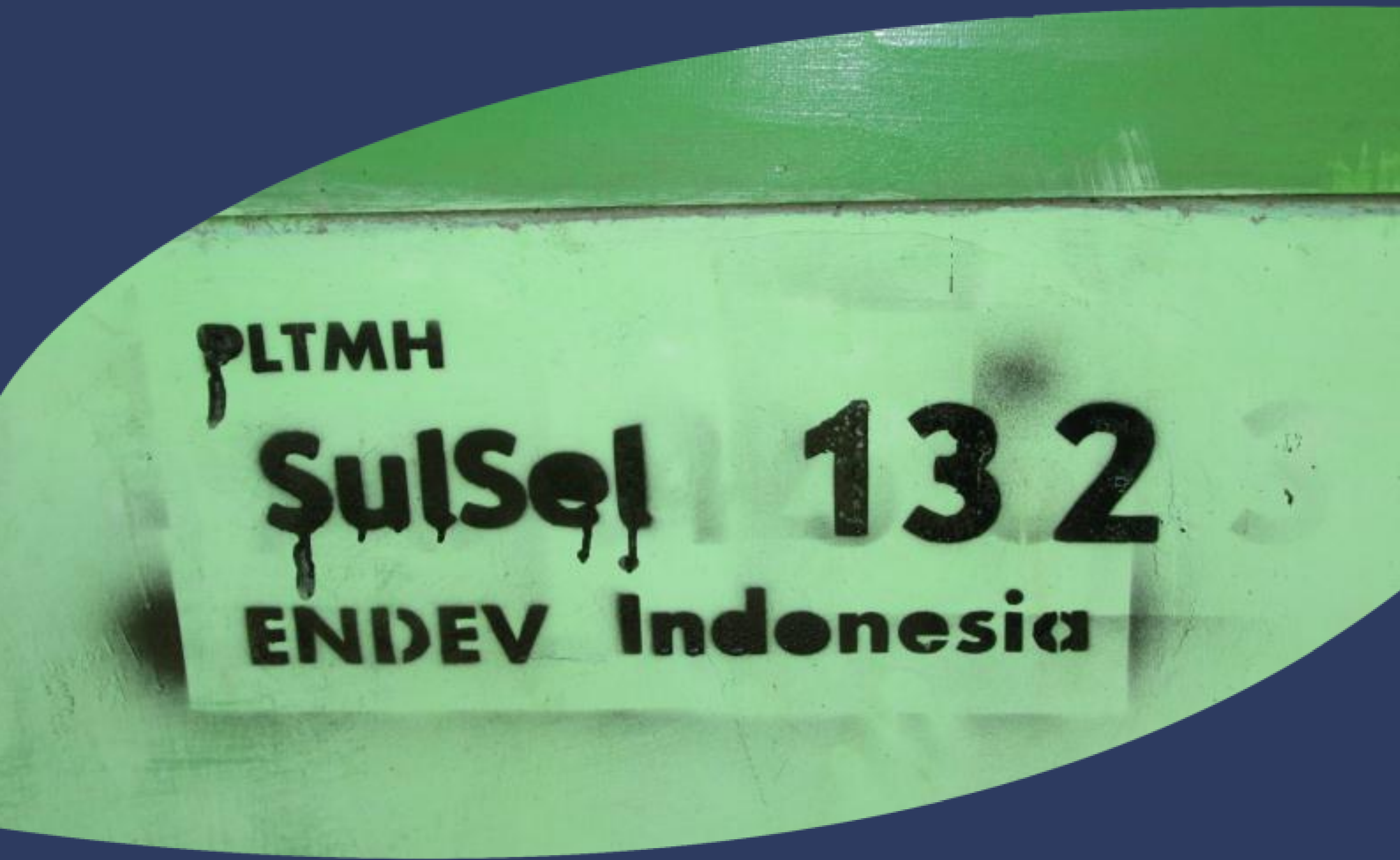

EnDev2 Indonesia: Impact on Sustainability

A Comparative Study

June 2013

Compiled by: Atiek Puspa Fadhilah, Amalia Suryani and Robert Schultz

In close collaboration with: Andrea Ranzanici

kerja sama jerman
DEUTSCHE ZUSAMMENARBEIT

Implemented by:
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Contents

List of Figures and Tables

Abbreviation

APBD	Anggaran Pendapatan dan Belanja Daerah (Local budget)
APBN	Anggaran Pendapatan dan Belanja Nasional (National budget)
CSO	Civil Society Organisation
CUKK	Credit Union Keling Kumang
DAK	Dana Alokasi Khusus (Special Allocation Fund)
DGEEU	Directorate General for Electricity and Energy Utilisation
DGNREEC	Directorate General for New and Renewable Energy and Energy Conservation
DME)	Desa Mandiri Energi (Energy Self-sufficient Village)
ELC	Electronic Load Control
EnDev1	Energising Development 1 (2006 – 2009)
EnDev2	Energising Development 1 (2009 – 2014)
GIZ	Gesellschaft für Internationale Zusammenarbeit (German Agency for International Cooperation)
GSM	Global System for Mobile Communications
IPP	Independent Power Producer
KPDT	Kementerian Pembangunan Daerah Tertinggal (Ministry for Development of Disadvantaged Areas)
KPI	Key Performance Indicators
KUKM	Kementerian Koperasi dan Usaha Kecil dan Menengah (Ministry of Cooperative and Small and Medium Enterprises)
kW	kilo Watt
MEMR	Ministry of Energy and Mineral Resources
MHP	Micro/mini hydro power
MHPP	Mini Hydropower Project
$MHPP^2$	Mini Hydropower Project for Capacity Development
ML	medium to long-term
MOHA	Ministry of Home Affairs
MW	Mega Watt
NGO	Non-governmental Organisation
PLN	Perusahaan Listrik Negara (National Power Utility)
PMD	Direktorat Jenderal Pemberdayaan Masyarakat dan Desa (Directorate General of Community and Village Empowerement)
PSS	Proportional-to-size sampling
PNPM	Program Nasional Pemberdayaan Masyarakat (National Programme of Community Empowerment)
SDA & TTG	Direktorat Sumber Daya Alam dan Teknnologi Tepat Guna (Directorate of Natural Resources and Appropriate Technology)
VMT	Village management team

1 Executive Summary

Energising Development (EnDev) Indonesia launched its second phase in 2009, known as EnDev2. EnDev2's objective was to a) support sustainable access to modern energy services for rural communities in Indonesia and b) to consolidate the gained MHP expertise for the counterpart and sector stakeholders. Monitoring the provision of modern energy access is relatively straightforward however, sustainable access requires a long-term monitoring intervention ideally with comparison to a baseline.

In April 2013, EnDev2 launched a study, as a means to commence with assessing the sustainability impacts of its support to Green PNPM, by comparing its "success/failure" with other non-EnDev2 MHP support initiatives against a set of sustainability factors. This "comparative study" was concluded in June 2013 and its findings are reported herein.

Preceding the field-based survey of the comparative study, a situational analysis was conducted, in an attempt to collect and review available data on MHPs at a national level. Data was sought from different public and private agencies involved in funding and supporting MHP development in Indonesia. Apart from EnDev2 (and its predecessor EnDev1) data records were wholly inadequate and in the best case only provided some basic data (such as installation location, installed capacity and/or year of installation). Unfortunately in almost 40% of over 1,300 MHP sites recorded in Indonesia, not even this rudimentary data was centrally available. Particularly government-funded programmes (which account for over 75% of funding for MHPs installed) are at risk, since lack of data does not allow for planning, monitoring and adjusting their rural electrification programmes.

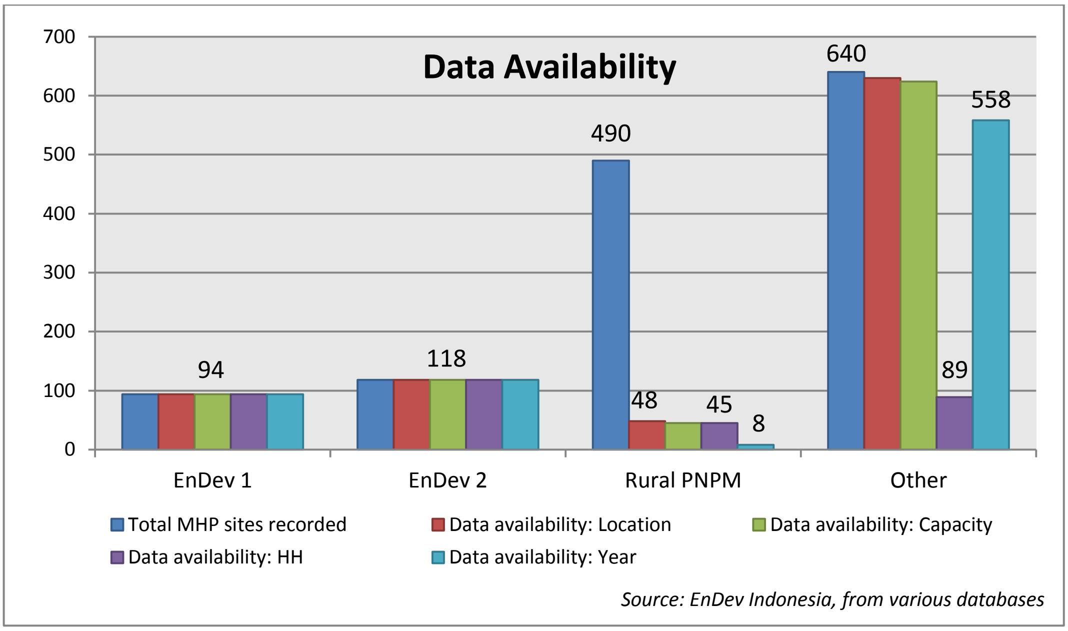

Figure 1 MHP schemes data availability

Sustainability is a process of continuous improvement from lessons learnt, rather than a fixed position. Improvement requires monitoring, which in turn is only possible if sufficient data are meticulously collected, inventoried, regularly analysed and available. If data availability and comprehensiveness are regarded as necessary towards sustainability, EnDev2 sites have far great prospects than sites supported through any other programme.

The field-based comparative study undertook in-depth surveys of 32 sites in Sulawesi, Indonesia. The sites included EnDev2 and various non-EnDev2 MHP installations. The overriding finding was that EnDev2 MHP sites perform far better in terms of technical sustainability, while being amongst the top performers for economic and social sustainability. Environmental sustainability appears to lag behind, but this is due to natural events beyond control.

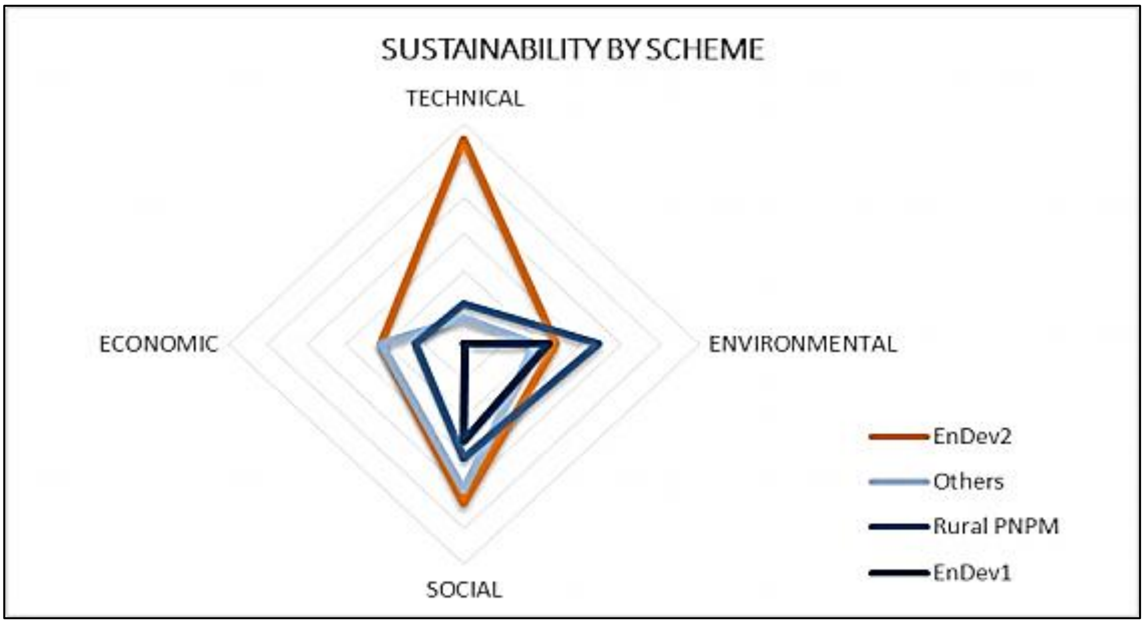

Figure 2 Radar diagram based on four sustainability factors

Of particularly delight was the revelation that overall MHP sustainability in Indonesia appears to improve. While both EnDev1 and EnDev2 are reluctant to claim full credit, several sustained sector interventions by these projects undoubtedly contributed towards this steady improvement.

Chapter 2 of this report explains the rationale for this comparative study, while Chapter 3 provides contextual background information and describes the different MHP support schemes assessed. The chapter also present the results of the situational analysis conducted prior to the comparative study and field surveys. Chapter 4 is dedicated to the methodology of the comparative study to demonstrate that a scientifically objective approach was pursued, within the logistical and resource limitations at hand. Chapter 5 then presents the findings of the comparative study. The comparative study was conducted by a master student for the elaboration of his master thesis, and this chapter extracts the most pertinent results. This report concludes with Annex A, which describes the non-operational MHP sites discovered during the field surveys in more detail.

Figure 3 EnDev2 identification

Under EnDev2 the MHP power house door or wall is sprayed with the database site code, making the MHP clearly identifiable for third parties.

Source: Andrea Ranzanici (GIZ, 2013)

2 Introduction

2.1 Study Rationale

Indonesia's tropical climate and topography is reason for its abundant micro hydro power (MHP) potential across remote rural areas in the archipelago. This makes MHP technology an attractive option of rural electrification programmes for both public and private sector players. Consequently the technology has a long track-record in Indonesia. It is widely recognised that several thousand MHP schemes are installed throughout the country.

