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SUSTAINABILITY OF GROUNDWATER FARMER-MANAGED IRRIGATION SYSTEM (GFMIS) IN INDONESIA
A case study on Gunungkidul and Nganjuk/Kediri areas

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ABSTRACT

In the late of 1970's the Government of Republic of Indonesia launched Groundwater Development Project (GDP) as effort to overcome water shortage in several surface irrigation command areas and to alleviate the poverty problems in the region with limited natural resources. The GDP constructed several numbers of tubewells pumping system in the whole country. During the first two years after construction, The GDP undertakes O&M activities and then the system is turned over to the WUA under supervision of local government.

Sustainability of the systems after turning over was examined in this paper. The sustainability of pumping systems were classified into two levels. Pumping system is considered sustainable at level I whenever its sustainability is attained without any support from the government or external agencies. If the sustainability is attained through government support in replacement or heavy maintenance, the pumping system is categorized as second sustainable. Several samples of GFMIS located in Gunungkidul and Nganjuk/Kediri areas were taken.

Result from study showed that GFMISs in Gunungkidul could be classified as level II of sustainability. In Nganjuk/Kediri, the present status of sustainability of most in deep tubewell pumping systems could be categorized between level I and level II , i.e government subsidies is provided for minor repair only. Meanwhile in intermediate tubewell area, private pumping system started imposing the GDP irrigated area. It seemed that the existence of the GDP system would not be longer because its positions in the competition was weaker than private pumping system.

irrigation in this area is very limited and farmers plant their lands twice during wet season only.

Most of geological formation in Gunungkidul is limestone, groundwater is found in the particular area because distribution of permeability within the limestone is very varied and difficult to detect. So, groundwater pumping irrigation system can not be developed in the whole area. Major aquifer is only found in the Wonosari plateau 36,000 ha and Gunungsewu 70,000 ha (Sir McDonald and Partners, 1984). Totally, 34 deep wells have been installed and irrigate about to 1,100 ha. The main objective of development of GDP in this area was to alleviate poverty problems.

<u>Nganjuk and Kediri area</u>

The side by side Nganjuk and Kediri districts are located in about 120 km South West of Surabaya, the capital of East Java Province. Nganjuk/Kediri area located in flood plain area. Different with Gunungkidul most of geological formation in these areas is volcanic-alluvial aquifer. The important aquifers are developed in the volcanic clastic sediments and their reworked and sorted alluvial. Weathering profile over lavas, or joints and cracks within the lava may also be water bearing (Sir McDonald & Partners, 1979). These wide range of aquifer characteristics emphasizes variation in geology. Groundwater can be withdrawn from various depth by constructing whether shallow, intermediate and deep wells with well's yielding up to 60 l/s. There are 72 wells in Nganjuk and 91 units in Kediri are available to serve 1322 ha and 5296 ha irrigated area, respectively.

Several surface irrigation were also established in Nganjuk/Kediri areas. However, during dry season, surface water is very limited and can not to be spread out in the whole area, as results some parts of the systems suffer shortage of surface irrigation water. Hopefully, by developing the GPIS in these areas, problems of lacking of irrigation water can be overcome.

RESULT AND DISCUSSIONS

Government policies in developing GFMIS

In the development of GFMIS in the country, the GDP constructs tube well irrigation systems in the selected areas. All investment cost including design and consultant costs, are covered by the GDP. Following the completion of construction, the GDP guides and trains farmers in water management and farming systems during the first two years period. In this period the GDP encourages farmers to set up Water User Association (WUA) in the irrigation scheme, even all of O&M activities and cost of the system are still rest to the GDP.

After two years operations, the responsibility on operation and minor maintenance of the system are turned over to the WUA under supervision of the Local Government. In Yogyakarta, heavy repair of the pumping unit and monthly incentive of pump operators (as a temporary employee) are covered by Provincial Irrigation Service (PRIS) as a part of Local Government O&M budget. This policy is implemented because the main objective of development of GFMIS in Gunungkidul is for poverty elevation.

