixed as 12m.

4 HYDROLOGICAL AND SEDIMENTATION STUDIES

Except for the drawings, the original design manual of the dam is missing/ damaged. Conducting a detailed sedimentation study is beyond the scope of this mission.

Dam design details missing.

4.1 Catchment characteristics

Omi and Kampe Rivers are the main source of water for people within its catchment area. The catchment area characteristics are unknown – data awaited from the department/ministry.

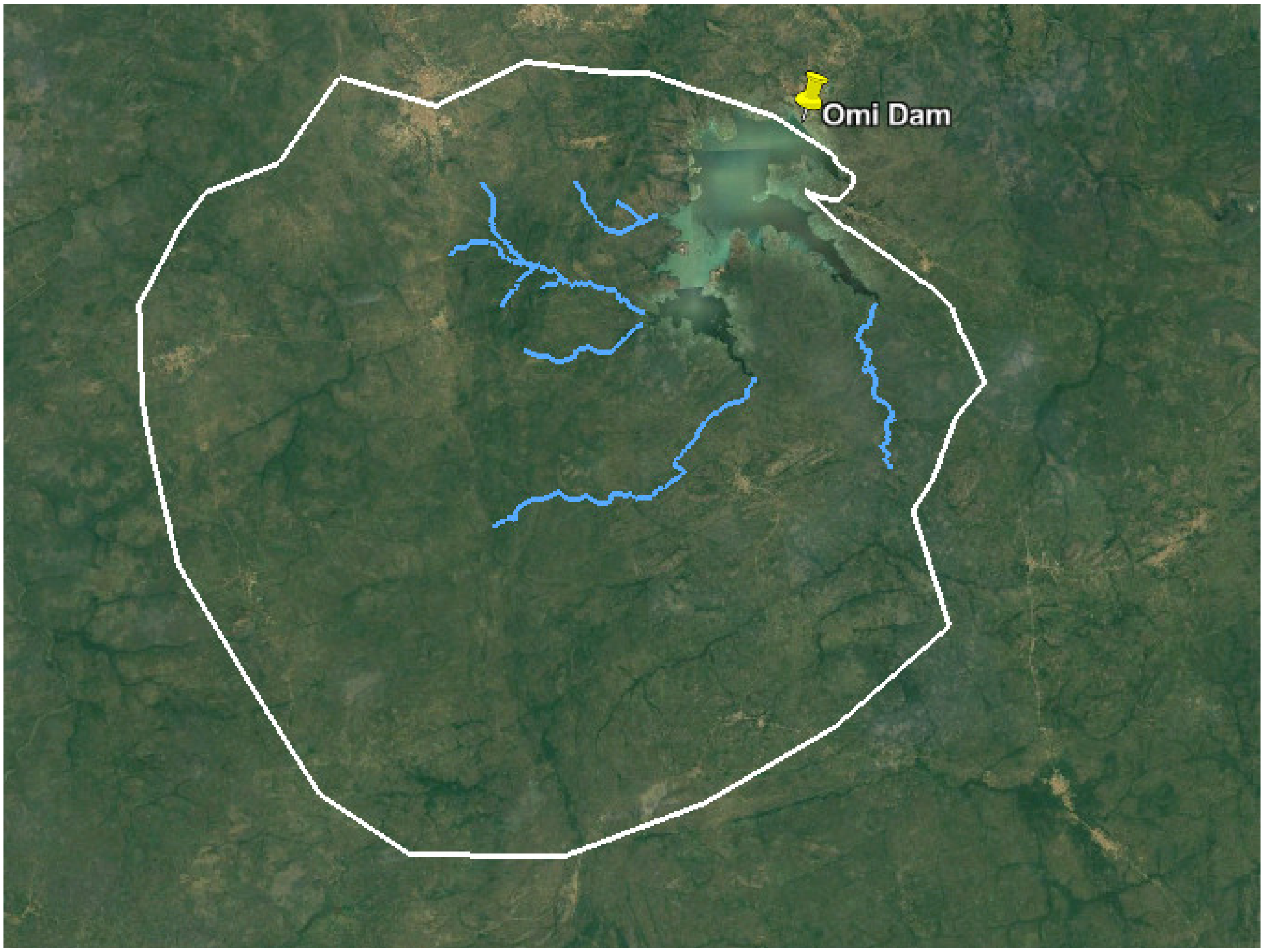


Figure 5 Catchemt area of Omi Dam

4.2 Rainfall, climate and precipitation data analysis

Rainfall data recorded in Lokoja Kogi state station is used in this analysis. Data from 1995 to 2016 is obtained and the average monthy rainfall is presented below.

Month	Average rainfall in mm
Jan	7.5
Feb	19.1
Mar	58.8
Apr	108.2
May	157.7
Jun	167.4
Jul	163.3
Aug	149.8

Sep	244.6
Oct	144.6
Nov	21.4
Dec	13.7
Total	1256.1

As it can be seen, April to October is the wet season with peak rainfalls in June and September. The catchment area above the existing dam is shown in Figure 4. The total area is about 530 km^2. The run-off characteristics for the region is not well-established. As the catchment area is said to be barren, run-off can be assumed to be low . We have taken 16%[4] for this DPR to arrive at the component sizing for the scheme.