As part of its role in energy provision, the Ministry of Energy and Mineral Resources (MEMR) has developed MHP-based rural electrification through funding schemes such as Desa Mandiri Energi (DME) and Dana Alokasi Khusus (DAK). Rural electrification utilising MHP technology is not exclusively implemented by MEMR however. At least five other ministries are involved in the sector namely Ministry of Home Affairs, Ministry for Development of Disadvantaged Areas (KPDT), Ministry of Cooperatives and Small and Medium Enterprises (KUKM), Ministry of Marine and Fisheries, and Ministry of Agriculture.

Additionally, provincial and district government also contribute in MHP development through their local budgets (APBD). Besides the public sector, various actors from both private and civil organisation have been proactively initiating MHP installations for more than two decades. This includes environmental NGOs, social businesses, cooperatives, credit unions, technical colleges, and communities themselves. Some of these initiatives are sponsored and/or supported by international donors and agencies.

Inopportunely, MHPs are usually characterised by higher capital costs and greater technical complexity compared to their "competitor" namely generator-sets (genset) fuelled with diesel or gasoline. For this reason, off-grid MHP systems are in most cases still dependent, both in financial and technical terms, on external support without which local communities would hardly be able to implement such system. Specifically in Indonesia, such external support is often provided by international technical support agencies that operate in the country. Germany's Gesellschaft für International Zusammenarbeit (GIZ), for instance, has been fundamentally involved in supporting MHP development since the 1990s, and the GIZ's current support programme EnDev2 (Energising Development Phase 2) has provided in-depth technical support since 2009.

A study conducted on behalf of the World Bank Group in 2012[1], reached one of a number of conclusions stating that: *"the additional cost/kW of TSU [EnDev2] is contributed to better material quality and additional training and capacity building through TSU [EnDev2] support, which may likely lead to better sustainability of the MHP operation".* Based on this conclusion, EnDev2 launched a comparative study (ComStu) in April 2013 in order to assess the programme's impact on MHP sustainability in Indonesia, compared to other support schemes in the country. ComStu was conducted in close collaboration with the development of a Master Thesis[2], which is available as a supplement to this report.

---

[1] Castlerock Consulting; "Final Report - Micro Hydro Power (MHP) Return of Investment and Cost Effectiveness Analysis "; World Bank Group, Indonesia, 2012

[2] Ranzanici, A; *Sustainability comparison between EnDev and non-EnDev micro-hydro power (MHP) in Indonesia*; UNIVERSIDAD POLITÉCNICA DE MADRID (European Joint Masters Programme), 2013

2.2 Objective and Research Question

The overall objective of ComStu was to assess the hypothesis that "*the EnDev2 concept improves the sustainability of off-grid MHP systems compared to other off-grid MHP support schemes in defined project areas of Indonesia*". ComStu was conducted as an investigation and comparison into the social, economic, environmental and technical sustainability of the MHP systems falling into and outside the EnDev2 support scheme for selected areas in Sulawesi Selatan and Sulawesi Barat.

To test the hypothesis, a research question was formulated: "*Does the EnDev2 concept improve the sustainability of the MHPs compared to other off-grid MHP schemes in Sulawesi?"* This central question lead to four further derivative sub-questions on various aspects of sustainability:

1. **Technical sustainability**: to what extent guarantee the design and the hardware of the installed MHP systems medium to long (ML) term operations while offering a high-quality output of electricity produced?
2. **Social sustainability**: to what extent have the local communities (benefiting from the MHP systems) been involved and made active participants in order to guarantee the self-sustainability of the operations in the ML term?
3. **Economic sustainability**: to what extent have economic considerations been addressed and actions put in place over the life cycle of the systems in order to maximize the economic sustainability of the MHP systems in the ML term?
4. **Environmental sustainability**: to what extent have environmental boundaries been taken into consideration and their importance associated to the ML term operations of the MHP systems acknowledged?

2.3 Research Scope

ComStu compared different MHP support schemes and clustered them into "EnDev2" and "Non-EnDev2" (the latter comprising several different support schemes). The research scope was a) defined by the geographic area of EnDev2's support activities (i.e. districts in Sulawesi Selatan and Sulawesi Barat) and b) the utilisation of EnDev2's established Key Performance Indicator (KPI) survey methodology. The KPI methodology allowed for assessing the four principal aspects of sustainability namely technical, social, economic, and environmental aspects. In preparation to field surveys extensive desktop research was required, in order to undertake an overall situational analysis and then define the sample size.
ComStu involved five main activities, as visualised in the diagram below.

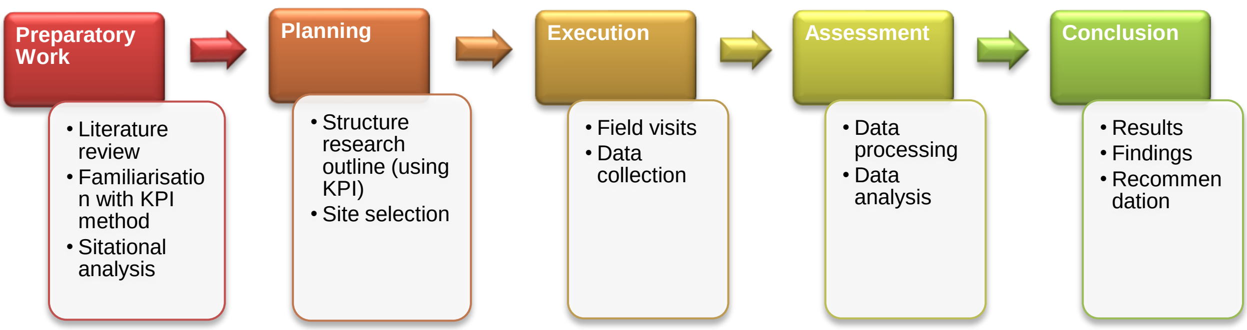

Figure 4 Flow of ComStu activities

3 General Background Information

3.1 MHP Systems in Indonesia

MHP, in an Indonesian context, generally comprises MHP schemes with a capacity of less than 100kW. The technology is based on a run-out--of-river approach: water from a stream or small river is diverted at a weir into a channel that leads to a forebay. The forebay is designed to allow sediments to settle (for later flushing out) and to catch floating debris. The resulting "clean" water enters a penstock pipe, which is attached to a turbine in a powerhouse. The powerhouse is located several meters below the forebay. This height difference (along with the quantity of water flow) reflects hydro power's energy potential. "Falling" water turns the turbine and then returns to the stream. The turbine's rotation is transferred to a generator, which produces electrical energy. While this electrical energy can be transferred directly to a distribution grid, more sophisticated (and commendable) MHP schemes contain electronic load controls to improve system performance and ensure electricity supply quality.

Figure 5 MHP system overview

An overview of a run-of-river MHP system that is commonly used for rural electrification programmes in Indonesia.

These MHP schemes are typically operated, maintained and managed by the village communities. In some cases these villagers also constructed the plants[3]. Generally the communities would also appoint a village management team (VMT) to ensure operation and maintenance and to collect revenue from electricity sales to households, businesses and other clients. Accrued income is used to pay a salary of the VMT members, cover routine maintenance expenses and save funds for future major replacements and repairs. Under Indonesia's current policy frameworks there are no schemes to encourage external service providers, on an Independent Power Producer (IPP)-basis, to undertake MHP-based rural off-grid electrification on a financially feasible basis.

[3]This particularly refers to "community-based" approach where the community applies directly, or through the provincial government, for funding.

While Indonesia has a long track record of deploying MHP systems as part of its rural electrification programmes, sustainability concerns remain. Through previous assessments, EnDev2 has learned that MHP sustainability is at risk if the system is either not well managed, technically maintained, vulnerable to environmental influences or where the national grid becomes accessible (in the latter case, an MHP scheme is often simply abandoned).

In September 2012, EnDev2 conducted a survey to assess the key performance indicators (KPI) of MHP sites supported under EnDev2. It was identified that among 47 surveyed sites, 8 sites were not-operational (17%) with categorised reasons as shown in Figure 7 Reasons of non-operational sites.

Figure 6 Village management team activity

A VMT treasurer accepting and recording payment for electricity supply from a household.

Source: Masri Vani, EnDev Indonesia (GIZ, 2012)

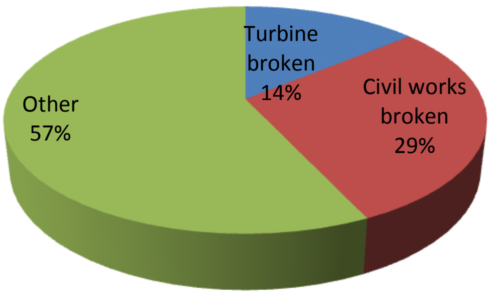

Figure 7 Reasons of non-operational sites

Source: KPI Survey on Key Performance Indicators for Indonesian Micro-hydro Power Sites - EnDev Indonesia

Under category "Other", the most common reason was the reduced water flow in dry season. From field it was also observed that rapid deforestation plays a significant role in quality and quantity of water supply.

"Encroachment" of the national grid also suggests a sustainability risk. During the same KPI survey it was found that over 10% of total households were not connected to the MHP schemes surveyed, due to expanded grid connection by PLN. While this does not compromise overall rural development, it does lead to a waste of resources, where MHP schemes were constructed without due consideration or awareness of the national grid expansion programme.

A complete MHP scheme costs about IDR 64million/kW[4] installed. This expense can be reduced by opting for lower quality electro-mechanical equipment. Generally however, an average 74% of the expense is related to civil construction and transmission/distribution network costs.

3.2 MHP Support Schemes in Indonesia

"MHP support schemes" in Indonesia comprises organisations and programmes that provide MHP technical support and/or financial support. While some MHPs are funded directly by the community, non-governmental organisations (NGO) or international donor agencies, the vast majority of funding for MHPs is sourced from central government via different ministries. Most notable in recent years are the National Community Empowerment Programme (PNPM) administered by the Ministry of Home Affairs (MOHA) and Desa Mandiri Energi (DME) administered by the Ministry of Energy and Mineral Resources

[4] Source: EnDev Indonesia Monitoring Report July - September 2012. The value reflects the cost based on design. The average cost based on measured electrical output is IDR 83million/kW

(MEMR). In addition to financial support there are a number of technical support agencies, initiatives and programmes. These include several national non-governmental organisations, but also international agencies, such as the Gesellschaft für International Zusammenarbeit (GIZ)'s Energising Development (EnDev) programme.

ComStu identified the following prominent support schemes involved in developing MHP in Indonesia and grouped into two categories: "EnDev2" and "Non-EnDev2". The latter comprises a number of different support schemes as described below.

3.2.1 Category 1: EnDev2

Energising Development (EnDev) is a multi-donor impact-oriented initiative promoting the supply of modern energy technologies to households and small-scale businesses in 21 countries in Africa, Asia and Latin America. Implementing agency for EnDev is the GIZ. EnDev Phase 2 (EnDev2) in Indonesia commenced in mid-2009 and comprised initially two complementary components:

1. The Green PNPM Micro Hydro Power Technical Support Unit (MHP-TSU) to directly support the access to energy through 136 MHPs that are financed by the Green PNPM programme (pilot programme under Rural PNPM), and
2. The Mini Hydro Power Project for Capacity Development (MHPP[2]) as a capacity development component to institutionalise know-how and learning from experiences for a sustainable MHP sector development in Indonesia.

EnDev2 has clearly specified partners, namely the Green PNPM (a pilot programme under MoHA's Directorate of Natural Resources and Appropriate Technology) and Directorate General for New and Renewable Energy and Energy Conservation (DGNREEC, established in August 2010, under MEMR). The latter however only became fully operational towards late 2011, while the former was terminated in December 2012 (see also Section 3.2.2). Indeed Green PNPM was intended to complement Rural PNPM with the specific focus on environmental and natural resource management activities, including MHPs (see Section 3.2.2 for the historic background of Green PNPM and linkage to Rural PNPM).

Figure 8 Transporting a turbine across a paddy field

Community participation to the project can be in a form of in-kind contribution.
Source: Masri Vani (GIZ, 2012)

EnDev2 provided extensive technical support exclusively to Green PNPM-financed MHPs, with direct community-level support stretching over the whole construction phase. This technical support comprised the complete activity chain leading to the operationalization, management and administration of MHPs and included:

- Full technical assistance (proposal screening, feasibility studies, design, tender documents, construction supervision, commissioning)
- Supporting early community preparation and participation

- Introducing operation, maintenance and management procedures
- Introducing principles of good business administration, tariff-setting, billing, savings
- Capacity building of stakeholders (villagers, village construction team, management team, local government, manufacturers)
- Support and initiate productive-use-of-energy as a key sustainability measure
- Compile, produce and disseminate information materials and guidelines in various print and multi-media formats

During the height of EnDev2, the programme comprised several permanent MHP engineers and advisors, and 35 local field technicians and support staff in Sulawesi and Sumatra. It maintained several field offices, vehicles and testing equipment. EnDev2 was instrumental in determining the technical specifications for each MHP system, oversaw construction quality and established strong collaboration with beneficiary communities that applied for, and received, funding for an MHP under Green PNPM.

3.2.2 Category 2: Non-EnDev2

- **RURAL PNPM**

Established under PMD (Directorate General under MoHA) in 2007 (the predecessor programme, Kecamatan Development Programme was already established in 1998), the National Programme of Community Empowerment in Rural Areas (or Program Nasional Pemberdayaan Masyarakat or Rural PNPM) provides funding for infrastructure development to villages in rural Indonesia, in order to improve socio-economic and local governance conditions.

Under this programme, villages identify their development priority and apply for funding via District Government. Funds are provided directly to the community and paid out in tranches according to performance milestones. Labour is provided by the community. Rural PNPM also has access to field facilitators that can provide basic technical support. The most typical priority areas for rural communities are roads, bridges, irrigation systems, clean water systems, elementary schools, and village health centres. Several hundred MHP schemes have also been funded under Rural PNPM, but this comprises only less than 1%[5] of total funding volume, as communities in general regard electricity access as a lower priority.

