PERFORMANCE OF GUN SPRINKLER IRRIGATION AND PARTICIPATORY MANAGEMENT

(Case study at Akar-akar villages, North Lombok, NTB)

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ABSTRACT

Sprinkler irrigation as one of the pressurized irrigation technologies is a promising alternative to be developed in the area of limited water availability. Theoretically, it has a higher efficiency as it is compared with surface irrigation because it can reduce water loss due to deep percolation and surface run-off. Improved efficiency and effectiveness of irrigation water use is largely determined by the performance of irrigation system itself, while the performance of the irrigation network is determined by the results of design. This research was conducted in 2009 at Akar-akar village, North Lombok, NTB. The design of the sprinkle system is of a rectangular type and used permanently for maize. The research was undertaken collaboratively with Water Users Association (WUA's) where the farmers act as the main actors and the spearhead of the management. The results showed that the irrigation system has good Coefficient of Uniformity (CU), with CU value of 85.23% and with average operating pressure of 4 to 4.5 bar. Water saving was 49.8% as it was compared with furrow irrigation. The cost for operation and maintenance is also lower. It was about half of that under furrow irrigation and most of the cost could be fulfilled by the farmers themselves. Therefore it is considered profitable with the estimated incremental B/C of 2.1.

***Key word*: Sprinkler Irrigation , Performance, Participatory, Farmers.**

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1. INTRODUCTION

Upland agro ecosystem is one that has a great potential for agriculture, *it includes* food crops, *and* horticulture (vegetables and fruits). In addition to improving the productivity of existing *upland*, food production can be increased through expansion of planted area.

One of the potential that needs attention is the upland region of NTB in the district of North Lombok. A sandy land village by the name of Akar-akar, *has* the potential to *be* developed as productive agricultural land due to its substantial groundwater resources. Since 1990, the government has begun to develop wells to pump groundwater *for* agricultural development. There are 520 units of well pumps spread over Lombok Island (300 units) and Sumbawa Island (220 units). However at present time, only about 40% of pumps in Lombok Island and 25% of that in Sumbawa Island are well performed. There is a potential to improve the performance of existing pumps. In Lombok, additional investment cost of approximately Rp. 15 billion, and for Sumbawa of about Rp.13 Billion are needed to repair up to 80% and 70% of pump capacities in respective islands. (Dit. Irigasi, Ditjen SDA, 2008).

Akar – akar village has about 90 units of pump wells or about 30% of the total number of pumps in Lombok Island that needs to be optimized because of the inefficient irrigation practices namely furrow irrigation. Inundation in such a system could cause a loss of water into the deeper soil layer that, will lead to excessive and inefficient water use. As a result the crop will be vulnerable to moisture stress. and consequently it will be vulnerable to decrease in yield and even crop failure.

The fundamental problem that faced by up land agriculture is insufficiency in soil moisture content. Such a problem could not be easily addressed by existing irrigation practices. For that reason we need a method of appropriate and effective irrigation in order to maintain soil moisture around plant roots. Effective irrigation could provide the most efficient water by applying an appropriate amount according to the optimal needs of the plant directly around the roots zone.

2. OBJECTIVES AND GOALS

The objective of the program is to improve agriculture performance in up land area of Akar-akar village, North Lombok, in order to achieve the ultimate goal to reduce poverty and malnutrition.

Full-scale test was undertaken by introducing a development model of sprinkler irrigation system (gun sprinkler) in Akar-akar village through participatory management. A target to be achieved is developing a sprinkler irrigation system through collaboration with farmers in addressing the problem of daily irrigation practices.

3. METHODOLOGY

The scope of activities include performance assessment of gun sprinkler irrigation system and measurement of parameters of water requirement, duration of irrigation, irrigation interval, water use efficiency, profitability, and degree of farmer participation. The location of application is in SPB pump 233, Arungan Bali, Akar-akar Villages, Bayan sub district, North Lombok, West Nusa Tenggara, with an area of approximately 18.1 ha. Maize is a major crop planted to this area.

The field experiment was carried out by using experimental methods, arranged according to randomized completely block design. Each field coverage area following by wetted diameter of Gun Sprinkler Irrigation.