The total run-off in a year = 1.256 x 1642 x 10^6 x 0.16= 329,976,320,m^3

The average flow rate = 10.46 m^3/s

4.3 Flow Duration Curve

With limited available data, a FDC was prepared. Q57 is selected as design flow. This flow will be available for nearly 7 months.

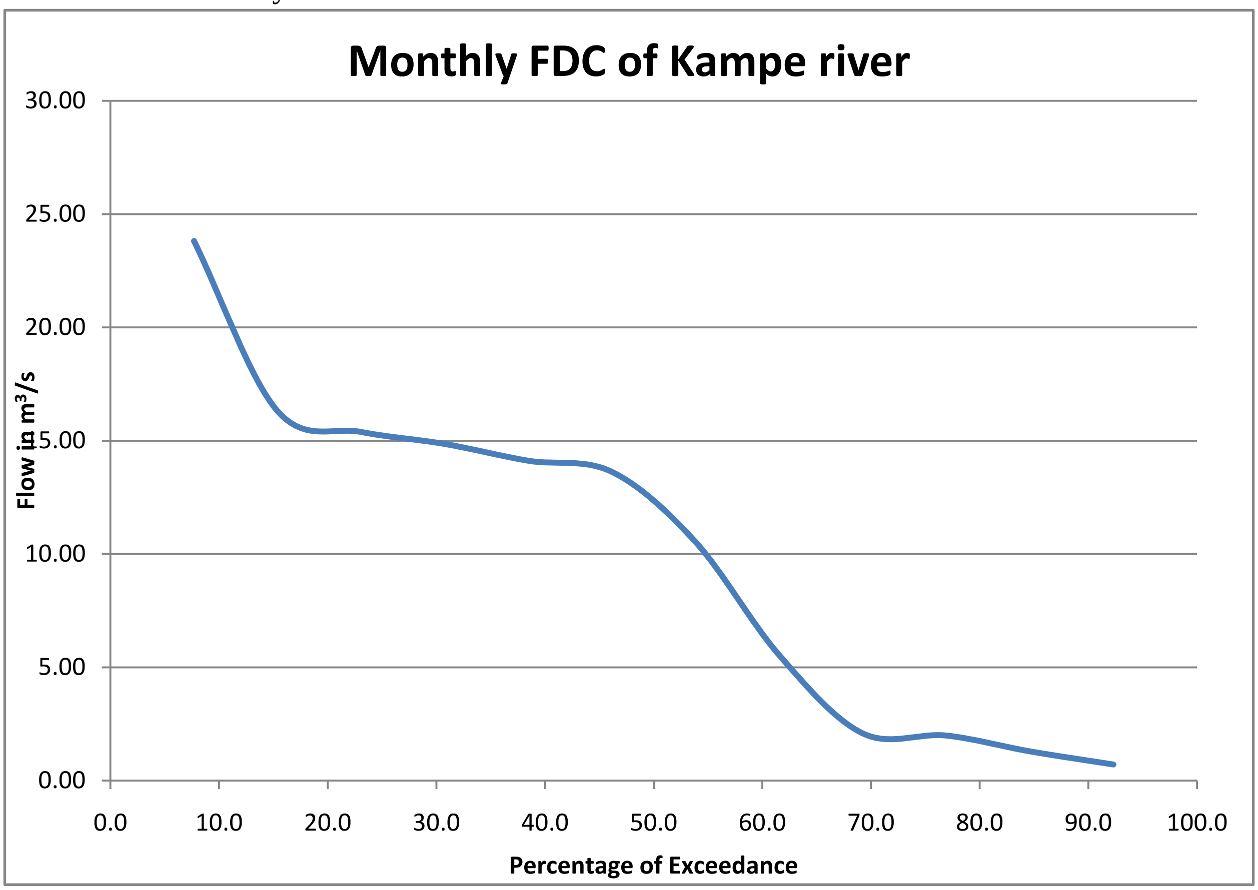


Figure 6 FDC for Kampe/Omi River

[4] JICA report

5 GEO-TECHNICAL STUDIES

A detailed geo-technical study was not within the scope of this visit.

6 SUMMARY OF ENVIRONMENT AND SOCIAL IMPACT ASSESSMENT (ESIA)

6.1 Environmental Impacts

The proposed site already has a dam. No further damage to environment is possible.

6.2 Social Impacts

Three villages are to be connected. NO information available from them.

6.3 Assessment of significance of environmental and social impacts

Being an existing dam site, there is no significant impact noticed. An in-depth study was not carried out at this stage. When the project moves onto the next stage of detailed technical design, this study could be taken up.

7 PROJECT OPTIMIZATION

7.1 Estimation of Power and Energy Production

Details of the existing intake structure are not available.

It is assumed that there is sufficient space in the existing structure to accommodate two new pipes of 1.75 diameter for a length of 150m.