Case example: Rural PNPM rural infrastructure support

Paraphrased from 2010 Progress Report:

400 sub-districts and almost 3,000 villages were added in 2010 as a result of administrative redistricting. Block grant funds totalled approximately USD 740 million, of which 99.8% was disbursed as of April 30, 2010. Roughly USD 139 million of these block grant funds was contributed by district governments. 2010 outputs from block grant fund sub–projects included:

- 18,279 km of farm/rural roads built
- 2,147 bridges built
- 3,447 irrigation systems built
- 2,053 clean water systems built which benefit >1.4 million people
- 6,135 public toilets and washing facilities built
- 438,432 m^2 of school buildings built or rehabilitated
- 157,054 m^2 of health facilities built or rehabilitated

[5] Source: http://pnpm-support.org/pnpm-rural

- **283 village electricity units built which benefit >127,000 people (note: this includes MHP and solar PV system)**
- 3,001 education activities supported
- 1,601 health activities supported
- 29,489 women revolving loan fund activities supported

Annually, these sub–projects benefit 34 to 35 million people and provide approximately 9 to 10 paid working days each to some 3 million villagers, around 70% of whom were classified as being very poor by their own communities. Women continued to be highly involved in the planning aspects of sub-projects; they accounted for more than half of the participants in village and inter–village meetings. They also initiated about 60% of all the sub-projects funded.

It is against this background that Rural PNPM launched the pilot programme "Green PNPM" in 2008, specifically designed to integrate environmental issues into the local community-driven development (CDD) planning process. Green PNPM was only active in selected target locations in Sulawesi and Sumatra Islands and the block grant funding was earmarked to support community investments in 'green' sub-projects. About 50%[6] of the block grant funding disbursed through Green PNPM was allocated specifically to finance MHP schemes. The particular focus on decentralised MHP was based on:

Figure 9 Two penstocks one powerhouse

Two MHPs built side by side in Sungai Keruh, Sumatra Barat; one by RuralPNPM and the other by GreenPNPM.
Source: Masri Vani, EnDev Indonesia (GIZ, 2013)

- Perceived demand by rural communities deprived of electricity and located far from the electricity network
- MHP is dependent on a continued and protected water flow which is best ensured through communities' effective management of surrounding water catchment areas.

The primary differences between Rural PNPM and Green PNPM include:

- Green PNPM promoted MHPs specifically, regardless whether it was a perceived priority by communities. The consequence was that many communities applied for MHP funding, simply because it was easily available.
- Under Rural PNPM, communities determined their own priorities and development needs, while the utilisation of Green PNPM funding for an MHP was often driven by district government persuasion.
- Rural PNPM field technical facilitators, while knowledgeable in other infrastructure development, had little knowledge of MHP construction
- Both programmes were administered by PMD, but under different Directorates. This resulted in less efficient coordination of activities and a duplication of administrative structures.

[6] World Bank Group; MHP Indonesia Cost Effectiveness Analysis Report (Indonesia, September 2012)

- While Rural PNPM will continue for the foreseeable future, Green PNPM was regarded a pilot project only, and was terminated in December 2012. Initiatives are currently underway to incorporate lessons learnt through Green PNPM into Rural PNPM.
- EnDev2 supported only MHPs under Green PNPM.

- **ENDEV1**

EnDev1 started in Indonesia in 2006 (concluded mid-2009) as an extension of the GIZ Mini Hydropower Project (MHPP). It adopted the already developed MHPP approach, and also continued the cooperation with the counterpart, the Directorate General for Electricity and Energy Utilisation (DGEEU) within the MEMR.

The project focussed on building the expertise and management competency of actors engaged in constructing and operating mini-hydropower schemes in rural areas towards a systematic scale-up. It facilitated contacts between service providers and users, transferring the necessary know-how to various actors: operators, political authorities and user groups. Besides this sector development, MHPP directly supported 94 MHPs in rural Indonesia. This support mainly focused on socialization, basic village management training and a minor financial contribution to overall MHP construction costs. In terms of ensuring sustainability, EnDev1's primary strategy was to:

- Support community preparation and participation
- Introduce operation, maintenance and management procedures
- Introduce principles of good business administration, tariff-setting, billing, savings
- Conduct capacity building (manufacturers and suppliers, village management team)
- Promote productive, income-generating end use of electricity

Figure 10 From head to the powerhouse

MHP Kali Babak in Lombok Tengah, Nusa Tenggara Barat supported by EnDev1

Source: Catoer Wibowo, MHPP (GIZ, 2008)

Unlike EnDev2, EnDev1 only had very limited influence on the technical specifications and construction quality of MHP schemes. Also the counterpart DGEEU underwent structural reform (through which DGNREEC was established) toward the end of EnDev1's implementation period, resulting in the loss of an institutional partner to anchor lessons learnt with.

- **OTHER**

Various state and non-state actors with MHP support programmes are lumped under this sub-category. Depending on their institutional configuration, the actors principally applied two different implementation methods:

1. **Project-based**: where a project developer (usually a government agency) assigns a contractor through competitive tender to construct the MHP scheme. The beneficiary community is not involved beyond providing menial labour, seldom adequately consulted during the planning

process and generally not well prepared to operate and maintain the given power generation facility. All MHP sites built by ministries and government agencies in Indonesia adopt this approach, as required by government procurement procedures.

2. **Community-based**: where the community itself contributes significantly in developing the scheme from planning stage until completion of the project. The community often directly controls the procurement of components and undertakes most construction activities. This approach is typically used by civil society organisations.

Figure 11 Penstock buffer made of skinny wood

Simple yet fragile installation of MHP Ansok in Sintang, Kalimantan Barat initiated by the community and supported by CUKK.

Source: Amalia Suryani, EnDev Indonesia (GIZ, 2012)

Case example: Community-based approach

Credit Union Keling Kumang (CUKK) is a civil society organisation based in District Sintang, Kalimantan Barat. The credit union is membership-based and started supporting renewable energy initiatives, specifically MHP installations, in 2007. They are regarded a MHP pioneer in a region with less than 60% electrification rate (NREEC, 2012). To date CUKK has successfully installed 14 MHP schemes across the district. Support by CUKK to its members ranges from technical advice to funding (as co-funder or sole-funder) MHP infrastructure.

MHP development in Indonesia is widely influenced by the presence of various civil society organisations including academia, colleges and NGOs which work mostly in environmental and community development sectors. After government, civil society organisations are a substantial contributor to MHP development in Indonesia. Some organisations have a track record of more than 20 years (for example Yayasan Mandiri and IBEKA).There are almost 200 community-based MHP sites identified in DGNREEC's database.

Finally, also Indonesia's national electricity utility Perusahaan Listrik Negara (PLN) has supported the construction of MHPs under its rural electrification programme until the 1990s. In DGNREEC's database, about 60 MHPs were constructed during the period of 1950s to 1990s under PLN. The oldest recorded site (in JawaTimur) was built in 1927 (before independence) but it is no longer operational.

3.3 Preparatory Situational Analysis

In preparing for ComStu, MHP data was acquired from several sources. The objective was to a) determine the population (and resulting sample size) relevant to ComStu and b) to undertake a situational analysis to identify possible sustainability risks that might be present on a national level.

In 2011, EnDev2 commissioned the compilation of the publication "Best Practice Guidelines for Off-Grid MHP for Rural Electrification". This document was the basis for comparison during the situational analysis preceding ComStu. There are six major elements to implementing off-grid MHP schemes that affect its eventual sustainability and these are briefly described in the table below:

Table 1 Best practice elements for sustainable MHP development

Element	Description
Enabling Environment	A combination of activities and/or pre-conditions that are not directly linked to an individual MHP rural electrification investment programme, but are setting the framework for and making such programmes feasible. This may include incentive schemes, transparent development planning, capacity building measures, data availability, and procedural and legal frameworks.
Community Preparation	Activities and interventions that prepare the rural beneficiary community for MHP ownership and for proper utilisation and management of an MHP scheme. This would include involvement in early decision-making and mechanisms to require, to enforce and/or encourage community participation in the entire MHP process.
Technical Project Development	The sum of activities that characterise the development of a rural electrification scheme, from identification and pre-feasibility to tendering and contracting the main contractor. This includes all pre-construction activities, the basis of which will determine the detailed technical parameters for the MHP scheme.
Scheme Implementation	The physical work and other activities, from mobilisation on the ground (stake out) to commissioning of the plant and formal hand-over of the plant from the main contractor to the plant owner. Invariable, this also includes adaptation to original plans and often results in differences between the planned and actual MHP scheme in terms of costing and performance.
Management, Operation and Maintenance	Post-construction activities that aim to manage the scheme to produce sustained benefits to the rural community and opens up opportunities for generating income and improving the economics of the scheme. Capacity building initiatives and establishing village regulations are important activities here.
Monitoring and Evaluation	Various activities that measure and monitor the performance and impact of the MHP scheme, in technical, physical, financial, environmental and socio-economic terms. It combines the monitoring carried out by government authorities at national and local level, with the monitoring at the village level carried out by the MHP plant owners and operators. This requires a combination of technical metering/monitoring equipment, data capturing, reporting and feed-back mechanisms (log books, etc.), and village management diligence.

In preparation for the situational analysis, causality relationships, depicted in the form of an Ishikawa diagram (Figure 12), were developed. Using the best practice guidelines, the diagram depicts cause and effect that could mar MHP sustainability on a national level.

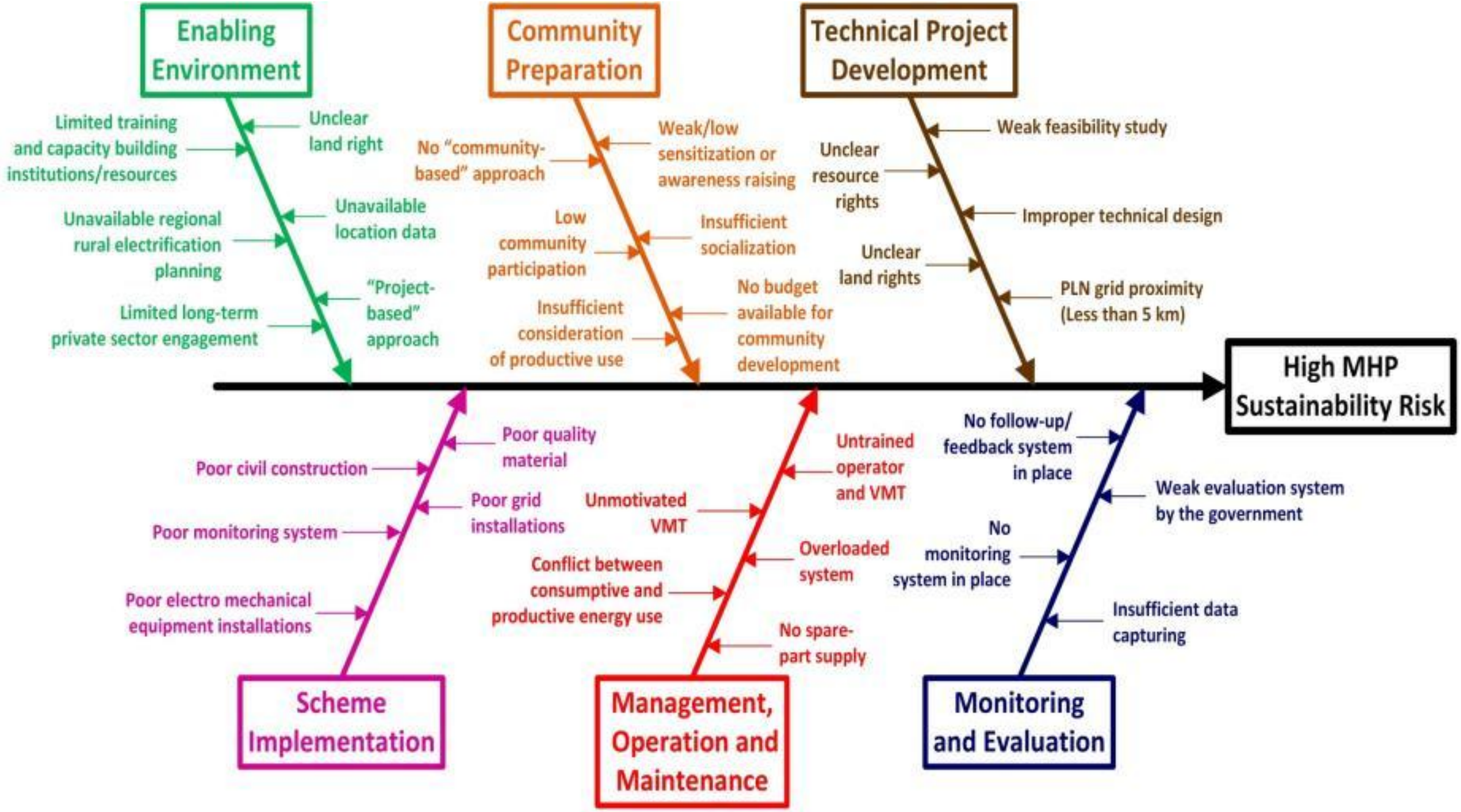

Figure 12 Fishbone diagram on "MHP Sustainability Risks" for Indonesia

3.3.1 Analysis on Data Availability

Data availability relates to both the **Enabling Environment** and **Monitoring and Evaluation**. The assumption is that a planning and implementation authority should maintain a minimum of accurate data in order to ensure transparent and efficient planning and monitor progress and the achievement of the national development agenda. Data availability also relates to **Technical Project Development** vis-à-vis proximity to the national (PLN) grid.