Different with Yogyakarta Province, the East Java Province only provides mechanics and workshop facility which are located in the district capital to do major maintenance only. The WUA has to purchase spare parts and contribute small parts of repair cost (usually as transport fee of mechanics). In recent years the East Java Provincial GDP limits the support of fuel up to 1,000 hours/years in the first two years. By implementing this policy, it will makes the WUA to be stronger and operate pumping system in more efficient way.

Variables to measure sustainability

Based on figure in Appendix A and table in the Appendix B, all variables and parameters which affect sustainability of GFMIS can be expressed in four variables only, i.e.: i) pump operation hours; ii) system efficiency; iii) actual discharge and irrigated area; and iv) fee collection and the WUA's saving.

The number of pump operation hours can be considered as the main indicator of the project technical impact on the GFMIS performance. However, this variable is affected by several limitations as follows : a) policy of provincial GDP in supporting and providing subsidies and facilities; b) cropping pattern and kind of crops grown in the area; c) number of rainfall; d) other factors, such as conjunctive use and competition with individual farmer pump.

Together with pump operation hours, system efficiency and actual pumping discharge reflect the suitability of design, construction, skill and attitude of operator and O&M activities of the system. Meanwhile, the capability of farmers to involve in O&M activities and renewal pumping unit when the technical live finished are measured by fee collection and the WUA's saving.

Performance of GFMIS

<u>Pump operation hours</u>

Following the development of GFMIS, whether cropping intensity and cropping pattern in both study areas have been raised. In Gunungkidul, cropping pattern increases from rice

(R) - upland crop (UC) to be R - UC (beans/maize) - UC (beans/maize) - UC (maize). In the last UC farmers grow maize as green seed for animal feeding with age of crop less than two months.

With this kind of cropping pattern, water requirements will be relatively constant every year. So, pump operation hours only depend on the number of rainfall only. By considering to this phenomenon, the relationship between long term period of number of rainfall with pump operation hours can be expressed as simple regression as follows :

$$Y = A + B X \quad \ldots\ldots\ldots\ldots \quad (1)$$

with : Y = monthly pump operation hours (hrs.)
X = monthly amount of rainfall (mm).

Relationship between these two variables of 10 GFMIS samples in Gunungkidul during the beginning period of operation, 1979-1983 and the recent years, 1989-1991, is given in Eqns. (1) and (2), respectively, as follows:

$$\text{Year 1979 - 1983}: Y = 307 - 0.70 X \quad \ldots\ldots \quad (2)$$
$$r = -0.97, \text{ mean of } Y = 168.1 \text{ hrs}$$

$$\text{Year 1989 - 1991}: Y = 259 - 0.69 X \quad \ldots\ldots \quad (3)$$
$$r = -0.84, \text{ mean of } Y = 136.4 \text{ hrs}$$

Comparing these two equations, it seems that the sensitivity of farmers to operate pump with respect to the number of monthly rainfall little bit decreased. In the recent years, they tend to operate pump longer when they have the same value of decreasing amount of rainfall. Decreasing mean of monthly pump operation is suspected that farmers try to minimize the pumping hours because upland crops more tolerant to water shortage than rice, and the cost for pumping is quite expensive.

In another hand, in Nganjuk/Kediri pump operation hours does not reflect any technical performance of GFMIS yet due to several reasons as mentioned previously.

System efficiency, the actual irrigated area and actual discharge

According to Ferguson (1987), efficiencies of diesel engine and turbine pump are 44% and 60 %, respectively. So, the system efficiency will be 24%. Result of calculation of pump efficiency, engine efficiency and system efficiency in both study areas is presented in the Table 5.

From this table , system efficiency in both study area are relatively the same. However, special attention should be given to Gunungkidul area, where farmers enable to attain this efficiency and they have to operate the pumping system with actual discharge exceed design discharge. Pusposutardjo and Arif (1992) show that drawdown in Gunungkidul in the recent years increases even the static water level is relatively constant. This phenomenon is suspected to the increase of well losses.

Significant decrease command area in several intermediate wells in Nganjuk/Kediri is attributed to competition with individual/private pumping system.

Fee collection and the WUA's saving.

