Asian Journal of Applied Research for Community Development and Empowerment. Vol 8 (2024), No.2

AJARCDE
ASIAN JOURNAL OF APPLIED RESEARCH FOR COMMUNITY DEVELOPMENT AND EMPOWERMENT

Journal home page: http://ajarcde-safe-network.org ISSN 2581-0405

Technological Innovation Drip Irrigation for Dry Land Chile Farming in Rural Salut, Kayangan Sub-District, North Lombok Regency, West Nusa Tenggara, Indonesia

Halil Halil[1], Taslim Sjah[1]; I Ketut Budastra[1]; I Gst Lanang Parta Tanaya[1], Efendy Efendy[3)], Fakhrul Irfan Khalil[3]

1). Study Program of Dry Land Agriculture, Postgraduate Program at Mataram University, and Study Program of Agribusiness, Master Degree at Faculty of Agriculture, University of Mataram, Indonesia.
2). Study Program of Agribusiness, Agricultural Socio-Economic, Faculty of Agriculture, University of Mataram, Mataram, Indonesia
3) Agricultural Engineering Faculty of Food Technology and Agroindustry Study Program, University of Mataram, Indonesia.

ARTICLE INFO

Article History:
Received: 23 May 2024
Final Revision: 17 June 2024
Accepted: 19 June 2024
Online Publication: 20 June 2024

KEYWORDS

Innovative Drip Irrigation, Dry land, Horticulture, chilli farming, Action research

CORRESPONDING AUTHOR

*E-mail: hkholil50@gmail.com

A B S T R A C T

The high cost of surface irrigation in dry land vegetable farming is a serious problem farming households face yearly. Therefore, innovation in drip irrigation technology with an automatic gravity control system using plastic waste is very necessary for the irrigation of dray land vegetable farms. This research aims to analyze and find savings in irrigation water use, cost efficiency, and profitability of drip irrigation technology. It was a short- to medium-term action research method that started at the beginning of the dry season. The research approach applied is participatory action research, namely action research by applying a rural community participatory approach. The results showed that innovative drip irrigation technology could save water and casual labors. Drip irrigation technology is profitable and financially and economically feasible for dry-land vegetable farming. However, there is concern that this technology will be difficult to implement in rural areas of Rural Salut because of the relatively expensive materials and equipment for drip irrigation. Therefore, irrigation equipment can be adjusted or adapted to overcome the high cost by replacing some components with cheaper and more readily available materials. The water requirement for chili cultivation in one growing season is around 22,000 liters per 500 m2 at IDR 150,000. Meanwhile, by manual method (surface flow), namely by draining water from drilled wells to the planting area of 75,000 liters per 500 m2 with a monastery of IDR 400,000. This proves that drip irrigation technology can save water and energy. The chili farming calculations show that the financial turnover obtained from chili cultivation using drip irrigation technology was IDR 5,525,000 per 500 M2, while that obtained by local farmers was IDR 3,365,000.00 per 500 M2.

1. INTRODUCTION

1.1. Research Background

Various studies have been and are being carried out in North Lombok Regency (NLR) by researchers in the Research and Development Agency, lecturers at universities, and students on dry land management as a strategy to strengthen food security and food sovereignty. However, very few studies have specifically analyzed the development of gravity control system drip irrigation as a climate change adaptation strategy that supports food security. There is relatively little available irrigation water during the dry season and the cost of irrigation for vegetable farming with pump well water is relatively expensive (IDR 40,000 -IDR 50,000. - per hour), and a lot of water is absorbed along the canals, so that the water that reaches the plants is not up to 75%. The need for water for irrigation of vegetable and seasonal fruit crops is more or less the same as the need for irrigation water during the rainy season. Dryland farmers only cultivate vegetables during the rainy season, while farmers' main concern is farming on dry land. To overcome the need for water in times of water shortages is to use drip irrigation. In drip irrigation, irrigation can be adjusted to the water needs of each type of plant, which varies depending on the growth phase and type of plant. In farming in yards, the need for water is very important, considering that water is one of the determining factors for plant growth. With drip irrigation, water can be used more efficiently, and farmers can grow crops anytime.