The situational analysis took a broad perspective involving a range of centrally available data, statistics, literature, official and non-official statements, and observations. The analysis was conducted through desktop study where existing available materials were reviewed. It rearranged[7] the existing data and analysed these from different perspectives. Very early in the process substantial data gaps were identified, limiting the depth of the analysis, but nonetheless providing insights into sustainability risks. Data that could be obtained and the consequent MHP support schemes reviewed are listed in the table below:

Table 2 Data source of MHP schemes in the study

Support scheme	Remarks	Data source
EnDev1	These are the sites that received support from GIZ during 2006 - 2009	• EnDev1 database: comprising sites supported by EnDev1
EnDev2	These are GreenPNPM sites that received extensive technical support from GIZ during 2009 - 2012	• EnDev2 database: comprising sites supported by EnDev2 under Green PNPM funding scheme commissioned from 2010 until May 2013
Rural PNPM	MHP construction of all PNPM scheme is funded by national and multi-donor trust funds, administered by Rural PNPM	• Rural PNPM database: comprising sites built under Rural PNPM scheme • EnDev2 archive on refurbishment sites and support initiative for (several) Rural PNPM sites in South Sulawesi
Others	All sites do not belong in previous categories.	• DGNREEC database: comprising Indonesian MHPs built since 1927-2010 (last updated in 2010) • KPDT archive on the sites built by KPDT within 2006-2009 budget years • DGNREEC archive on DME sites in 2010 and 2011 • CUKK archive on sites supported by the credit union in 2007-2010

Data collection of MHP installations on record was a challenging process. This information is critical to present better overview on MHP current situation. Such data was not well collected and the accuracy is questionable. In many cases, MHP sites are identified but the inventories do not even provide basic essential information such as precise location, installed capacity (kW), and number of beneficiaries

[7] The assessment includes data consolidation to avoid overlapping among databases. While all care was taken, categorisation may still contain double entries due to limited detail information in some databases.

(connections). The graph below indicates the sum of MHP installed in Indonesia based on the collected data from reviewing available databases.

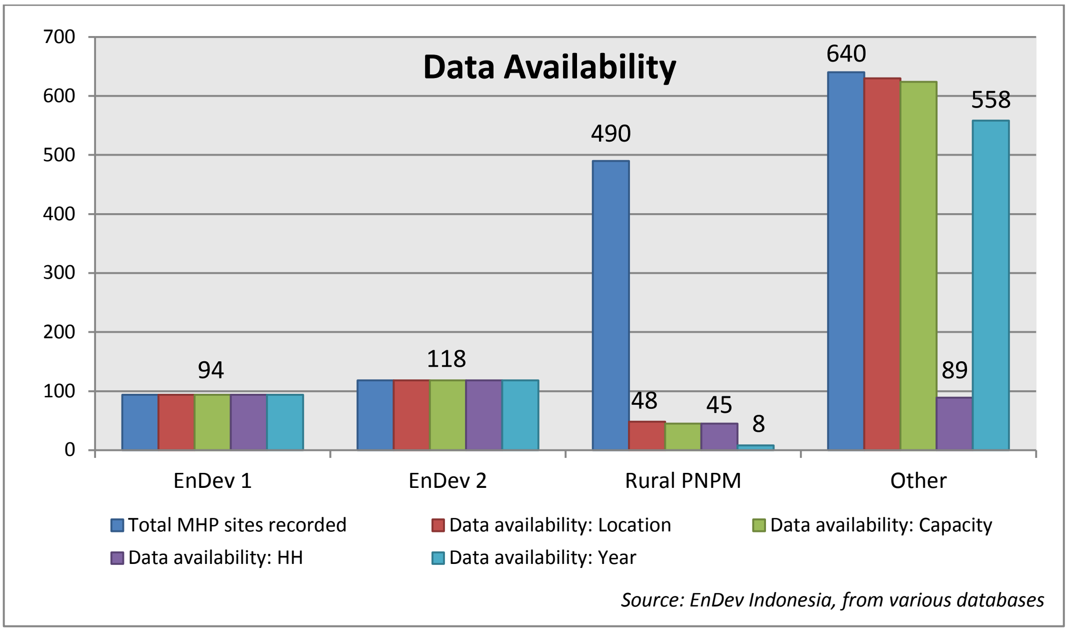

Figure 13 MHP schemes data availability

In the case of Rural PNPM for instance, 490 sites (across Indonesia) are recorded between 2006 to 2009 budget years, although the data quality is very poor. The Rural PNPM database only notes location information up to sub-district level (kecamatan) and not even the village name. This database does not record any information on capacity nor households either. EnDev2 could identify more detailed information for 48 sites out of 490 sites through its field facilitators in Sulawesi.

Within Other, all MHP installations not included in the previous categories are collected. This includes the sites built by ministries (other than MOHA and MEMR), local government, NGOs, credit union, colleges, and community. The location data is partially identified and very little data (negligible) on number of households is present. In the DGNREEC database, most data are not completed with number of beneficiaries. Other than that, the inventory is not updated due to the absence of monitoring system. For sustainability reason, these types of information are very important so that the government could monitor better thus could perform better electrification planning.

3.3.2 Analysis of Installation year

Installation year relates to **Management, Operation and Maintenance** in addition to the data availability issue raised above. Without an understanding of the age of the system, no maintenance, refurbishment and/or component replacement decision can be made.

The graph below shows that MHP development (on record) has significantly increased after 2001. In fact, 93% of these sites were built between 2006 and 2012 (however, considering the poor availability of pre-2001 data, this could imply that MHP databases were marginally better maintained since 2001).

While it can be argued that maintaining reliable data on MHP schemes older than 20 years might not be feasible, this argument does not hold for sites younger than 10 years, vis-à-vis their potential sustainability risks. While, for instance, Rural PNPM has 490 sites recorded since 2008 to 2012, data on the exact year (let alone month) of installation/commissioning could not be obtained (beyond the 48 sites which were informally assessed by EnDev field facilitators in Sulawesi). For a significant number of sites, no installation date is available at all.

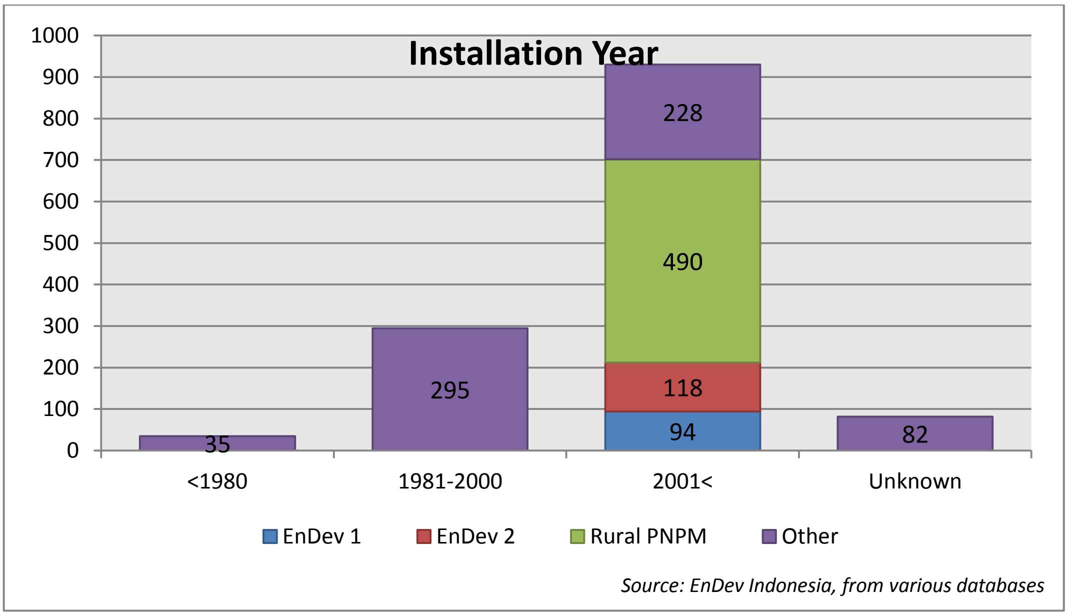

Figure 14 MHP installation year

3.3.3 Analysis on Funding Mechanism

Various source of funding in Indonesia suggest that rural electrification through utilisation of micro hydro power is not only the government's concern, although the government plays the biggest role in providing people with access to electricity.

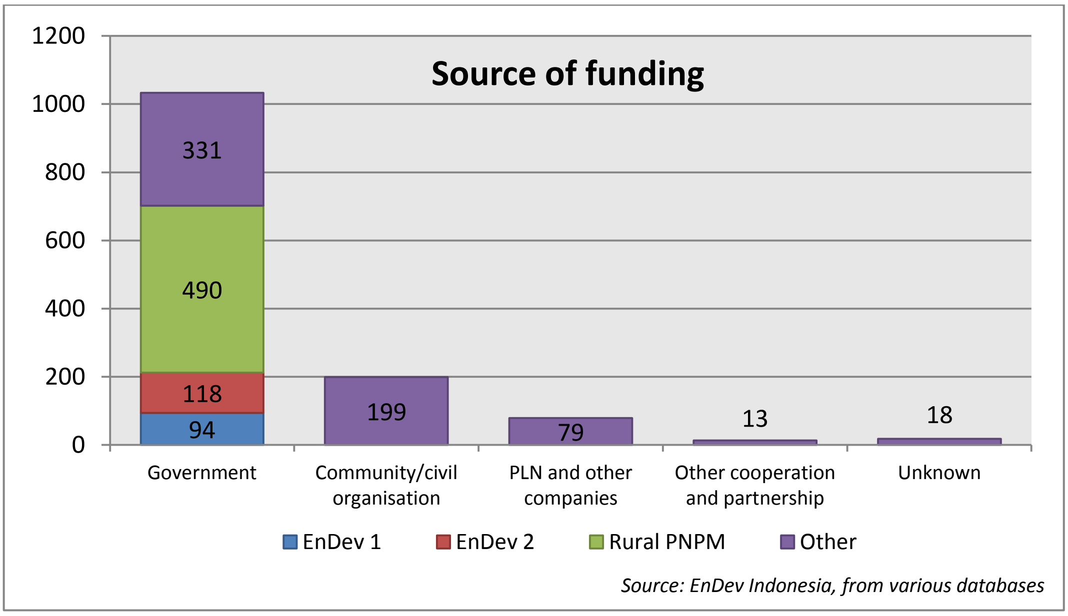

Figure 15 Source of funding categories

Figure 15 Source of funding categories shows that other than government, community or civil organisations have been contributing in MHP development until now. These organisations work using the community-based approach where community participation is somewhat high compared to the project-based approach, which is typically applied for government MHP development project.

3.3.4 Analysis of Operational Status

The operational status of an MHP is directly related to its sustainability. From over an estimated thousand MHP sites installed throughout the country, it is a challenge to monitor the operational status for each site. Nonetheless, a periodic review would be most useful in terms of assessing whether electricity is indeed provided to a community. Of course such a review is only possible if basic site data is available to begin with.

The graph in Figure 16 Operational status of the MHP recorded shows that for more than 80% of the recorded sites it is not known whether they are operational or not. This shows a weak monitoring scheme, which could lead to poor planning for future MHP programmes. While the operational status of most EnDev2 sites is also unknown, contact information of the VMT is available and follow-ups can be conducted as the need arises.

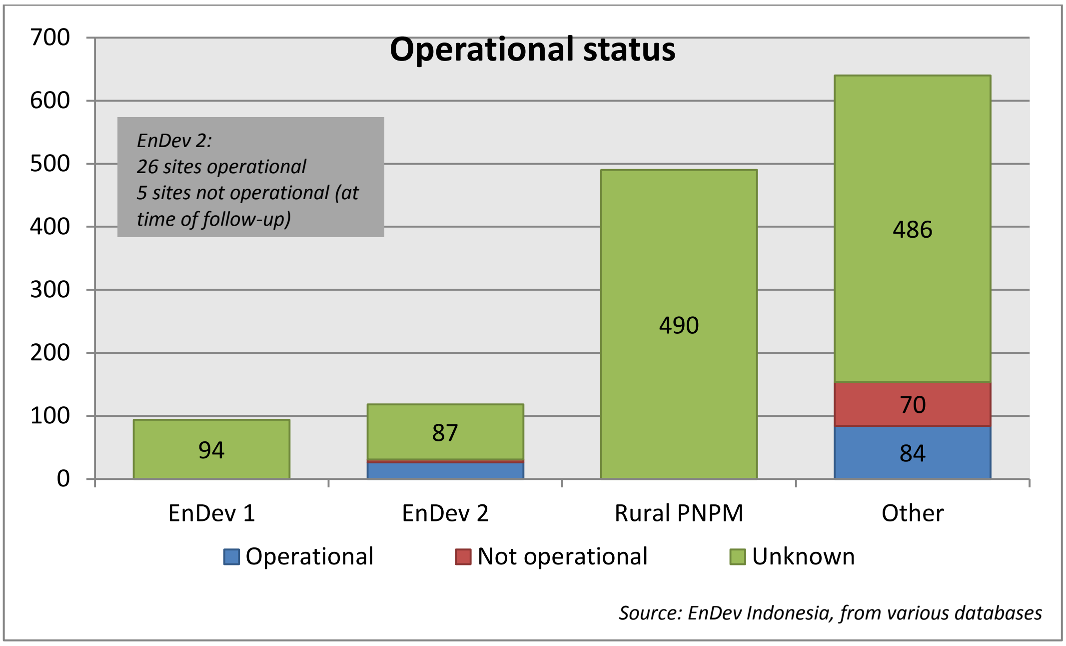

Figure 16 Operational status of the MHP recorded

3.3.5 General Remarks

While the situational analysis could not provide insight into the sustainability of MHPs in Indonesia, per se, the “lack of insight” is already indicative of sustainability risks. Only knowing that an MHP site was installed (as per available records) is not sufficient, particularly if there is no information on its exact location, year of commissioning, number of beneficiaries or installed capacity. Only EnDev2 and EnDev1 MHP sites provide consistent data.

The lack of data does not imply that no data exist, but simply that it is not adequately consolidated into comprehensive databases. Scattered data makes assessments very time consuming and frustrating, particularly where inconsistencies undermine reliability. Only EnDev2 maintains a comprehensive database, and also has follow-up survey methodologies in place.

Insufficient data greatly undermines MHP sustainability by exposing the MHP system to PLN grid encroachment, providing only a poor understanding of whether rural electrification targets are reached, leading to logistical uncertainties about a site’s location or having no information about its technical performance nor age.

Community preparation is a key sustainability criterion, since in most cases the community is tasked with management of the MHP. Apart from EnDev2, no information is available regarding adequate training of the community, facilitation of necessary management structures, information materials and management tools provided or any contact details of the individuals involved.

With no commissioning date recorded for many MHP sites, no assessment of its technical performance can be made, nor can preventative maintenance be encouraged. The DGNREEC database for instance provides this information particularly since the MHPs are installed by contractors (selected through a tender process), but Rural PNPM, where funding is provided directly to the community does not record this data. This implies that under Rural PNPM no adequate post-commissioning follow-up or verification is done.