At present, the O&M fee of pumping unit per hour varies between US $ 1.00 to $ 1.50 for deep well and $ 0.50 for intermediate well. The biggest part of the operation fee goes to fuel and oil cost (80%), and maintenance fee is only 10 % and nothing for saving to renewal pumping unit when the technical lives is attained.

By observing to the component of O & M fee, seemingly farmers do not provide enough fund for maintenance. Annual reports of the GDPs in both study areas show that maximum the WUA's saving is less than $ 150.00. This amount clearly is not enough for major repair of pumping units as well as irrigation structures.

Moreover, monitoring report of GDPs also indicate that income of farmers is relatively low. It is only about to $ 200.00/month/ha. By this amount of farmers income the WUA faces difficulty to increase the O & M fee.

The individual/private pumping system

In Nganjuk/Kediri area, several places have a great potential to provide groundwater even in shallow aquifer depth. So, actually, the groundwater irrigation system has been introduced since the Dutch Colonialism period in sugarcane plantation. In this system the Dutch government used steam engine to lift irrigation water from the open dug wells.

As well as farmers knew that groundwater is available in the shallow aquifer, they also constructed open dug wells in their own lands and used buckets manually to elevate water and irrigate their lands. After the GDP introduced technology of installing tubewells in this area, farmer also able to construct shallow tubewell pumping system up to 30 m depth using manual auger hole.

Development of machine industry in the country has encouraged farmers to purchase small portable pumping unit. Several trade marks with engine horse power up to 8 Hp are available in local market complete with after sale service, spare parts and workshops. Using this kind of engine they can elevate water in 10 lps to 12 lps which can be utilized to irrigate up to 2 ha of land.

The development of these individual/private pumping systems in the former GDP command areas causes strong competition among of them. In several areas farmers seem prefer to shift from the GDP system to the individual/private system. Reasons of farmer to shift their choice from the GDP to private owned pumping are : i) farmers have understood technology of shallow tubewell pumping system whether in term of construction or O & M technologies; ii) easier procedures to request water and payment method and, iii) greater conveyance efficiency and greater possibilities to have irrigation water in the private pumping system.

Impact to the sustainability

From the technical performances it seems that except intermediate well most of GFMISs showed appropriate conditions, eventhough, some of them have been operated since last 10 years. To keep this way, roles of local government such as what the Yogyakarta PRIS has done in supporting the O & M activities are very useful. However in another side this policy makes farmers who manage the pumping irrigation system rather spoil. They always request to the government subsidies when they faced problems in managing pumping unit. Actually, what they needs are more on management and technical assistants rather than government subsidies.

The relatively loose of government intervention in O & M activities in Nganjuk/Kediri have made the management of GPIS (whether WUA or individual/private system) stronger. In the deep tubewell systems, the WUA can manage the pumping unit in the appropriate ways as reflected by system efficiency. Another example was found in the TW 182 Ringinpitu, when the well damaged, farmers were capable to reconstruct new well even construction cost were more than $ 3,000.00. In the intermediate tubewells area where several individual pumps exist, farmers do not too much depend upon the government pumping systems. A good example was found in TW 138 Nglaban, the pumping unit has been out of order since January 1991, however, no effort of WUA to repair the unit, because farmer like to use their own pumping system. This was reflected by increasing number of pumping unit from 20 units to 25 units during one year (from 1991 to March 1992).

More attention should be given by local government because some wells have met the technical lives. Data on farmer income in both study areas showed that farmers are not capable to reinvest the new pumping system. Seemingly, up to present there are no fix plans or programs will be implemented to anticipate this problems. Revolving funds such as being implemented in several places in the country may can be considered to be practiced in both study areas. However, the local governments have to strengthen the WUA management before this program is implemented.

CONCLUDING REMARK

According to classification of sustainability, all of GFMISs in Gunungkidul can be categorized as sustainability level II since they need government subsidies for O&M and major repairments. In Nganjuk/Kediri the coming up of individual pumping system in the intermediate tubewell command areas causes decreasing irrigation service area and makes farmers are not dependent upon government subsidies anymore. However, in another side this phenomenon makes government investment to be useless. So, according to the sustainability classification the private pumping system is under level I sustainability. In case of deep tubewells, a little subsidy is still needed in major repairing, so, class of sustainability in this system may be classified in between level I and level II sustainabiltiy.