The production of horticultural crops (vegetables and seasonal fruits) has the potential to wastewater. The main characteristics of horticultural crops require sufficient but not excessive water, requiring farmers to provide water with frequent frequency and in amounts that often exceed the needs of the plants. So, it is common for us to see farmers watering their plants every morning and evening, especially during the dry season.

The development of horticultural farming based on seasonal vegetables and fruit on dry land in Rural Salut, Kayangan District, North Lombok, has made a significant (positive) contribution to strengthening the economic empowerment of farmer households [1,2]. The magnitude of this contribution is indicated by the large farm income per farmer household in each production process. Production activities can be carried out by each farmer twice to 3 (three) times a year because it is supported by the availability of water from boreholes, water pumps and agricultural machinery facilities such as hand tractors assisted by the local government [2].

The profit of seasonal vegetable and fruit farming can increase if the share of irrigation costs is saved (efficient) because the proportion of irrigation costs is the largest in the cost structure of horticultural farming based on seasonal vegetables and fruits [2]. The large proportion of irrigation costs in vegetable farming in the dry land of North Lombok is due to the manual irrigation system from drilled wells to the planting area for IDR. 40,000 to IDR 50,000 per hour. In addition, manual surface irrigation systems in the dry season tend to be wasteful of water because it is estimated that the water reaching the farming area does not reach 75% because most of the water is absorbed along the canals.

In the dry season, very little water is available, while the need for water is more or less the same as the water requirement in the rainy season for irrigation of seasonal vegetable and fruit crops. Meeting the need for water during hard water times (dry) can be overcome by using drip irrigation. In drip irrigation, irrigation can be adjusted according to the water needs of each type of plant, which varies depending on the growth phase and type of plant. Meeting the water needs in seasonal vegetable and fruit farming on dry land is very important because water is one of the main inputs and becomes a determining factor for plant growth. Water can be used more efficiently by applying a drip irrigation technology.

Management of water resources and proper utilization are the most important factors in determining the success of farming in terms of quality and quantity in increasing crop production. Water content in the soil is one of the important things in crop production. The success of the planting system will be achieved if the amount and time of water administration are regulated. Excess and lack of water will also inhibit growth and affect crop production. Water is needed for plant growth as a medium for transporting nutrients from the soil to all parts of the plant. In general, irrigation management aims to maximize crop production in terms of efficiency, operating costs, and operational ease. Therefore, drip irrigation is an option for irrigation water, but its efficiency must be proven through intensive and in-depth research. Drip irrigation systems can be used for almost all types of plants, such as vegetables, fruits, vines, and other plants with high economic value.

One of the drip irrigation systems that has not been widely tried and researched is the gravity drip irrigation system, which has not been well developed, and there has not been much research related to the gravity drip irrigation system. Even this is only done with an infusion tube, as done by Ref. [3].

Related to increasing the ability of farmers to cultivate profitable seasonal vegetables and fruits on dry land, this is greatly supported by irrigation factors and agricultural machinery such as tillage tools because the cost of cultivating land is relatively high. Therefore, irrigation facilities require the government's attention to implement its policies in empowering farmers. Researchers should carry out their roles and functions in improving and increasing farmers' ability in aspects of Better Farming, and the agricultural extension officer should support and provide information to farmers so that Better Farming is perfect. Vegetable farming in Kayangan District has also been carried out in several villages, such as in Amor-Amor and Gumantar Rural areas, because the development of horticultural agribusiness based on dry land vegetables aims to support the tourism industry in North Lomok. Therefore, information and scientific findings are needed through research on the Development of Drip Irrigation technology with a Gravity Control System in Dry Land Seasonal Vegetable Farming in the Rural Salut area, Kayangan District, North Lombok Regency. The research results are expected to be considered in developing horticultural agribusiness to strengthen the economy of farmer households and support aspects of food security [4]. The research question should be whether innovative drip irrigation technology can save water use and how much it can be cost-efficient, profitable, and financially and economically feasible.

It was a short- to medium-term action research method that started at the beginning of the dry season. The research approach applied is participatory action research, namely action research by applying a rural community participatory approach.

1.2. Research Objective

This research aims to analyze and find savings in irrigation water use, cost efficiency, and profitability of drip irrigation technology fro dryland chilli farming.