While it is encouraging that several different funding schemes are available to support MHP development in Indonesia, there is a lack of coordination between the different initiatives, at least in terms of providing key data to a central agency (such as DGNREEC). Even other government ministries maintain their own records, without automatically submitting same to DGNREEC.

A periodic review of the operational status of MHPs is advisable. Apart from EnDev2 though, none of the databases maintained any contact details of the MHP management team. This implies that the closest source of information would only be the District Authority, via the Provincial Authority, which involves a cumbersome process of query and follow-up. Note that, even for some sites that were recorded as “operational”, this data is not up-to-date and without site contacts data no follow-up can easily be conducted.

4 Methodology

The ComStu methodology outlines the study approach towards providing an objective comparison among different MHP support schemes, concerning the site selection and aspects in the KPI that will be analysed vis-à-vis the research questions (see Chapter 2). The different aspects of the methodology are briefly described below:

4.1 Defining Target Population

Through the situational analysis available data regarding different MHP support schemes were collected and analysed and sample criteria defined in order to reduce possible bias:

1. **Budget year**. The MHP's commissioning date was defined, since MHPs of extended age might perform less well than newer sites (particularly since EnDev2 sites were mostly commissioned from 2009 onwards). Since however for many sites only the budget year was known, it was decided to only consider MHPs for the 2005/6 budget year (assuming that the earliest MHPS were thus commissioned in 2006/7.
2. **Commissioned**. The MHPs under comparison must be assumed commissioned, i.e. not be in the process of construction and/or extensive refurbishment.
3. **Location**. The MHPs must be located in four districts (Mamasa, Tana Toraja, Toraja Utara and Luwu Utara) within the provinces of Sulawesi Barat and Sulawesi Selatan. This reduces possible cultural, socio-economic and demographic differences inherent to Indonesia's significant cultural diversity across the archipelago. Also EnDev2 sites were restricted to Sulawesi and Sumatera during the Green PNPM pilot phase.
4. **Availability of site information**. The MHPs exact village location should be known as means to avoid unnecessary logistical expenses and time delays in search of sites.

The table below shows the influence of the criteria on the sample size:

Table 3 Filtered ComStu sample size

	EnDev1	EnDev2	RuralPNPM	Other
Initial population	94	61	201	82
After filtered by the criteria	41	43	42	36

4.2 Sampling Methodology

Statistical reliability of ComStu was ensured through random sampling combined with proportional-to-size sampling (PSS). Thus each MHP support scheme is equally depicted in compliance with the defined proportion for each population.

Sample size after applying the PSS method is presented in the table below. Total sample size is 32 sites, which EnDev2 and Rural PNPM shares the same sample size. After the sample size is ascertained, the sites were randomly picked from the database.

Table 4 Final ComStu sample size

EnDev1	EnDev2	Rural PNPM	Others
8	9	8	7

While bigger sample sizes allow for more accurate assessments, the remoteness of the MHP locations required the use of a smaller sample size. As an overview, most areas require 4WD cars and some others can only be reached with two to three days one-way trip by dirt trail. This logistical and time constraint needed to be considered. Even with such a smaller sample size, the survey required more than 30 field days, with two parallel survey teams.

4.3 Execution

Two survey teams conducted surveys at 32 sites within 30-day period. Each team comprised one EnDev2 staff and one local field facilitator. First initial surveys were conducted jointly by the teams, supported by an experienced EnDev2 surveyor, in order to establish a common understanding regarding the survey questions and their possible interpretations. This was necessary to minimise bias on perception among the surveyors. The figure below highlights the general execution procedure:

Figure 17 General steps to KPI survey

The geographic distribution of the surveyed MHP sites and their respective MHP support schemes are indicated in the map below.

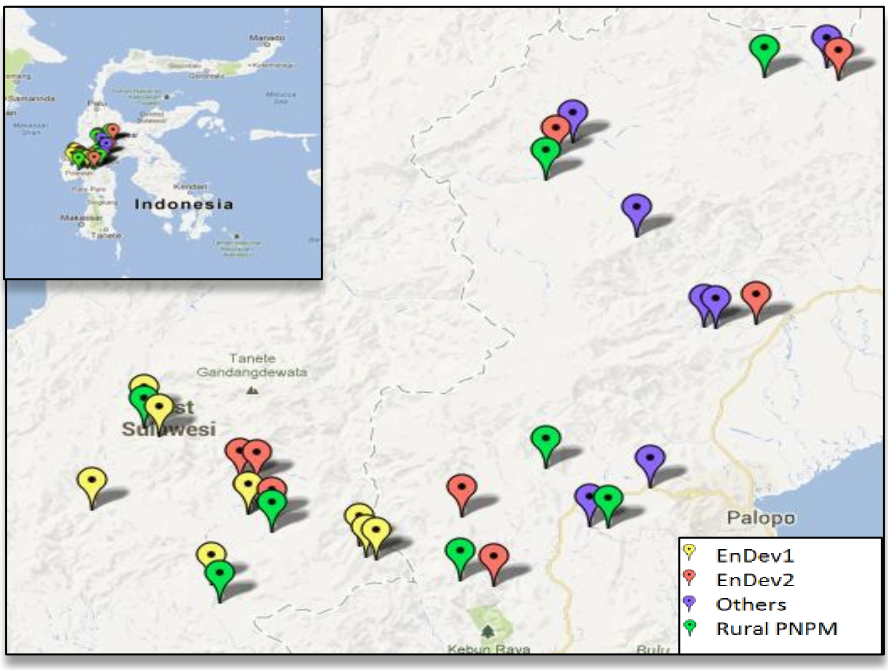

Figure 18 Site locations for ComStu survey in Sulawesi, Indonesia

4.4 Data Evaluation

Data evaluation comprised a number of steps below.

1. **Data pre-processing**

Pre-processing the raw data from the survey identified and clarified or removed data errors or inconsistencies. Usable data might require synchronisation between what was written and the notes or pictures taken. While unusable data was considered for data which are unavailable and inconclusive. This screening method caused variety in sample numbers (N) for different subsequent analyses.

2. **Calibrating the findings**

Qualitative assessment is usually affected by the authors' and surveyors' bias, therefore, calibrating the findings between the two teams aimed at minimising such bias. Calibration was conducted by joint review by comparing the assessment made and adjustment to the agreed standards where required.

3. **Problem identification**

Causal relationships were identified using Ishikawa (fishbone) diagram (see Figure 17), with the four indicators of sustainability relating to the research questions.

4. **Modelling sustainability**

Creating a new model for this study was needed due to an absence of suitable sustainability assessments for MHPs in the literature. Other sustainability matrixes were considered (such as the EnDev Sustainability Matrix), but did not prove applicable to Indonesian context. In the KPI methodology, shifting from qualitative to quantitative assessment was necessary to compare the performance among different sites. For this purpose a scoring system for sustainability indicators was designed, ranging from +1 (positive) to – 1 (negative), with reference values determining a 0 score, as shown in the table.

Table 5 Scoring reference

INDICATOR	REFERENCE VALUE	SOURCE
Community satisfaction	Mostly satisfied/satisfied	KPI Survey
Civil construction	On average	KPI Survey
Electro-mechanical equipment	On average	KPI Survey
Repairing time	7 - 14 days	Experience
Water competitive use	"no reference value; either Yes or No"	KPI Survey
Extreme weather conditions	Less than 5 flash-floods and landslides per year	KPI Survey
Community involvement	On average	Experience
VMT organisation	On average	KPI Survey
Financial administration	50 - 150 thousand IDR per month	Experience
Distance to the grid	10 - 20 km	KPI Survey

The scoring results (to one decimal point) is reflected in graphs generated through the ComStu analysis as presented in Chapter 6.

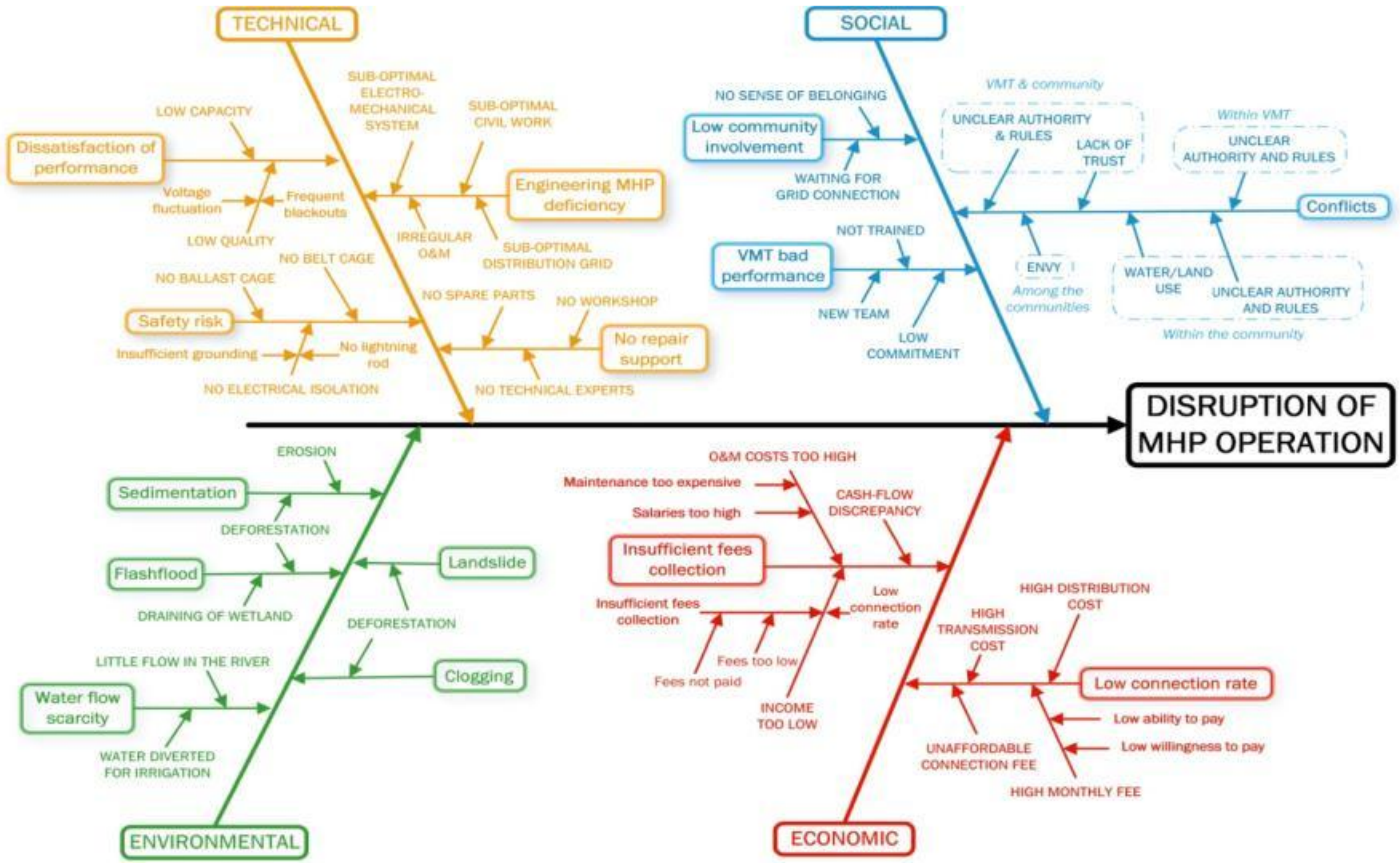

Figure 19 Fishbone diagram on "Disruption of MHP Operation"

4.5 Challenges and Limitations

A number of challenges and limitations were encountered during the survey process.

1. **Sampling to population generalisation**

To be able to deduce the survey results into general conclusions, a bigger sample size is preferred. For ComStu, **Hyper geometric distribution** was thus selected as the best sampling methodology for two reasons, they are 1) small size population and 2) its characteristic of non-replacement (one site cannot be picked from the population more than once). Compared to normal distribution, the hyper geometric is considered better representing the confidence interval for small population. In addition a **naturalistic generalisation** is a process was chosen as it permits the study to be considered as representative of the overall populations. It also allowed for the consideration of previous experiences by EnDev2, which were captured in previous KPI surveys.

2. **Operational status**

As a consequence to random sampling approach, some selected MHP sites were found not operating either for a quite long time or a very short time before the team visit.

Table 6 Reasons for non-operational sites

Reasons for non-operational sites					
	Technical	**Social**	**Environmental**	**Economic**	**Total**
Number of sites	4	2	2	1	9

Nonetheless, observations were still continued for these non-operating sites to investigate the case. The cases of “non-operation are included as **Annex A**).

3. **Inconsistencies with previous information**

A survey selection criterion was to consider only MHPs built from budget year 2005/6. There were three sites, which are actually older than what was recorded. Within some limitations, these sites were nonetheless included in the analysis. From the ComStu analysis, it also appeared that there is no correlation of the age of an MHP and its sustainability. This can be observed from the instances of “non-operating” MHPs as listed in **Annex A**.

4. **Participation reluctance by the communities**

There are several sensitive questions to be answered by the community especially those which are related to financial condition either of the MHP management or the household average income. For the latter question, it was advisable to ask the respondents in private, away from other villagers. Thus the respondent’s possibly subjective assessment needed to be considered for further analysis.

5. **KPI survey methodology**

Extensive questions in the KPI questionnaire (spread into 18 pages) are challenging for the surveyors to keep the respondents focused in answering the questions. Thus it needs the surveyors’ ability to observe through casual discussion rather than direct interview. Such casual discussions cannot always be easily incorporated into consistent data analysis.

6. **The importance of contacting the local community before the visit**

In a few sites with no GSM coverage, the local facilitators could not contact the villagers in advance to inform of the upcoming visit. Consequently, the communities were not prepared and the VMT was not fully available which caused delay.

5 Findings

The overall objective of ComStu was to assess the hypothesis that "*the EnDev2 concept improves the sustainability of off-grid MHP systems compared to other off-grid MHP support schemes in defined project areas of Indonesia*". ComStu was conducted as an investigation and comparison into the social, economic, environmental and technical sustainability of the MHP systems falling into and outside the EnDev2 support scheme for selected areas in Sulawesi Selatan and Sulawesi Barat.