Eventhough, technical performances in most system express good condition, however, technical life of several wells in the study areas have finished. It seems that renewal of pumping unit is beyond capability of farmers. With no government assistant this problem can affect the sustainability of GPIS in both study areas.

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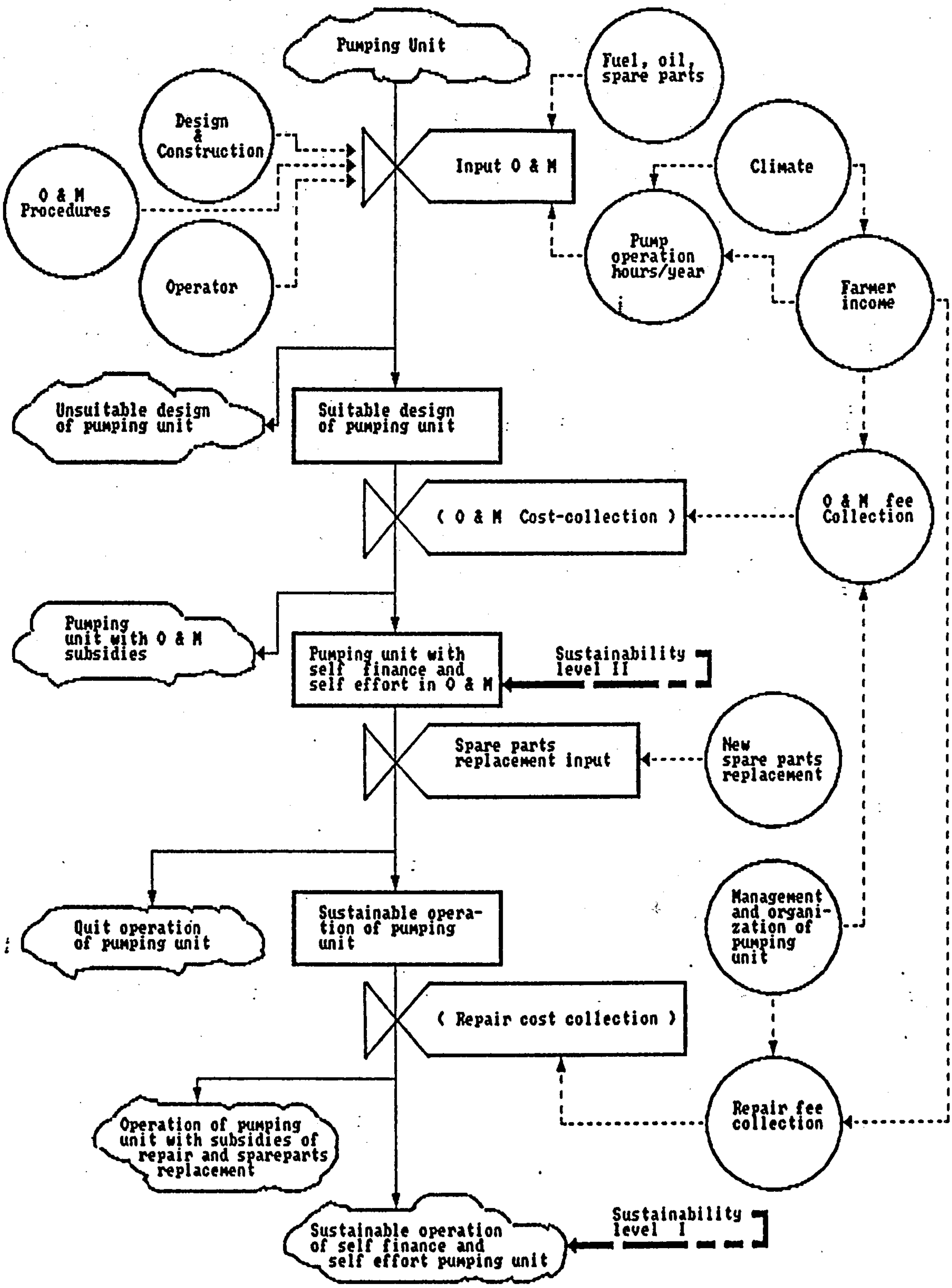