The main parameters of sprinkler irrigation on field performance are coefficient of uniformity (CU) and flows of the sprinkler head. Coefficient uniformity was measured in the field by placing a water collection container with a certain distance. During a certain operating time, the amount of water accommodated in the container was measured with a measuring cup, then water depth was calculated by dividing the volume of water with the area of mouth of container. Then the coefficient of uniformity can be calculated.

Values of water distribution uniformity expressed by a parameter called the coefficient of uniformity. These parameters depend on pressure, nozzle size, sprinkler spacing and wind conditions. CU value more than 85% is considered good for sprinkler irrigation. Coefficient of uniformity can be calculated with the equation below. (Christiansen, 1942).

$$CU = 100\left(1.0 - \frac{\sum\left|X_i - \bar{x}\right|}{\sum X_i}\right)$$

Where:

$\bar{x}$: average value of observations (mm);

Xi: value of each observation (mm).

Treatment in watering gun sprinkler system was done by giving water to a predetermined constant RPM. Watering made to irrigate root zone of corn as deep as 40 cm in accordance with crop growing period. After irrigation was given or after rain, the soil moisture content (depth of 0 – 40 cm) observed with tension meter starting from the beginning of planting until the day when plants did not need more water.

The next irrigation was given after the declining of soil moisture levels down to 50 -70% of the difference in moisture content at field capacity and wilting point. The result of standardization by tension meter indicated that the wilting point was reached when tension meter measurements showed a value of 2,3.

Soil moisture content (soil profile 0-40 cm) was observed on two points in each plot and monitored for each period of irrigation, depending on crop growing period. Crop water requirement for each crop growing period is calculated using a formula of water balance. Evapotranspiration (ET or WU) was calculated from the beginning of plant growth until harvest according to the equation (Marshall et. al., 1996) as follows:

$$\mathbf{ETa = \sigma S + P + Ir - Dr - Ru - Sp}$$

Where:

σ S	= change in soil moisture content between certain period (mm)
Ir	= irrigation water supply (mm)
P	= total rainfall (mm) (plant growth)
Dr	= water discharged through the drainage (mm)
Ru	= amount of surface runoff
Sp	= flow sideways

From the formula above, the amount of actual evapotranspiration of each plot can actually be determined by using the approach Caoili (1967) as follows:

$$d = kI \times BV \times D$$

Where, d, kI, BV and D is a thick of water in the root zone, moisture content (% weight), soil bulk density (gram/cm3), and depth of root zone (mm). Based on the formulas above, ETA (actual evapotranspiration) can be calculated as follows:

$$ETA = (d_i + CH) - d_f)$$

Where, d_i is a thick of water in the root zone before experiencing evapotranspiration; d_f is a thick of water in the root zone after experiencing evapotranspiration, and CH is the rainfall.

Determination of moisture content was done by gravimetric method. Soil samples were taken at two points each plot diagonally as deep as root zone (topsoil). Thus the difference between d-initial and d-final is the value of ETA during the irrigation period. Calculation of water use efficiency (EPA) and irrigation water use efficiency (EP-Ir) using the formula proposed by Gilley (1983) as follows:

$$EPA = \frac{Y(kg.ha)}{Eta\ (m3/ha)}$$

Irrigation interval can be calculated by tracing the moisture content available in the root zone i.e. by calculating {field capacity (mm/cm) - wilting point (mm/cm)} x root zone (cm). Irrigation interval (days) can be calculated as :

$$\frac{\text{Total decrease in water content allowed in the root zone (mm)}}{\text{Daily evapotranspiration (mm / day) from the previous calculation}}$$

4. RESULTS AND REVIEW

4.1. General Conditions

Research was located on up-land farming area that has not been widely utilized. Because the rainfall availability was limited, agricultural land is generally planted only once a year during the rainy season. Quite often during rainy season harvesting failure oftenly occurred because the rainfall was too low and the wet season period was very short (<3 months). Soil physical properties of porous, sandy loam-sandy together with high solar radiation, were the factors contributing to high operational costs which finally result in inefficient irrigation practices.