To test the hypothesis, a research question was formulated: "*Does the EnDev2 concept improve the sustainability of the MHPs compared to other off-grid MHP schemes in Sulawesi?"* This central question comprised four sustainability factors, namely:

1. Technical sustainability
2. Social sustainability
3. Economic sustainability
4. Environmental sustainability

This chapter provides a synopsis of information extracted from the comprehensive master thesis report by A Ranzanici.

5.1 Scoring Comparison

Each site was assessed with a sustainability model as explained in Chapter 5. Within the range of **-1** to **+1**, final scores of sustainability are generated. The sustainability scores are ranked which placed three EnDev2 scheme sites at the top three best sites, within the range of **+0.55** to **+0.60**.

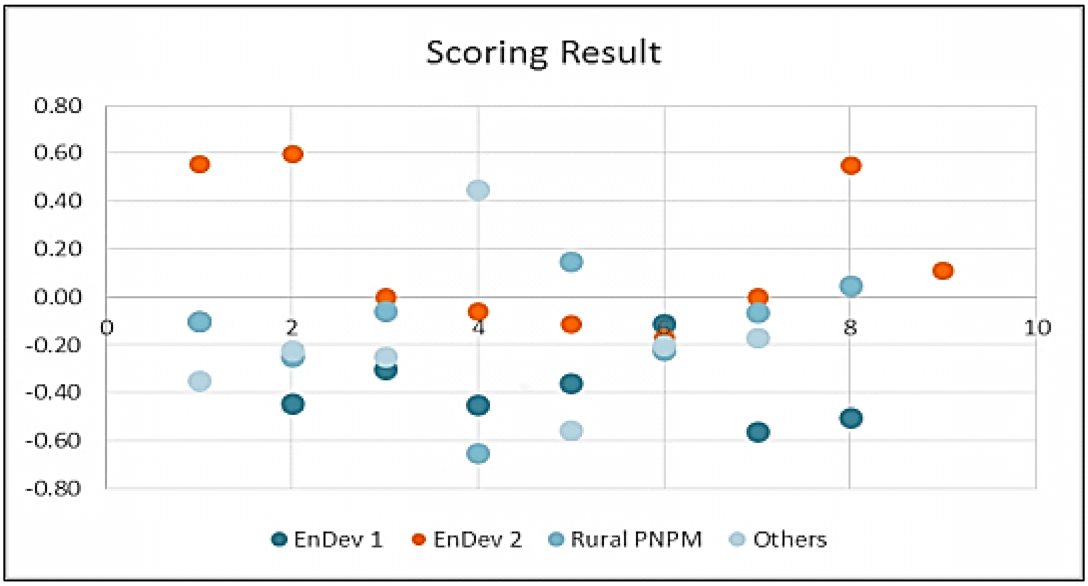

Figure 20 Scoring results between EnDev2 and non-Endev

On the other end of ranking scale, three worse performing sites are equally distributed between Rural PNPM, EnDev 1, and Others within the range of **-0.56** to **-0.65**. The average sustainability score of the surveyed sites is **-0.12**, and all EnDev2 sites, except one site (at -0.17; non-operational due to PLN grid encroachment) scored above average.

5.2 Development Phase Effectiveness Comparison

Sustainable MHPs for rural electrification in Indonesia comprise interventions from design and construction to community training and operation support. The below analysis considers the effectiveness of the different MHP support schemes across their respective sites. EnDev2 sites score highest for both the Design&Build (DB) phase and the Train&Operate (TO) phase.

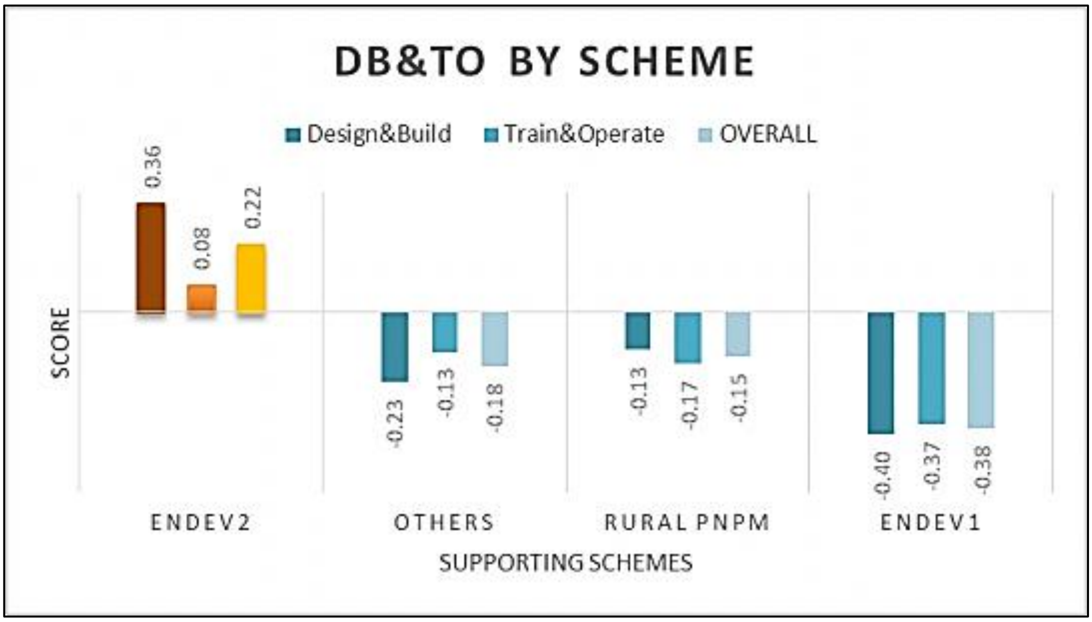

Figure 21 Development Phase effectiveness between EnDev2 and non-EnDev

The results show that EnDev2's substantial technical design and construction supervision support at grassroots level had the desired impact of enhancing sustainability. While the TO score appears rather low, EnDev2 is the only support scheme with a dedicated and comprehensive Village Management Team training approach. The "low" score can be ascribed to the high dependence on individual initiative and commitments of VMT members, which cannot be readily trained.

5.3 Community Training Effectiveness Comparison

The Training&Operate (TO) aspect highlighted above encompasses several different aspects, which merit further detailed review. TO effectiveness was gauged by analysing the extent of "community satisfaction", the diligence in "financial administration" and the MHP "repairing time" in the event of technical failures. The comparison between the different MHP supporting schemes is presented in the figure below. Apart from "community satisfaction", EnDev2 out-performs non-EnDev2 by significant margins. The table provides more perspective on the reasons behind the respective results.

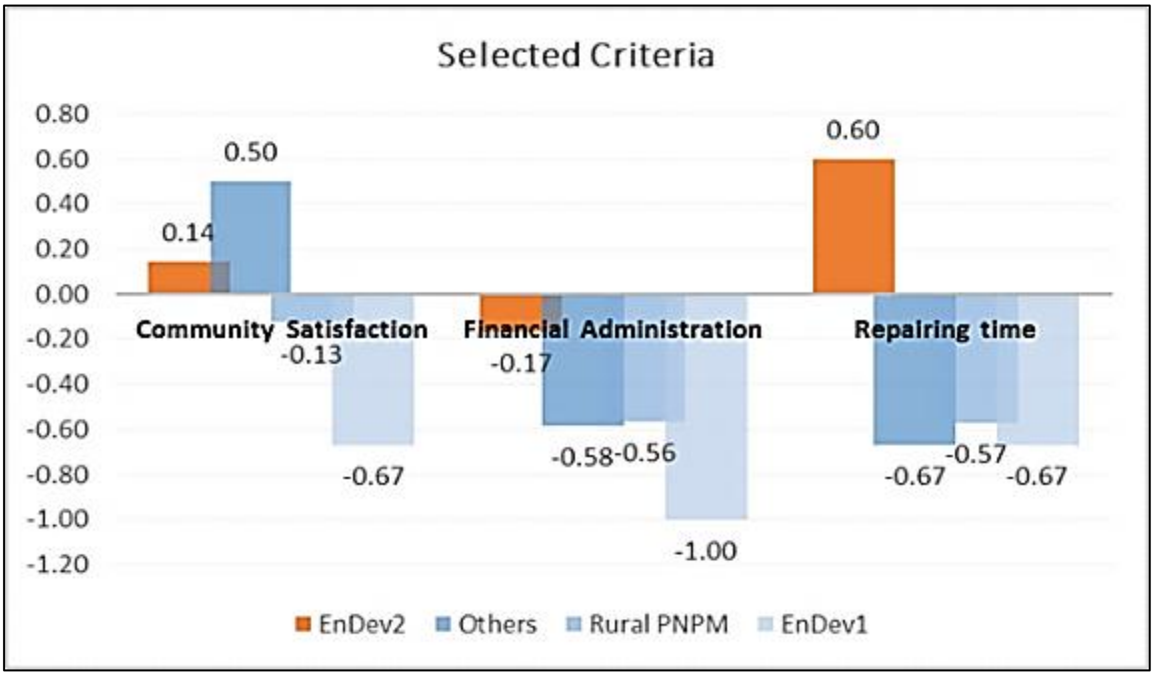

Figure 22 Community Training effectiveness between EnDev2 and non-EnDev

Table 7 Reasons for TO scoring results

Indicators	Best performance	Findings
Community involvement	**Category Others**	Sites built by community initiatives (2 sites) and provincial or district governments (3 sites). These proven contributed to higher degree of involvement and ownership from local actors. Local actors had more understandings of their needs, and had identified electricity supply as a priority.
Financial administration	**Category EnDev2** Monthly saving of IDR 315,000 compared to less than IDR 35,000 for other schemes	The indicator shows the extent of financial record-keeping and savings in order to ensure long-term operations and handling breakages and irregular maintenance. Average EnDev2 sites can save IDR 315,000 per month, while Non-EnDev2 sites could only save less than IDR 35,000 per month.
Repairing time	**Category EnDev2** 5 days to handle technical problem, compare to a range of 25 to 62 days for other schemes	There was difference on the community capacity to handle technical problems, which was measured by how long it was required to do it. To compare the time, the study decided to use 7-14 days as acceptable time for repairs. EnDev2 had the shortest repair time of 5 days, compared to the category “Others” of 62 days to get the system back in operation. Average repairing time of 62 days was mainly caused by lack of training or technical support for these sites in the Development Phase (Design & Build).

5.4 Operating Status Comparison

A number of MHP sites surveyed were not operating during the time of survey. While for some sites this was only a temporary condition, others were permanently abandoned. In the case of EnDev2, two sites were found to be non-operational because a) the village received PLN grid extension and the MHP was abandoned and b) the system was damaged by a landslide and is undergoing repairs.

By comparison, Rural PNPM sites reported only one instance of non-operation due to technical faults on the civil construction as a result of poor workmanship. EnDev2 put much emphasis on high technical quality and thus their sites are far less prone to technical damage.

.

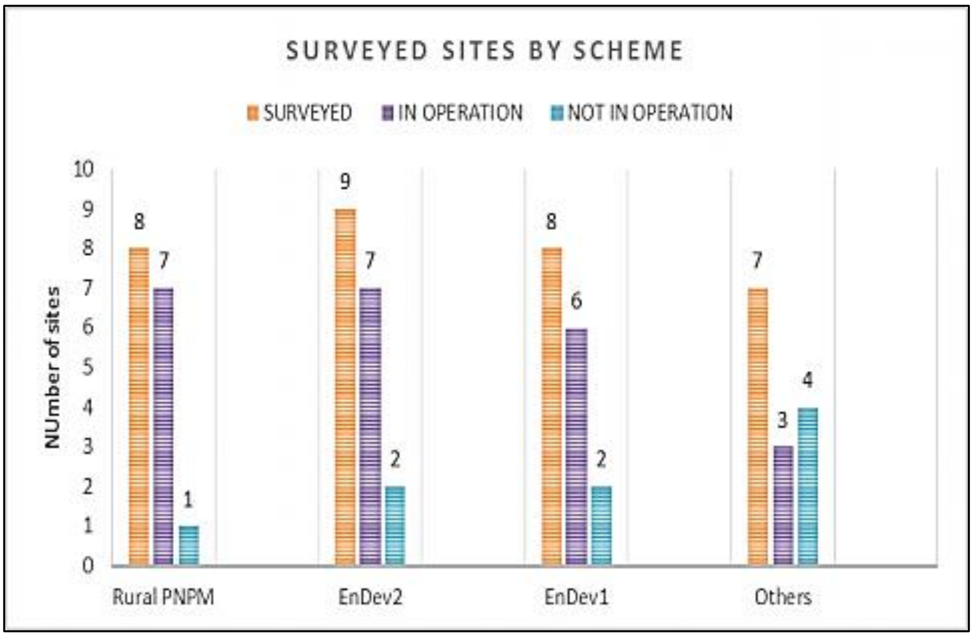

Figure 23 Operating status comparison between EnDev2 and non-Endev

ComStu also considers whether there is a correlation between non-operation and MHP age. The rationale being, that older sites might be more prone to technical failures as a result of wear and tear. As can be observed from the figure below, there appears to be no evidence of this however, within the surveyed sample. Non-operation can occur at any time regardless of MHP age, indicating that older sites are still able to compete with newer sites in terms of performance.