Figure 1. Block model diagram of sustainability of G F M I S (Pusposutardjo & Arif, 1992)

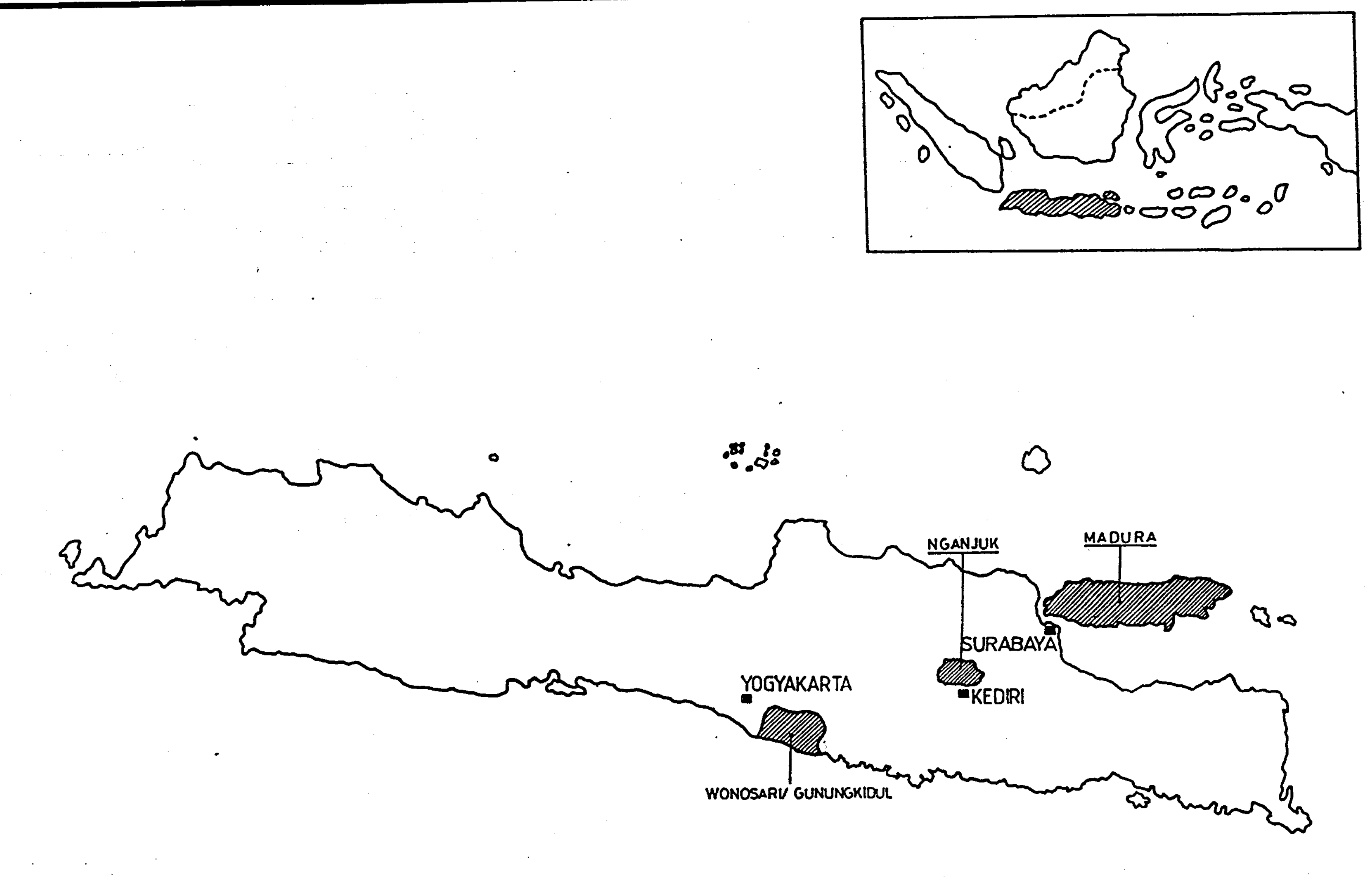

Figure 2 : Location of Study of Area

Table 1. List of variables and parameters used to measure sustainability of GFMIS