7.1.1 Plant capacity

The proposed capacity of the power plant is 900 kW. The available head, is 12m. The design flow is 10.7 m^3/s.

7.1.2 Plant factor

The plant factor 0.92 for this project will be quite high as the storage capacity of the dam is large to compensate for the lean periods.

7.1.2.1 Annual energy

The generation profile is given in the table below:

	Power kW	Energy kWh
Jan	750	558,000
Feb	750	504,000
Mar	750	558,000
Apr	750	540,000
May	900	669,600
Jun	900	648,000
Jul	900	669,600
Aug	900	669,600
Sep	900	648,000
Oct	900	669,600
Nov	750	540,000

Dec	750	558,000
	Total	7,232,400
Installed capacity		7,884,000

The plant factor is 0.92

7.2 Cost Estimates

The total project cost is estimated to be 2 million USD. Approximate Break-up of costs are given below:

The electro-mechanical equipment cost is estimated to be 0.75 million USD and the total civil works cost is estimated to be 1 million USD.

8 PROJECT DESCRIPTION AND BASIC DESIGN

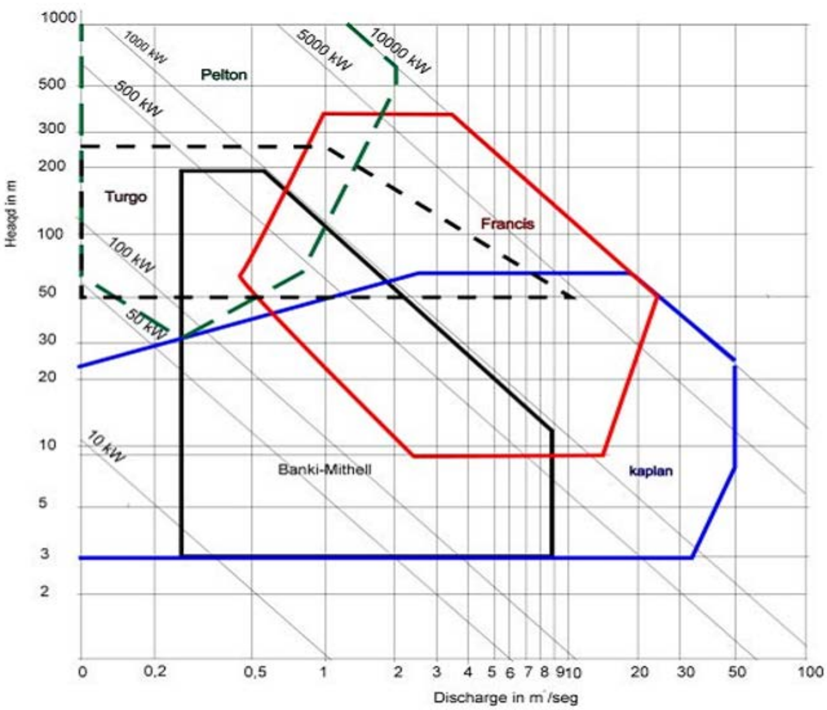
The project site has an existing small earth dam. The powerhouse location is at about 50m from the dam site. It will have two turbine units. The turbine will be of Kaplan turbine.

The tail race will be 5m long and leads the water back to the irrigation canal.

Existing intake structure can be used as with additional installation of pipes.

A total of 10 km long transmission network is needed to connect the three villages.

8.1 Turbine choice



Kaplan turbine will be suitable for this site as the specific speed (metric) lies between 750 to 1600.

8.2 Generator

A three phase AC synchronous generator with horizontal arrangement and air cooled as per the

IEC regulations is considered for this project. Two sets of generators will be installed which can also be synched with each other through a power electronics panel.

Each unit has a synchronization microcomputer automation device to perform synchronism connecting to the grid. Switchyard is also equipped with a set of microcomputer automation synchronization device and a set of manual synchronization device, mainly used to finish synchronism connecting to net of main transformer and 33 kV line.

9 DISTRIBUTION / TRANSMISSION LINE AND CONNECTION TO THE GRID

Transmission network is present at Omi village. No information about the other villages.

10 OPERATION AND MAINTENANCE REQUIREMENTS

Most of the operation will be automatically controlled with SCADA. A team of 3operators will manage the power plant to monitor the proper functioning of components.

The maintenance requirements are mainly desilting the dam once in a year, checking the seepage losses in the dam, fixing penstock leaks, transmission line issues, etc.

11 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions are made:

1. Omi hydro project is technically and financially feasible.
2. Installed capacity and energy: The installed capacity of the plant is 900 KW with a design discharge of 10.7 m^3/s and gross head of 12m. The gross energy production is 7.2 GWh
3. Transmission network is present in Omi village. Can be upgraded/ used to connect the omi hydro station.
4. A construction period of 15 months has been considered.

Based on the findings of this study, the project is financially attractive. It is recommended the detailed design for the dam & reservoir, penstock alignment, powerhouse and transmission& distribution design be initiated immediately.

[i] Energy Sector Study – GIZ NESP 2015-16 report