Figure 1. Field condition at Akar-akar villages, Lombok Utara

Research location has a land relief with relatively flat, but with a lot of gully erosion, some mound (small hill) that rounded as a residual erosion. It indicated that the area was initially had a hilly relief, then experienced a geomorphic processes (erosion and deposition) that led to reach an equilibrium (relatively flat). Although ,The depth of soil, however, was quite diverse despite homogenous appearance of land surface.

4.2. Climate

Regional surveys include a rain shadow areas, dry climate (climate type E4, Oldeman et al, 1980) with an annual rainfall of less than 1000 mm with rain month <3 months, as shown Figure 2.

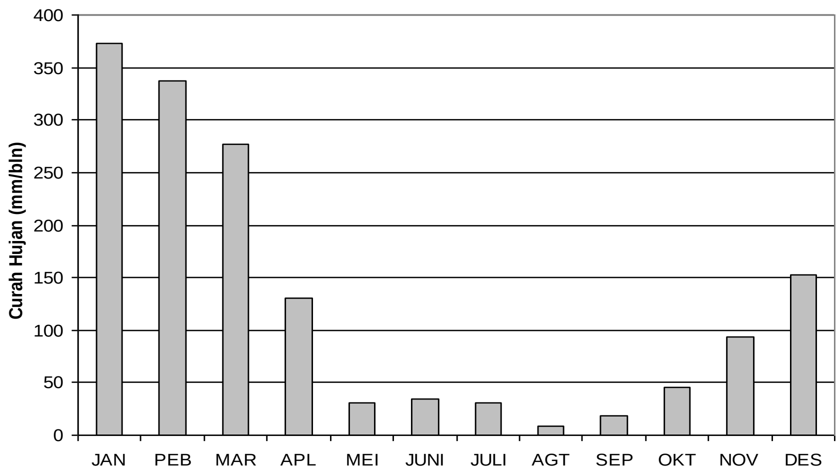


Figure 2. graphs the mean monthly rainfall data at the observation station of Ganges 1986 - December 2006

4.3. Soil and Character

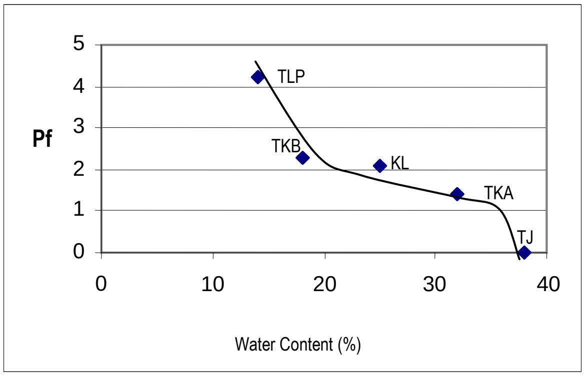
Some physical and chemical properties of soil are important in connection with the relevance of this research can be seen in table 1 below.

Table 1 The analysis of the nature and characteristics of the soil study sites

Parameter analisis	value	Category
pH (H_2O)	6,31	Netral
N Total (%)	0,15	Low
P Potensial (mg/100 gr)	6,76	Low
K Potensial (mg/100 gr)	86,71	High
Kation-dd (me/100 gr)		
K	0,24	Low
Na	0,12	Low
Ca	0,08	Very Low
Mg	0,05	Very Low
C Organik (%)	1,58	Low
Tekstur (%)		
Sand	62	
Silt	35	
Clay	3	
Texture class		Silty Sand
BV		1,220 g/cm^3
KTK (me/100 gr)	14,3	Low
P Olsen (ppm)	24,22	Low
saturated point/pF=0	38 %	Reading with tension meter =0
field capacity= pF 2,42	25%	Reading with tension meter 2,2
wilting point = pF 4,2	14%	Reading with tension meter 2,56
Upper critical point (TKA) (%)	32%	Reading with tension meter 1,5
Low critical point (TKB) (%)	18%	Reading with tension meter 2,1

Data source: Results of laboratory tests of Soil Science, Faculty of Agriculture, University of Mataram, in 2007.