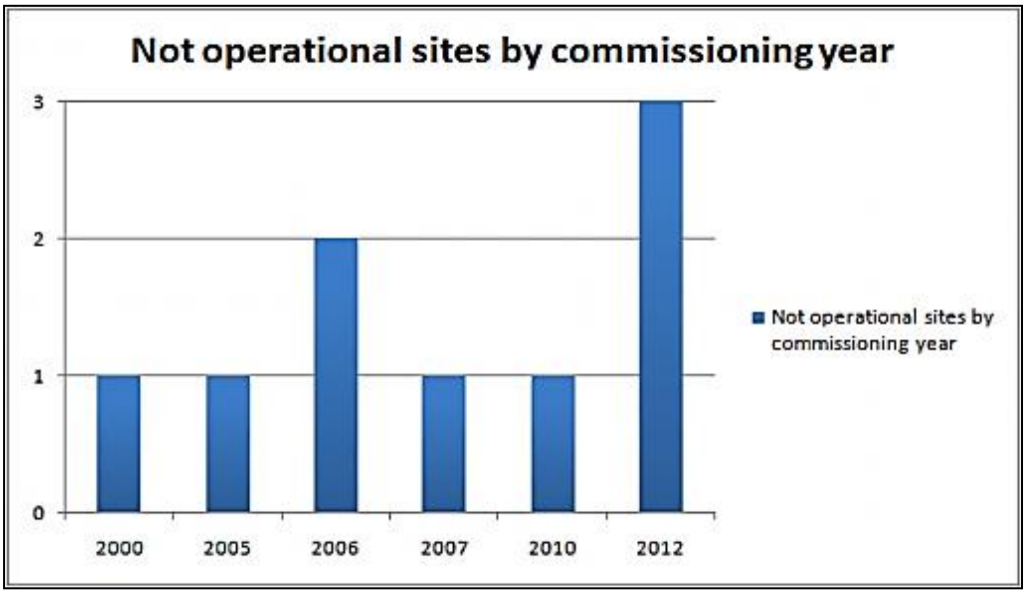

Figure 24 Non-operational MHP sites by commissioning year

However, this does not imply that newer MHP installations are not overall more sustainable! This is further discussed in section 6.7 in this chapter.

5.5 Sustainability Comparison

ComStu comprised an assessment of the four sustainability factors technical, social, economic and environment. The graph below compares the performance of each of the MHP support schemes, based on these four factors. Comparison is conducted by using radar diagram in which each pillar is represented in each of four corners and each scheme is represented by different line colours. Lines that reach the farthest on every corner indicate highest values. EnDev2 out-performs non-EnDev2 sites significantly in terms of technical sustainability, while also being the top performer (albeit together with Others) for social and economic sustainability. While EnDev2 appears to perform more weakly on environmental sustainability than Rural PNPM, this is because the EnDev2 sites surveyed were subject to environmental "failures" (i.e. landslides) by pure chance and beyond the control of the project's intervention.

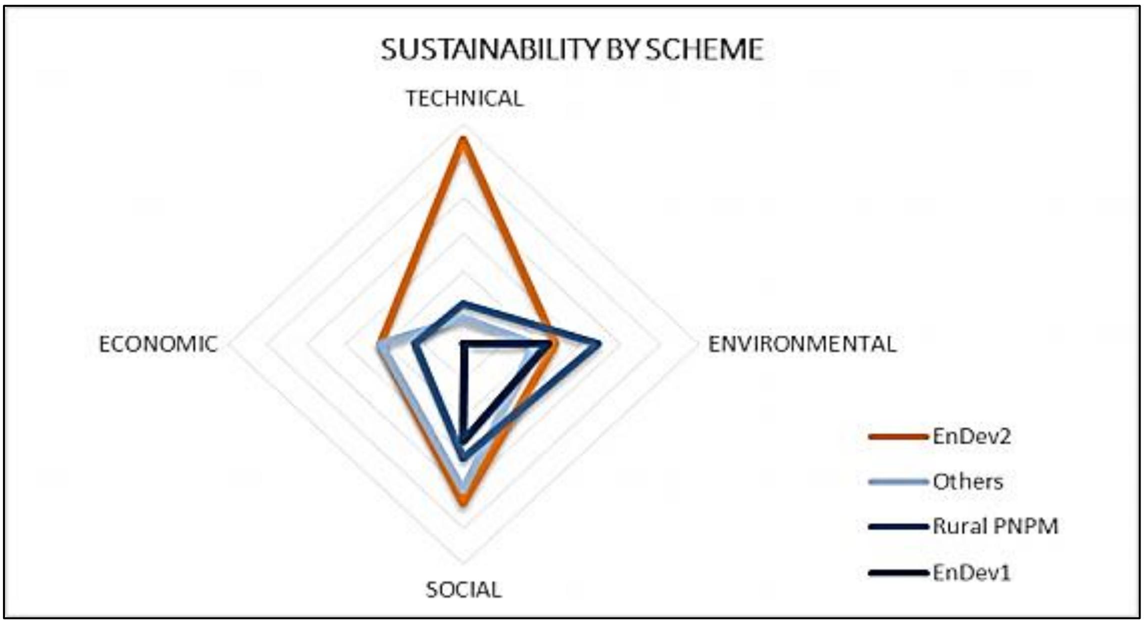

Figure 25 Radar diagram based on four sustainability factors

The table below provides further insights into the sustainability performance of the different MHP support schemes:

Table 8 Reasons for sustainability scoring

Sustainability factor	Best performance	Finding
Technical	EnDev2	Better quality in design and development supervision combined with extensive training on MHP maintenance and management led to better performance of EnDev2.
Environmental	Rural PNPM	This sustainability aspect was mostly affected by uncontrollable causes. Those are extreme weather condition which affected floods and landslides, and also competitive water use.
Social	EnDev2 and Others	Considering the score of all variables considered under the social aspect, EnDev2 performed best on VMT performance while the 'Others' had a higher degree of community involvement and Ownership, particularly for the community-based sites.
Economic	EnDev2	EnDec2 sites were able to collect and record revenue and make monthly savings to address future maintenance costs and repairs.

		This ability was mostly neglected at non-EnDev2 sites, which left these sites highly dependent on external donors or debt repayment.

5.6 Sustainability vs Time Comparison

Scoring of sustainability indicators are time-dependent. As can be seen from the graph below, there is a clear upward trend for technical sustainability with less pronounced upward trends for economic and social sustainability.

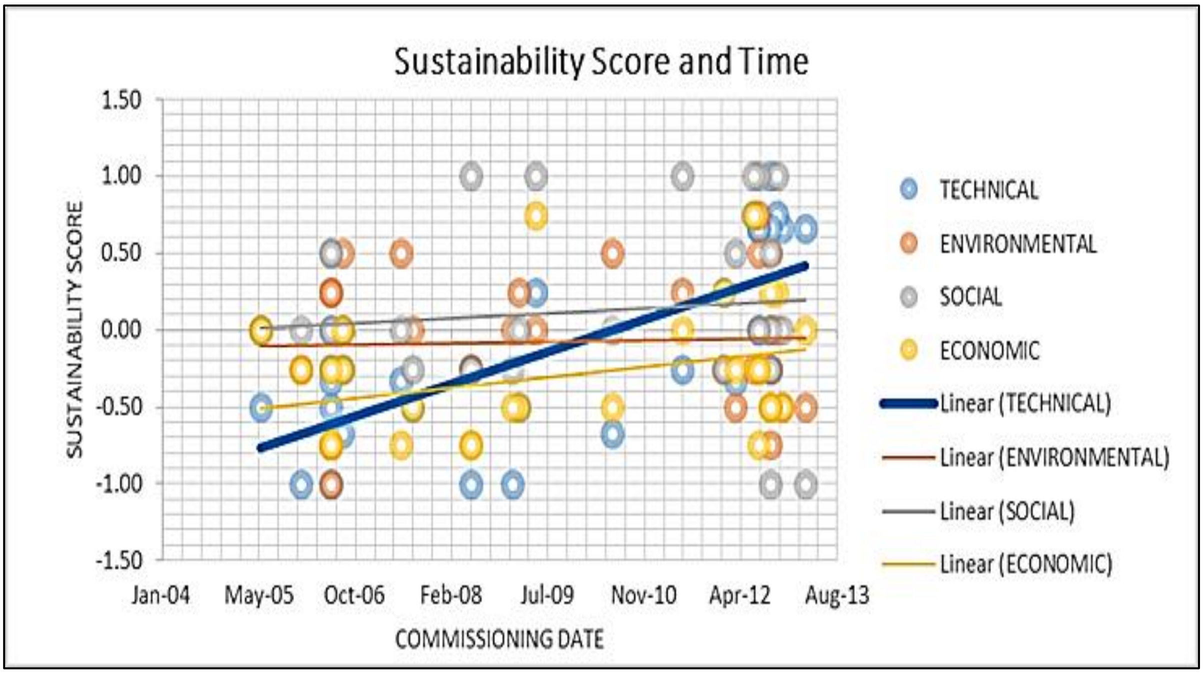

Figure 26 Relation between sustainability score and time

While these trend lines are influenced by high EnDev2 scores, there is an overall improvement of MHP sustainability in Indonesia (as can be seen from the follow-up graph that excludes the EnDev2 score). Rural PNPM sites for instance benefitted from EnDev2 field facilitators (where Rural PNPM field facilitators interacted with EnDev2 facilitators), while technical specifications for new MHP systems, regardless of MHP supporting scheme, mostly reflect latest technological improvements. Both EnDev 1 and EnDev2 for instance conducted training on quality aspects and improved manufacturing for Indonesian turbine suppliers and this had positive spin-off for other support schemes. Same applies to VMT training materials compiled under EnDev1 and further elaborated and refined under EnDev2, which are now generally accessible and have been widely distributed.

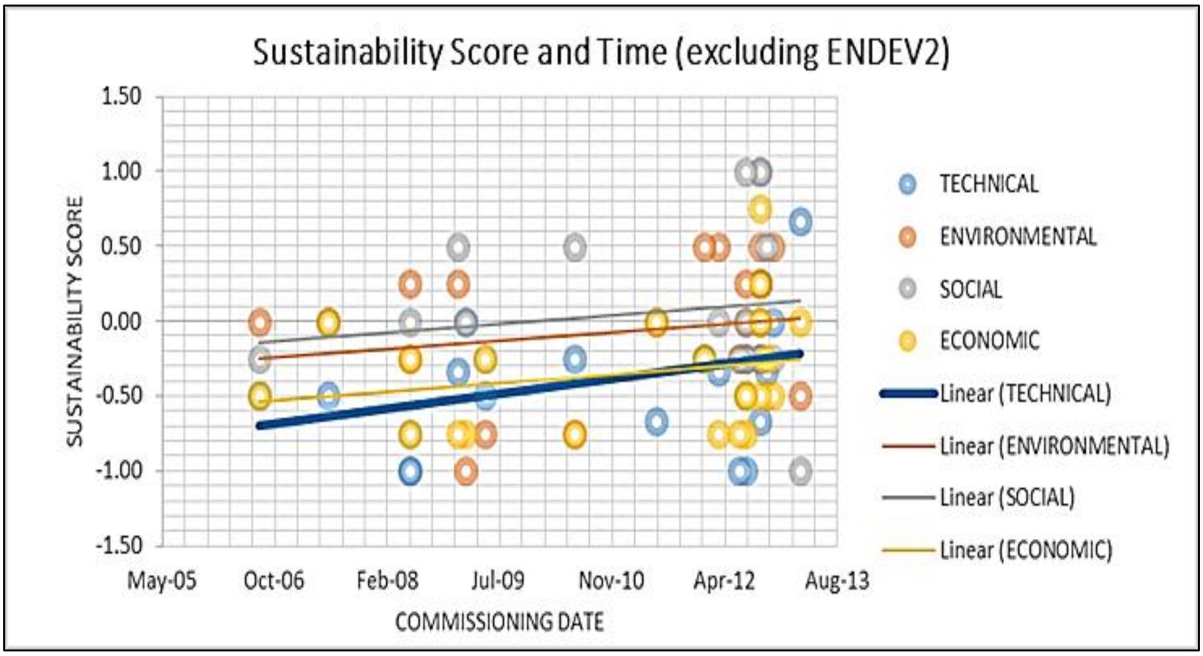

Figure 27 Relation between sustainability score and time (excluding EnDev2)

These up-ward trends towards sustainability bode well for the future of MHP development in Indonesia. The technology enjoys a high level of community acceptance, can draw on good quality local manufacture and best practices are in place, supported by user-friendly awareness and training materials. Given the trend of increasing fossil fuel prices (even in Indonesia reducing fossil fuel subsidy is now pursued), the sustainability prospects for MHPs will likely strengthen further.

Case example: Genset vs Diesel in Luwu Utara district

During the EnDev2 comparative study (May - April 2012), the survey teams also collected information on general energy consumption in rural Indonesia, where easily available. For sites in Luwu Utara district the teams received feedback regarding the use of diesel and petrol generator sets.

Diesel is sold in these rural areas at a cost of 230% above the retail price in towns and cities. While the latter price is about IDR 4,500/litre, a rural consumer would pay about IDR 15.000/litre due to the difficulties of fuel transportation.

Small gensets owned by households usually consume about one (1) litre of diesel to provide electricity for lighting and small appliances for about two (2)-three (3) hours. Therefore, assuming that electricity is only used during evening

Figure 28 Diesel genset for PUE

There is still a prevalence of diesel gensets in rural households and businesses, operated at significant expense.

Source: Andrea Ranzanici, EnDev Indonesia (GIZ, 2013) times, from18:00 to 24:00, each household would roughly spend IDR 30,000 per day.

As a term of comparison, MHP monthly fees in the surveyed sites equal to IDR 10,000 to 30,000 per household per month. Even considering raising the monthly fees in order to increase the economic sustainability of these systems, which was found to be a critical aspect, this amount of money would be in any case much less than running a genset, especially considering that there is theoretically no time limitations for daily operational hours.

Figure 29 Transportation difficulties

Remote rural sites are difficult to reach.

Source: Andrea Ranzanici, EnDev Indonesia (GIZ, 2013)

6 Annex A – Case Analysis of Non-operational MHP sites

6.1 Overview of non-operational sites

Operational status of MHPs at the time of survey is shown in an operational matrix; rows represent districts and columns represent schemes. The last two columns and rows are the total and subtotal for each category. Each cell comprises information about:

a. Top-right: number of surveyed sites for each scheme and district.
b. Bottom-left: number of non-operational sites in red font and operational sites in green font.

Table 9 Overview table of MHP operational status

CATEGORY / REGION		EnDev1	EnDev2	Rural PNPM	Others	Total #	Total % not-operational
Mamasa		8 / 2 (6)	1 / (1)	3 / 1 (2)	0	12 / 3 (9)	25%
Tana Toraja		0	2 / (2)	3 / (3)	2 / 2 (0)	7 / 2 (5)	29%
Toraja Utara		0	3 / 2 (1)	0	0	3 / 2 (1)	67%
Luwu Utara		0	3 / (3)	3 / (3)	4 / 2 (2)	10 / 2 (8)	20%
Total	Total	8 / 2 (6)	9 / 2 (7)	9 / 1 (8)	6 / 4 (2)	Total sites not in operation	
	% not-operational	25%	22%	11%	67%	32 / 9 (23)	28%

At a glance, this information represents the sustainability status of MHP systems in medium-long term period. However, this only shows the surface of the deep and interconnecting sustainability situations on MHP systems in Sulawesi. More in-depth assessment based on cases found during survey uncover different aspects of MHP sustainability that lead to failures. Specific analysis on each non-operational site is performed case-by-case to provide better understanding on reasons why the MHPs stop operating.