No.	Principal variable	Variable descriptor	Parameter
1.	Appropriate design of pumping unit (pump, engine, irrigation water conveyance)	Suitability between : power engine, pumping load (pumping head, discharge, hydraulic head) well costruction, irrigation networks with climate and farming system.	- Hp/rpm - diameter of pump inlet & outlet - number and kind of pipe bends - depth and size of casing - depth of well, specific yield, discharge, SWL - distribution of depth and number of rainfall - water balance - length, size and kind of canal - number and kind of other irrigation structures
2.	Appropriate costruction	Suitability between design and costruction	- number, kind and starting occurrence of damages - occurrence frequency of damages
3.	Appropriate O & M	Suitability between actual O & M with procedure O & M	- availability of manual procedure of O & M - time schedule of O & M - repair method - availability of O & M facilities - availability of savety of operation
4.	Fuel, oil and O&M spare parts	Availability and accessibility	- number, quality, price, purchasing method
5.	Operator and mechanic	Availability	- number, skill, education
6.	Pumping hours	Number and distribution of pumping hours	- average pumping hrs/mo - distribution of pump operation hours.
7.	Replacement spare parts	Availability and accessibility	- kind, number, price and purchasing method.
8.	Replacement facilities	Availability of mechanics and workshops	- qualification, number and accessibility

Table 2. List of GFMIS samples in Gunungkidul and Nganjuk/Kediri

Location	Well #	Village	Subdistrict	Area (ha)	Year operated
GUNUNGKIDUL	W -05	Bogorkidul	Playen	46.6	05/1978
	W -08	Siraman	Wonosari	31.1	07/1978
	W -11	Jaran Mati	Karangmojo	30.5	08/1978
	W -14	Karangwetan	Karangmojo	42.2	03/1979
	W -16	Playen II	Playen	33.3	08/1978
	W -19	Ngipak II	Karangmojo	44.4	04/1979
	W -20	Awar-awar	Wonosari	11.0	03/1979
	W -21	Jatisari	Playen	42.2	05/1979
	W -22	Plumbungan	Karangmojo	41.2	04/1979
	W -28	Bolo	Playen	34.6	06/1980
NGANJUK/KEDIRI	W-152	Jaan	Gondang	43.93	12/1981
	W-153	Kepanjen	Pace	49.99	07/1982
	W-174	Sumberagung	Gondang	44.145	10/1985
	W-010	Sidowareg	Plemahan	49.20	08/1974
	W-025	Ringinpitu	Plemahan	44.353	11/1981
	W-061	Sidowareg	Plemahan	37.95	11/1987
	*				
	W-116	Putukrejo	Loceret	20.14	06/1979
	*				
	W-117	Putukrejo	Loceret	21.561	06/1979
	*				
	W-138	Nglaban	Loceret	24.745	03/1980

Note :
* : Intermediate well

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Table 3 . Total and mean of monthly pump operation (hrs) of 10 well samples in Gunungkidul.