Data of soil physical properties showed that research location has texture with high sand content fraction equal to 62% compared to dust (35%) and clay (3%). With high levels of fraction this land has a lower water holding capacity with a consequent of a very low water content. The important thing is the narrowness that is the range of available water for crop between field capacity and wilting point (25-14)% = 11%. It indicates that irrigation time interval becomes very narrow and if water management is improperly done it can cause a moisture stress to the crop. Such a process is essentially irreversible, and potentially could result in the declining of yields and even crop failure. For more details, the range of available water for plants (RAT), is depicted in figure 3.



Where:
TLP = Willing Point
TKB = lower field capasity
TKA = Upper field capasity
KL = Field capasity
TJ = Saturated Point

Figure 3 Water Retention Curve

Other important soil characteristic is low soil fertility in research sites, especially nitrogen content. With conditions like this sandy soil nitrogen fertilization is needed. With the application of sprinkler irrigation, nitrogen problems moving out of the service area of the roots can be avoided. Beside that, it is possible to preventing damage of soil land conservation efforts, because the distribution of water through the sprinkler gun is quite safe against erosion.

4.4. Sprinkler Irrigation System

In research location, Sprinkler irrigation system was built by Experimental Station of Irrigation, R & D Center of Water Resources in the area + 18.1 ha, and has made improvements in system irrigation. The technical data on the location of sprinkler irrigation experiment is shown in Table 2 below.

Table 2 Technical data Model Gun Sprinkler Irrigation System

Parameter	**Wellpump Arungan Bali**
Irrigation Area	18.1 Ha
The distance between the riser	33 m
Broad research sites	6.26 Ha
Well Pump	SPB-233
Discharge	20 liter/sec
The well depth	118 m
Pump position	34.1 m
RPM is permitted	1500 RPM
Type of system	Square
Mine line	Pipa PVC AW 5”
Lateral line	Pipa PVC AW 4”
Riser Pipe	Pipa Galvanized 3”
Network connection	System Solvent Cement shittim network connection
Wind speed (km / h)	> 5 km / h

Gun sprinkler irrigation system has been built with permanent system. Based on the technical tests and performance tests, sprinkler irrigation system showed a good performance, as shown by analysis of the uniformity of water distribution (uniformity coefficient, CU) is 85.23%. Average of operating pressure in sprinkler irrigation system between 4 to 4.5 bar and two sprinklers operate simultaneously. This is consistent with that proposed by Christiansen, in 1942 the value of that CU is a good criterion is the value of CU> 85%.

4.5. Application of Full-Scale Test

Water Resources Research and Development Center and Center for Tropical dry land Mataram University, introduced partnership approach with the local water users associations (WUA). The empowering of WUAs was done through daily interaction not only on operation and maintenance of the sprinkle system but also on daily management of irrigation and cultivation practices. .

The agencies involved in Implementing this full-scale include the local Department of Agriculture and Cooperatives Prosperous Mataram (SM), which had provided good corn seeds to the farmers

To stimulate and encourage partnerships with farmer groups, especially in Batu Gembung, Lembah Pedek and Batu Keruk, the National Land Agency (BPN), agrarian reform policy was carried out through a program to provide free certificates to farmers. Their land, then, can be used as to obtain loans from the banks.

4.6. Institutional Strengthening of WUA’s

Farmer Water User Association (WUA’s) play important role in managing irrigation. The farmers who are members of WUA’s are the main actor in operating sprinkler irrigation. They need to be supported by adequate resources in irrigation management. There are 29 associations spread over Akar-akar villages. The empowerment of these associations is needed so they may not continuously dependent on project aid.

Figure 5. WUA's empowerment for institutional strengthening

AS the first step, R & D Center of Water Resources (Water Resources Research Center) with the Center for Social and Economic Role of Culture and Society (Research Sebranmas) carried out the full-scale test model of development of sprinkler irrigation system. Institutional strengthening includes mentoring, training and formation of the WUA's working group. Mentoring activities incorporate several hamlets namely: Batu Keruk, Lembah Pedek, Batu Gembung/Arungan Bali and Gasan Gelumpang..