6.2 Vandalism in Pasappa Mambu 1 (Sul081)

The case of Pasappa Mambu 1 encompasses two main causes on operational disruption which both are related to social conflicts. The conflicts happened among two different communities and between the community and its VMT. The penstock was vandalised with a hammer, rupturing the pipe. According to the VMT, the vandalism occurred as a consequence of decision to reject connecting the nearby hamlet with the MHP due to insufficient capacity and distant location.

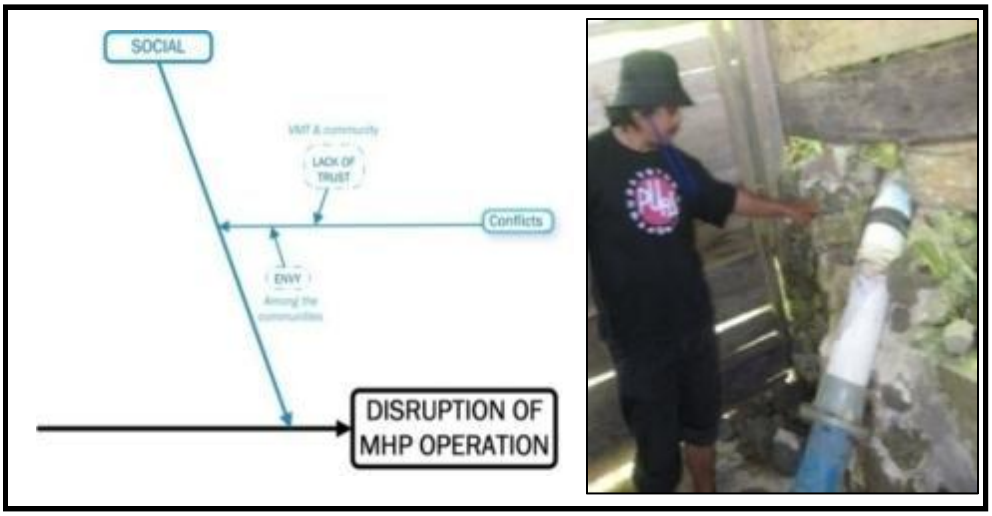

Figure 30 Vandalism leads to operation disruption

Location/Scheme/Year	Pasappa Mambu 1 (Sul081)/EnDev 1/2006
Cause	Social conflicts
Estimated restoration of MHP operation	No indication
Electricity supply status	None

6.3 Conflict of Land-use in Sasakan (Sul065)

There was a conflict of interest between Sasakan community and the land owner regarding the location of the MHP. The villagers proposed to have additional capacity which required more water flow that would be diverted from the existing irrigation channel. This intervention was feared to cause severe erosion to the embankment. The MHP had not been operating since a year ago and a proposal to construct a stone wall alongside the channel is still hindered by the budget availability and the land owner refusal to cooperate.

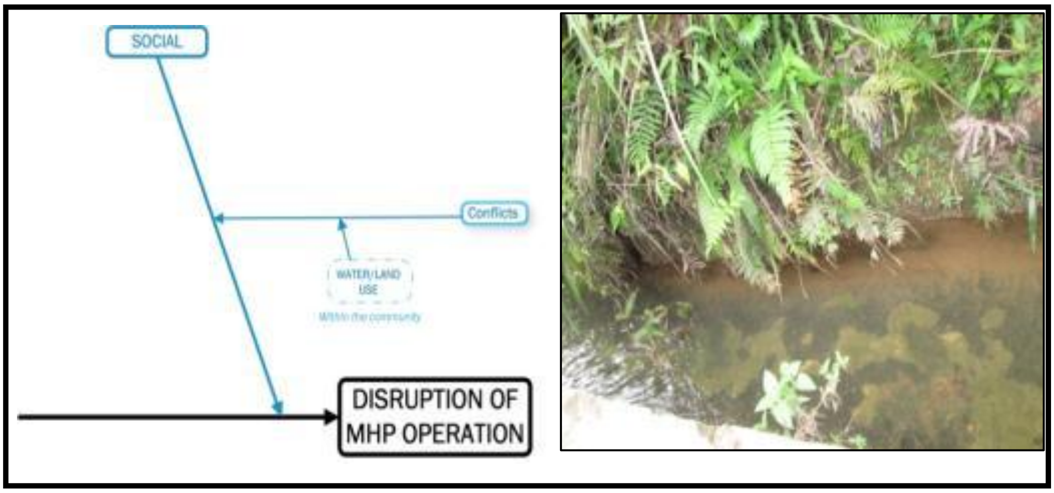

Figure 31 Land-use conflict

Location/Scheme/Year	Sasakan (Sul065)/EnDev 1/2006
Cause	Social conflicts
Estimated restoration of MHP operation	No indication
Electricity supply status	None

6.4 National Grid Encroachment in Appang Batu Village (SulSel028)

Appang Batu village started the MHP construction in 2009 and it was commissioned in 2012. By chance, the state-owned utility company (PLN) extended their grid to the village in 2010, although during proposal phase there was no indication of PLN grid extension to the village. At the time of survey, the community had decided to connect to PLN instead of the MHP as the PLN tariff was cheaper and that connecting to PLN is considered simpler than managing an MHP system. The MHP then lost its potential customer.

Tracing back to funding approval process, decision on MHP location was discussed among the community from various applicant villages. Recommendation from EnDev2 regarding distance to PLN grid had been conveyed, nonetheless final decision resided in the community consensus. Many social variables played roles in the decision making process where intervention from EnDev was limited only as recommendation.

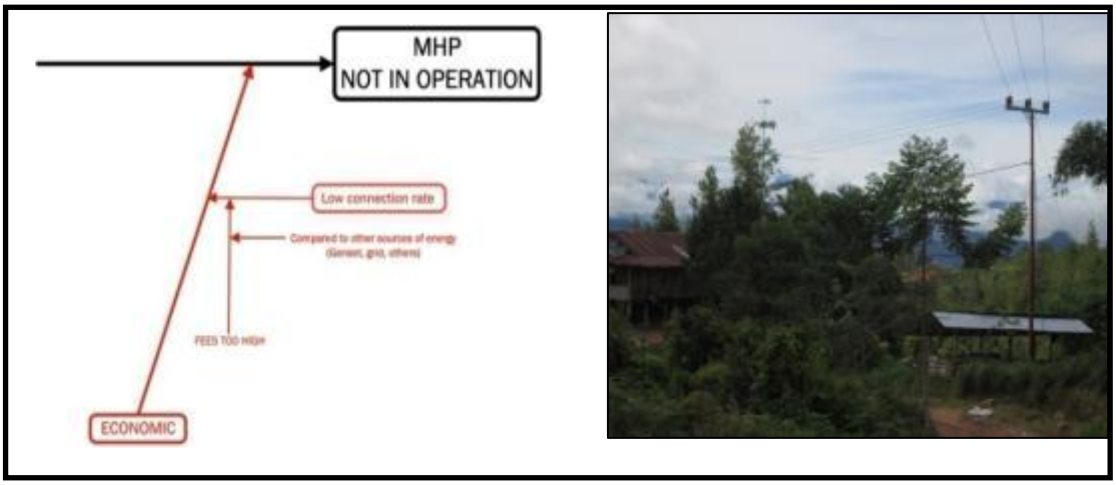

Figure 32 National grid encroachment

Location/Scheme/Year	Appang Batu (SulSel028)/EnDev 2/2009
Cause	National grid extension
Estimated restoration of MHP operation	No indication
Electricity supply status	National grid (PLN)

6.5 Landslide and National Grid Extension in Sapan Kua-kua (SulSel020)

Appang Batu and Sapan Kua-kua are located in District Toraja Utara. Besides major landslide that broke the MHP channels, PLN grid expansion also caused the MHP not to operate. The existence of PLN grid left the MHP system with only 13 connected households.

The situation was worsened by the recent landslide that afflicted the MHP channel which caused the MHP stop operating. By the time of survey, the channel was under repair. Concerning low connection rate in the village, productive use application can be pursued to help maintain the system from which VMT may get additional income for MHP operational expenses although such initiative would need further business potential identification.

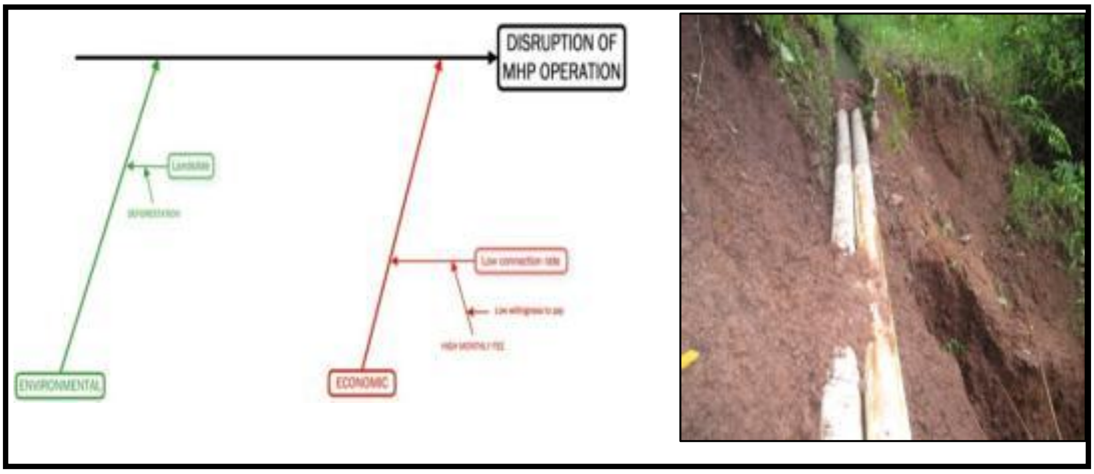

Figure 33 Landslide and PLN grid encroachment

Location/Scheme/Year	Sapan Kua-kua (SulSel020)/EnDev 2/2009
Cause	National grid extension and landslide
Estimated restoration of MHP operation	No indication
Electricity supply status	Partly MHP and partly national grid (PLN)

6.6 Landslide in Kadundung I

Landslides are potentially hazardous environmental events that disrupt MHP operation, which is the case in Kadundung I. To repair the MHP's broken civil work, the community is waiting until rainy season ended.

Figure 34 Landslide

Location/Scheme/Year	Kadundung I/Others/2000
Cause	Landslide
Estimated restoration of MHP operation	After rainy season
Electricity supply status	MHP

6.7 Poor Quality of Electromechanical in Embonatana and Lemo Menduruk

In two sites Embonatana and Lemo Menduruk, were both non-operational due to technical reasons: burnt control panel and broken generator. Based on available records, MHP Embonatana was built in 2006 and a year later the control panel burnt out. Fortunately, Embonatana community had collected funds for six years until finally they got a new control panel in early 2013. However, mixture of lack of installation expertise within the community and the fact that it had not been operating for six years implied that the system could not be restored to date.

Figure 35 Burnt control panel in Embonatana (left) and broken generator in Lemo Menduruk (right)

Location/Scheme/Year	Embonatana/Others /2006	Lemo Menduruk/Others/2007
Cause	Burnt control panel	Broken generator
Estimated restoration of MHP operation	No indication	Soon
Electricity supply status	Few diesel generator	-

6.8 Poor Quality of Civil Works in Padang Balua and Pasapa Mambu

Quality issues on civil works were observed in two sites: Padang Balua (Rural PNPM) and Pasapa Mambu 2 (Others). Concrete channel ruptures occurred in Pasapa Mambu 2 only after a few months of operation due to the poor quality civil works. At the time of visit, the community decided to replace the concrete channel with pipes. Meanwhile in Padang Balua, poor quality of design and construction of weir caused the MHP to stop operating on a regular basis. Interruptions occur regularly when higher rainfall increases river flow and sweeps away the unstable weir.

Figure 36 Poor quality of civil works

Location/Scheme/Year	Padang Balua/Others /2012	Pasapa Mambu 2/RuralPNPM/2012
Cause	Poor quality of weir	Ruptures on channel
Estimated restoration of MHP operation	Soon	Soon
Electricity supply status	Few diesel generator	-

6.9 Overview of Operation Disruptions

An overview in regard to reasons behind operation disruption of MHPs is shown below. The matrix illustrates operational status of all 9 non-operational sites categorised by scheme and region. Colour coding is used to distinguish the level of MHP operational disruptions; green for temporary disruption, yellow for unidentified disruption period, and red for sites that shut-down the system for good.

Table 10 Overview of operation disruptions

CATEGORY / REGION	EnDev1		EnDev2		Rural PNPM		Others	
	Typology	**Duration**	**Typology**	**Duration**	**Typology**	**Duration**	**Typology**	**Duration**
Mamasa	SOCIAL, Conflicts	Definitive	-		TECHNICAL, Channel	Temporary	-	
	SOCIAL, Conflicts	Definitive						
Tana Toraja	-		-		-		ENVIRONMENTAL, Landslide	Temporary
							TECHNICAL, Generator	Temporary
Toraja Utara	-		ECONOMIC, Grid	Definitive	-		-	
			ENVIRONMENTAL, Landslide	Temporary				
Luwu Utara	-		-		-		TECHNICAL, Control Panel	Definitive
							TECHNICAL, Weir	Temporary

Referring to categorisation in the matrix, it is observed that MHP sites in EnDev2 did not experienced major technical breakdown. However, their operational disruptions were mostly fatal, triggered by issues in social, economic, and environmental aspects.

Energising Development (EnDev) Indonesia
Jl. Tebet Barat VIII No. 52
Jakarta 12810 – Indonesia
T +62 21 830 9438
F +62 21 830 9032
I www.giz.de; www.endev-indonesia.or.id