2. MATERIALS AND METHODS

2.1. Method and Approach

The research was conducted on farmers' land belonging to the Pade Girang Farmers Group in rural Salut. There is a Borehole

TM 151, and the farmers always continuously farm vegetables with surface irrigation. The research was a short to medium term Action Research study (Short to medium Action Research), which begins in early May 2021 and March 2022 (every entering the dry season). Therefore, the Participatory Action Research method was the research method applied is, namely Action Research by applying a rural community participatory approach. The reason for choosing the Participatory Action Research method is because this method is considered to have several advantages in the process of introducing an innovation that has not been widely disseminated in a group of people. This method has several advantages [5, 6], including the fact that action research is based on objective and actual direct observation results, it is relatively flexible in conducting treatment models that will be tried out, and it works with on-the-spot experimentation.

This activity was divided into 3 stages, namely the initial stage (preparation), the implementation stage, and the final stage, all carried out for approximately 8 months. The implementation stage of this activity is divided into several stages, namely: (1) The design of tools/materials (assembly) begins with the preparation and measurement of planting media (making planting beds). (2) Preparation of tools and materials followed by designing and drawing a sketch of the Control System flow of the control circuit used in the installation of the device; (3) setting the drip irrigation network installation, (4) testing the emitter; (5) test the performance of drip irrigation networks on plants; (6) Observation, data processing.

The design of a drip irrigation system utilizes gravity pressure to drain water from the reservoir to the plants. The reservoir's main pipe (Brand of PIPAKU) measures 1.5 Inc., and the lateral pipe used in the drip irrigation system is 0.5 inches in size and consists of two lines in one planting bed. With a length of 25 meters each, each side is paired with a dropper (emitter) according to the spacing of the chilli plants.

The design of the Drip Irrigation System includes testing the dropper (emitter). The emitter used in the drip irrigation system design is a regulating stick emitter. The emitter used in the design of this drip irrigation system is a regulating stick emitter. Some of the parameters used in testing the characteristics of the dropper are the dropper discharge, operating pressure (head), the relationship between the dropper discharge and the operating head which is known as the emission component, the coefficient of variation of the dropper, the diameter of the dropper and the wet volume of soil.

2.2. *The formula of Dropper Discharge (Q) is [7]*

$$Q = \frac{V}{t} \ldots . (1)$$

Q = Dropper discharge (l/hour)
T = time (hours)
V= Volume (liters)

2.3. *Dropper coefficient of variation (CV)*

The dropper coefficient of variation (CV) [7] is a static parameter with which values are compared standard deviation of the dropper with the average dropper discharge, from a number of dropper samples tested with the same operating head.

$$CV = \frac{S}{Q_{avs}} \ldots . (2)$$

CV = Coefficient of variation
Q_{avs}= average debit (Liter per hour)

S = Standard Deviation

Observation and data collection includes plant growth (plant height and development of number of leaves), plant production. Observation time for several parameters is divided into: (1) observations are made every two days to calculate water requirements and room conditions in the planting beds; (2) Observation of growth every once a week until the plants are 90 days old—observation of plant production at each harvest.

The product testing phase is as follows: (1) Prepare tools and materials and determine the object of testing on the dropper. This tool has one reservoir with a volume of 3200 liters. (2}; (3) Place waste plastic cups under each output you want to test. Operate the drip irrigation circuit, then calculate the volume of water accommodated in each tank for the distribution of water in plastic cup waste using a measuring cup; (4) Testing the relationship between Discharge (Q) and Time (t) for 2 minutes, 4 minutes, 8 minutes, and 12 minutes in the process of distributing water to each water distribution holding tank and 10 discharge interval; (5) To test the relationship between Debit (Q) and Time (t) you can use the following equation: Q=V/t; (6) The next stage is to analyze the achievement of the goals achieved, the sustainability of the next program, and to prepare progress reports.