Institutional strengthening was done by the following strategies:

a) Facilitate the preparation of plan in a participatory manner, carried out by using the approach/ methodology of the PRA (Participatory Rural Appraisal) to allow program participants know, understand and agree on a role as well as events and constraints in implementing task responsibilities.

   The first step involves the local communities themselves, because they understand needs, problems and potential available locally.. Participatory planning is done by stages:

   Phase (i) self awareness, facilitate community to be aware of the problems and their own potential as a driving force to address of their own problems.

   Phase (ii) identification and formulation of the problem and recognition of the root of problem.

   Phase (iii) formulation of objectives, is purpose of formulating what they activities in their territories. This is about the effectiveness of the achievement objectives such as to increase revenue, disease prevention and developing groups.

   Phase (iv) identification and recognition of potential resource constraints, which is a process to recognize and exploit all the potential that exists in the target area surrounding both man and nature that need to realize the achievement of the objectives of the program. Similarly, constraints, weaknesses or shortcomings and obstacles have also to be identified.

   Phase (v) Selection of alternatives include the analysis of the opportunities or possible activities that can be utilized to solve the problem. Choice of activities is the most likely based on the sequence needs and capabilities of local community.

   Phase (vi) formulation of programs or activities, carried out after all stages were done. Formulation of the program is to create a list of activities as a response to the needs and problems identified by community..

b) Facilitation of business group activity, is any activity by a group of community members in order to improve their quality life either physically or mentally with steps set as following:

- Identify needs of group members to take inventory and sorting needs of group members in accordance with existing situation and conditions.
- Collecting potential members data to record all potential and resources in location with community. Data can be used as information to all parties or as a basis for planning program by community.
- This activity is done to get everything needed to implement the activities that had been prepared beforehand.
- Conduct technical and strategic preparation to realize the proposed activities.
- Realizing business activities accordance plan. Main reference for realization activities is agreement with looking at developments taking place. If any new developments influencing business or activities, needs to be adjusted actual conditions involve agreement of members.
- Controlling progress and make improvements if necessary. Controls in the form of monitoring or periodic evaluation through various ways such as group meetings.

c) To provide opportunities and role of women, men or women's groups are often marginalized in community activities and groups in decision making activities. They have to be facilitated to play a role in all phases of the program tailored to task and capabilities.

d) Activities conducted by group, is impossible through individual approach. The group approach is the base of economic activities, skills, institutions and relationships with outside parties.

e) Increasing the capacity of groups through training, carried out by qualified personnel according to type of expertise and experience required training. Training modules and curriculum need to be develop in order to have a more focused program..

f) Utilization of appropriate technology, does not eliminate traditions or customs of society in daily activities. Habit of society is tradition that support and stimulate efforts to improve economic and community skills such as agriculture activities and equipment used. Appropriate technology utilized to encourage and give motivation to community for improve the welfare of their daily life, accessible and simple / can be done by the community.

g) To provide incentive in the form of materials,, skills and funding. Assistance provided as grants is expected to be developed as initial capital. This needs to be explained to the public so that it will not use as precedence for continuous dependence. Similarly, the procedures should be agreed in order not to create the feeling that can lead to prejudice and jealousy among the members of the public.

h) Utilizing a familial spirit, that take advantage of the prevailing pattern of relationships in the community. In building relationships among people and with outsiders, this spirit is the spirit prevailing in the middle of society. This is a local potential that needs to be taken into account, for example in the settlement of internal and external conflicts, this spirit is usually effective in solving the problems. This local wisdom combined with external resources will become a major driving force for further development of society.

i) Establish a dialogue, consultation and coordination with all interested parties. This is necessary are to integrate the interests of stakeholders, and the roles and responsibilities of each in implementing the program.

4.7. Water Saving Irrigation

To calculate the obtained, water saving and its relationship with the operational cost of the pump, a pilot project was created with furrow irrigation with suppliers using flexible pipe (diameter 3 "). Furrow Irrigation was created with the concept of conventional irrigation approach commonly applied to the surrounding community. Water saving efficiency was then calculated by the difference in the amount of water used . Volume of water used in sprinkler irrigation systems can be

obtained by calculating the amount of operating time during the growing season, at the same operating pressure operation. Gun sprinkler used was type BIR V.1 (engineered by Experimental Station of Irrigation) which operated at a pressure of 4 bar with 9,11 liters / second. Pattern sprinkler operations are conducted with two operating simultaneously. Every provision of irrigation water poured discharge 18,22 liters / second. Calculation of irrigation water usage calculated as in Table 3.