Well #	Location		Month												
			1	2	3	4	5	6	7	8	9	10	11	12	Total
W-05	Bogor kidul	*)	22	33	97	184	235	409	458	435	461	285	205	123	2947
		**)	9	9	10	55	163	61	314	258	271	163	256	115	1684
W-08	Siraman	*	22	13	77	50	126	334	323	301	205	205	177	75	1908
		**)	24	6	15	24	81	24	245	206	197	101	207	85	1215
W-11	Jaran mati	*)	37	22	31	66	188	314	289	394	208	145	141	63	1698
		**)	4	33	18	18	144	34	294	295	213	184	286	288	1811
W-14	Karang wetan	*)	21	22	66	188	314	289	394	208	194	169	75	169	1778
		**)	3	11	4	144	34	294	295	213	133	27	52	135	680
W-16	Playen 2	*)	33	35	58	66	182	323	324	323	376	236	212	106	2274
		**)	11	16	12	21	110	28	320	243	220	124	176	140	1421
W-19	Ngipak 2	*)	82	30	79	132	217	308	294	285	136	115	108	80	1866
		**)	12	20	17	18	180	43	288	267	305	205	219	194	1758
W-20	Awar-awar	*)	18	19	32	30	87	145	175	136	127	101	58	106	1034
		**)	10	2	33	7	50	12	54	85	76	71	54	15	469
W-21	Jati sari	*)	63	65	129	166	228	387	303	394	450	311	285	171	2949
		**)	5	9	42	73	118	9	325	271	304	218	311	119	1804
W-22	Plumbungan	*)	31	54	99	143	257	329	350	385	253	231	175	123	2430
		**)	5	17	37	28	150	60	296	262	215	167	208	143	1588
W-28	B o l o	*)	17	16	44	101	256	424	327	258	159	126	103	62	1623
		**)	3	13	4	16	21	21	268	230	235	132	162	190	1295
	T o t a l	*)	346	309	712	1050	1961	2860	3063	2964	2569	1724	1539	1078	20577
		**)	76	136	192	264	1083	299	2542	2217	2169	1392	1931	1424	13725
	Mean	*)	34.6	30.9	71.2	105	196.1	286	306.3	296.4	256.9	172.4	153.9	107.8	2057.7
		**)	7.6	13.6	19.2	26.4	108.3	294	254.2	221.7	216.9	139.2	193.1	142.4	1372.5

*) Source : Sir McDonald and Partners, 1984
Monitoring data of 1979 to 1983

**) Source : Monitoring report of PRIS,Yogyakarta, 1989 to 1991

Table 4. Total and mean of monthly pump operation of sample wells in Nganjuk/Kediri (hrs)

Well #	Location	Month												
		1	2	3	4	5	6	7	8	9	10	11	12	Total
TW-152	Jaan, Gondang	51	31	35	64	93	146	153	223	274	252	128	98	1548
TW-153	Kepanjen, Pace	17	28	2	2	10	7	90	210	227	168	110	44	901
TW-174	Sumberagung, Gondang	21	9	3	5	53	28	52	54	134	129	74	40	711
TW-010	Sidowareg	5	2	52	1	44	40	112	160	169	102	86	14	741
TW-025	Ringin jati	32	21	20	11	132	188	291	315	314	260	165	84	1835
TW-061	Sidowareg	37	8	16	33	70	111	168	209	233	195	141	30	1255
	T o t a l	163	99	128	116	402	520	866	1171	1351	1106	704	310	6991
	Mean	27	17	21	19	67	87	144	195	225.2	184	117	52	1165

Source : Pusposutardjo and Arif (1992)