Table 3. Data of calculation and use of sprinkler irrigation water flow.

Irrigation Method	Area (Ha)	Operating Time (Hours)	RPM	Operating Discharge (l/det)	Volume Per Ha (liter)	(m3)
Sprinkler (2 operated) Pressure 4 bar	6,26	391,2	1400	18,22	4.098.976	4.099
Flow, pressure 4 bar	0,02	6.98	1400	6.98	8.166.600	8.167

Total irrigation water use during the planting season was 391.2 hours of operating time. Irrigation water use on 6.26 hectares which was operating at a pressure of 4 bar, was at 25.65959 million liters or a total of 25 660 m^3, so that if converted into a per hectare, with irrigation water use sprinkler irrigation system amounted to 4,098,976 or equivalent 4099 m^3.

So also with the calculation of water use with furrow irrigation system, calculated based on the amount of water on tap from the nearest riser with 1400 RPM spin pressure, was equivalent to 4 bar pressure in the sprinkler. Based on the calibration discharge coming out of the hose (outlet) for the supply of irrigation water to flow amounted 6.98 liters / second operating system in conjunction with irrigation sprinkler irrigation.

Water use irrigation calculated from the discharge that comes out of the outlet hole multiplied by the total operation time during the growing season. Total operating time for the pilot project area of 0.02 hectares is six hours during the planting season, so the total irrigation water use for irrigation per growing season inundation of corn amounted to 8.1666 million liters or equal to 8167 m3.

By seeing the above mentioned data occur very striking difference in numbers between the use of irrigation water between the two methods. The use of irrigation water supply by a greater flow four times higher than the gun sprinkler irrigation. Therefore, when calculated from the water saving sprinkler irrigation can save water use by 49.8%.

4.8. Financial Profitabilty of **Farming**

Analysis profitability of farming shows that planting corn with gun sprinkler irrigation systems in up lands is financially with the estimated incremental the B / C ratio of 2.1.

Figure 6. Preview at Location pilot project with (a). with sprinkler irrigation water supply (b) corn crop before harvest (c). Corn harvest

When compared with maize with furrow irrigation, sprinkler irrigation was quite promising. It could increase farmers' income amounted to 33.93% or nearly 40%. This is because sprinkler irrigation can produce crop water requirement in the root zone fairly uniform, and with low operating costs. If viewed from the operating costs, sprinkler irrigation can save operating costs of irrigation during a growing season by almost two-fold from that of canal irrigation.

4.9. Participatory Management and Integrated Patterns With The Farmer and Inter-Stakeholder Partnerships.

Development and management of irrigation system that aims to realize the benefits of water in agriculture was held in a participatory approach. Parties involved include the government, researchers, farmers and businessmen. The fourth element is a part that can not be separated and need one another. With the integration of the various parties, farmers can obtain guarantees from cultivation to marketing stage.

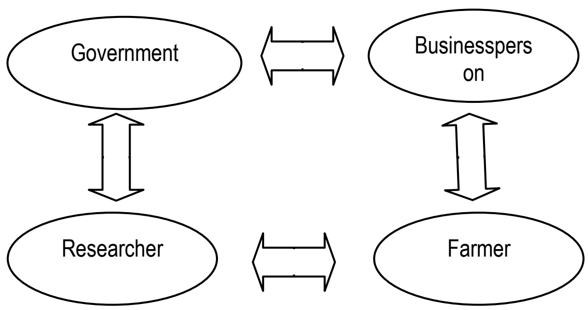


Figure 7. Interaction between farmers and stakeholders in partnership approach

The government agencies that played role in this research is Groundwater Management Agency / City Agriculture Office / City and National Land Agency (BPN), researchers in this case is the Central Irrigation Water Resources Research and Development Center, University of Mataram and R & D Center Sebranmas. While business people involved are PT. Golden Gate and the Cooperative Welfare NTB (maize), PT. HM. Sampoerna (Small Virginia tobacco), PT. Garuda Food (peanut) and the Cooperative Welfare Mataram (SM).

Groundwater Management Agency / City on duty to ensure the availability of water, the Department of Agriculture / City provides assistance for cultivation by farmers. While local BPN has pursued a policy of agrarian reform through a program providing free certificates to farmers, so that land can be used as collateral. In general, most farmers have no collateral and could not get loans from banks. With this partnership is expected the number of farmers who can manage the land increases. Until now, in Akar-akar villages there are 213 people who were members of farmer group union Putra Mandiri will receive a free certificate in July 2009.

Researchers in this case is Institute for Irrigation Research and Development Center of Water Resources, University of Mataram and Socioeconomic Research and Development Center for Culture and the Role of Civil Society (Sebranmas). Because sprinkler irrigation is a new technology for farmers in Akar-akar villages and application technology of sprinkler irrigation needs to be supported by adequate resources advanced irrigation management that is able to understand standard operating procedures (SOPs) are either in operation JIAT using sprinklers. It has prepared guidelines for the operation and maintenance. Moreover, to improve the performance of community groups, the Natural Resources Research and Development Center in conjunction with R & D Center Sebranmas in implementing full-scale test model of the development of sprinkler irrigation system, has been engaged in socialization as a first step for the introduction of sprinkler irrigation technology to community in Akar-akar Villages, North Lombok and West Nusa Tenggara. Institutional strengthening including mentoring, training and formation of the embryo begins WUA's working group. Mentoring activities include several hamlets: Batu Keruk, Lembah Pedek, Batu Gembung / Arungan Bali, and Dasan Gelumpang.

Businessmen involved in this trial has stimulated and encouraged the partnership of farmer groups, especially in the hamlet of Batu Gambung, Btu Keruk and Lembah Pedek by providing production facilities and accommodate the sale of crops. PT. Gerbang NTB Emas and Cooperative Welfare NTB (corn), PT. HM. Samporena (Small Virginia tobacco), PT. Garuda Food (peanut), Cooperative Welfare Mataram (SM), which holds the corn crop so that there is guarantee a market for farmers, NGOs, Universities, and other community organizations. Two local companies that handle the production of corn has partnered with PT. Surabaya Wonokoyo ready to receive the corn production of value added to the quota in 1000 tons / month.

5.1. CONCLUSIONS AND SUGGESTIONS

5.1.1. Conclusions

Based on the results of studies in the field, it can be concluded that:

(1). Gun sprinkler irrigation potential to be applied on up land farming in porous soil with high sand fraction content, such as Akar-akar village, North Lombok, NTB that water availability is very limited. From the results of field testing the gun sprinkler irrigation system is capable of providing uniformity provision of good water up to 85.23%.

(2). Sprinkler irrigation is one of the most potentially effective technology in order to optimize the ground water irrigation and up land farming development. With sprinkler irrigation, water requirements can be reduced to 49.8% when compared with conventional methods groove system.

(3). Maize farming with gun sprinkler irrigation is financially profitable and feasible with the estimated incremental B/C ratio of 2.1

(4). Participatory management and integration through partnership between stakeholders are very influential factors in the optimization of sprinkler irrigation and consent such a program has been able to increase the income and the welfare of the communities in Akar-akar village

5.2. Suggestions

1). Because soil fertility and characteristics in the survey locations have a low N and P contents the improvement of soil is necessary by providing inputs of manure or other organic materials from agricultural waste and by providing N and P fertilizers timely.

2). To Sustain the implementation of gun sprinkler irrigation technology introduction of high economic value crops in addition to existing maize crop so that the benefit obtained can be used to support not only the O and M cost but also the new investment in the future

3). As some components of gun sprinkler **might be** expensive and they have to rely on import further program is needed to improve domestic capacity in producing appropriate technologies. Intensive care, is needed for operation and maintenance, especially in terms of treatment components.

4). There is a need to develop a diversified farming systems in order to exercise integrated pest management and to obtain optimum and sustainable revenue from farms located in the study area.

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