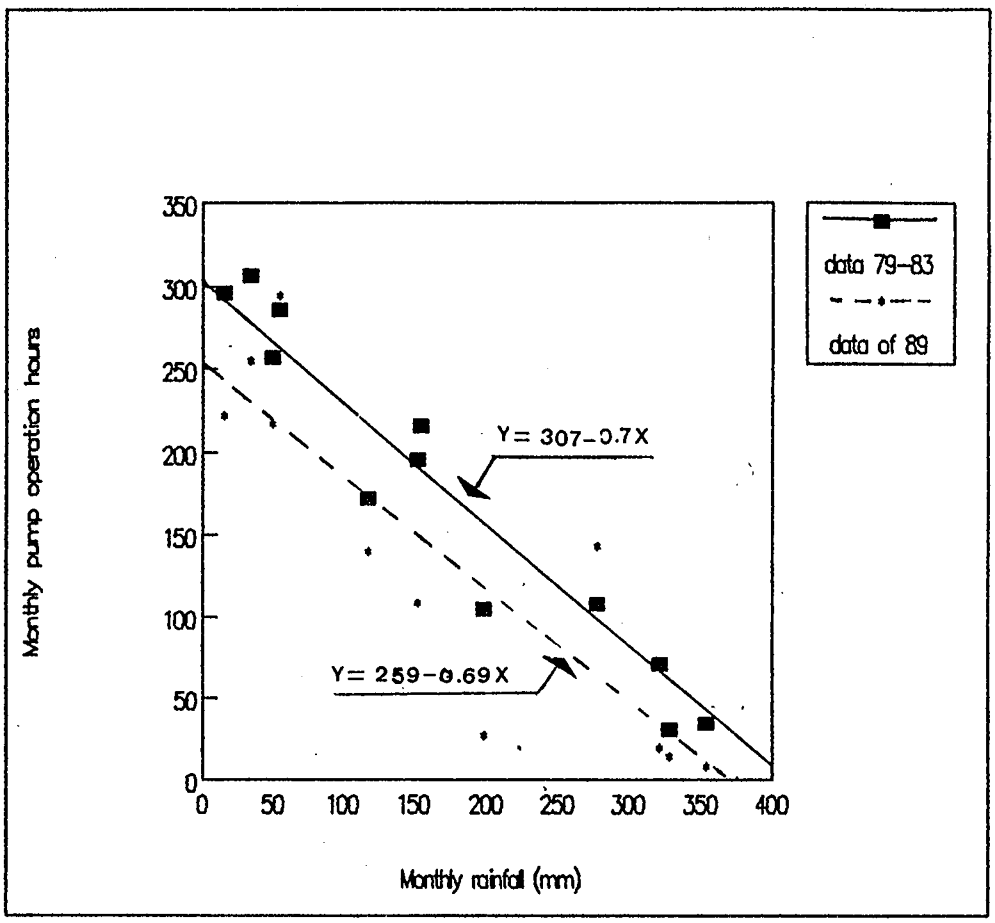

Figure 3. Relationship between monthly rainfall with monthly pump operation in Gunung Kidul.

Table 5. Relationship between pump efficiency, engine efficiency and system efficiency

Location	Qd l/s	Qa l/s	Qa/Qd	Fuel power KW	Water power KW	Pump Eff. %	Eng.Eff. %	Syst. eff. %	Hp
Gunungkidul									
Bogorkidul	31	24.3	0.78	43.21	3.8	28.3	31.07	8.79	18
Siraman	21	26	1.24	-	4	-	-	-	-
Jaranmati	29	25.6	0.88	38.88	4.14	30.83	34.5	10.65	18
Karangwetan	19	27	1.42	54.01	8.09	28.9	51.79	15	37.5
Playen II	25	29.5	1.18	43.21	5.2	38.72	31.07	12.04	18
Ngipak II	25	35.8	1.43	43.21	8.95	31.9	64.7	20.71	37.5
Awar-awar	20	18	0.9	43.21	4.41	32.84	31.08	10.21	18
Jatisari	25	53.4	2.14	-	5.23	-	-	-	-
Plumbungan	25	26.9	1.08	43.21	5.93	44.16	31.26	13.72	18
Bolo	17	23.2	1.36	43.21	4.32	32.17	31.08	10	18
Nganjuk/Kediri									
Kepanjen (W-153)	60	54	0.9	64.81	9.53	34	43.2	14.67	37.5
Jaan (W-152)	60	50	0.83	48.6	8.82	34.7	52.2	18.15	34
Sumberagung (W-174)	45	15.6	0.35	32.4	3.08	17.6	54.1	9.52	23.5
Sidowareg (W-010)	60	54	0.9	64.81	10.05	40.2	39.1	15.72	34
Sidowareg (W-061)	90	33	0.36	64.81	6.14	24.2	39.1	9.47	34
Putukrejo (W-116)	25	20	0.7	2	26.2	31	31	8.1	9
Putukrejo (W-117)	25	18	0.7	2	23.2	23.2	31	7.3	9
Nglaban (W-138)	25	17	0.7	1.5	22.3	22.3	41.4	9	9

Source : Pusposutardjo & Arif (1992)