2.4. *Data analysis method*

This quantitative data was gathered from the experimental research. This research focuses on profitability, economic efficiency, and profit and loss analysis [8,9]. The data analysis techniques used in this study are as follows:

π = TR – TC

Description
TR = Py. Y and TC = FC + VC
Where:
π = Py. Y – (FC + VC)
π = Income (profit)
Py = Commodity Price of shallots
Y = Profit
FC = Fixed Costs (fixed costs)
VC = variable cost
TR = Total Revenue (total revenue)
TC = Total cost (total cost)

3. RESULT AND DISCUSSION

3.1. *Drip Irrigation System Performance*

This drip irrigation system utilizes gravity pressure and water pressure from a water reservoir as a 3,300-liter Volume Reservoir as a water source (reservoir). The water is channeled to the plants. The main, manifold, and lateral pipes used in the drip irrigation system have the size of the reservoir, which is a 1.5-inch pipe (Brand PIPAKU) that branches to a Parallon

https://doi.org/10.29165/ajarcde.v8i2.422

consisting of two lanes of lateral pipes on a raised bed with a length of 30 meters. In each 0.5 Inc pipe that is installed laterally, a dropper (emitter) is installed. The dropper (emitter) used is a regulating stick emitter installed on the right and left lateral sides connected to a 5mm adapter and nipple with a distance of 40 cm (according to the spacing of cayenne pepper). In contrast, the distance between the pipes on the right and left sides is 60 cm (according to the bed size) as shown in the picture.

Table 1. Specifications for the Components of the Drip Irrigation System.

No	The component	Specification
1	Main pipe	PVC (PIPAKU) diameter 1,5 -inches with a length of 20 mch
2	Manifold pipe	PVC diameter ½ inch the length 40 m (10 sticks)
3	Pipa lateral (on the raised bed)	PPC diameter 0,5-inch length 840 m (210 sticks)
4	Supporting components	Stop Faucets, Valves, Water Faucets, Knee and T Connectors
5	The source of irrigation water	Drill Well TM 151 depth of 110 meter110 m,
6	Reservoir	Tank volume of 3,200 L, filled with a water pump machine Tandon volume 3.200 L, filled with a water pump machine
7	The name of the Water Pump Machine	TM 151

Drip irrigation is carried out on dry land rice fields where the average water content is unknown because laboratory analysis has not been conducted. Therefore, for the sake of analyzing the physical properties of soil as a planting medium based on drip irrigation, the role of soil experts must carry out laboratory tests on soil moisture content, texture, and structure. Data on the physical properties of dry land soils such as soil water content are needed to analyze the physical properties of the soil.

Table 2. Calculate plant water needs and operational time of irrigation.

Plant	Plant Coefficient	Plant water need	ETc Operational time (Hours)
Vegetative growth	0.65	4.33	0.75
Water stress for flower induction	0.00	0	0
Flower development	0.78	5.5	0.92
Fruits formulation	0.55	3.7	0.64
Young fruit growth	0.63	4.34	0.73
Fruit growth	0.80	6.15	1.05
Fruit ripening	0.76	5.4	0.93

Observations were made at the age of 8 days after planting, which was marked by the condition of the soil dried up because planting was carried out at the beginning of the dry season. So, irrigation water was only sourced from drilled wells, which were stored in reservoirs of 3200 volume. By the time the plants were 8 days old, the plant roots had started to develop fully. Absorb nutrients from the soil. The parameters measured were the growth of the number of leaves and the volume of irrigation water given at each irrigation. The dropper used illustrates that the lower the CV value produced, the better the performance of the dropper type. The EU value of 65.50% is categorized as low because there is head loss due to inappropriate drip irrigation system components.

From the observations that have been made, the average discharge of droplets using gravity pressure is 0.78 L/hour, while the average discharge of droplets using pump pressure is 1.25 L/hour. Calculating the uniformity of dropper discharge for irrigation using gravity pressure obtained a CV value of 0.27 and an EU value of 65.39%. The CV value indicates that the dropper-type constant is used. The lower the CV value generated, the better the performance of the dropper type.

The results of drip irrigation dropper count that uses gravity are calculated with

$Q = \frac{v}{t}$ dan $Cv = \frac{s}{Q_{avs}}$ obtained a CV of 0.30 which indicates that the dropper type constant used illustrates that the lower the CV value produced, the better the dropper type performance. The EU value of 65.50% is categorized as low because there is a head loss in the system due to the use of drip irrigation system components that are not appropriate.

The amount of water cayenne pepper plants need during evapotranspiration depends on weather conditions and crop efficiency. Observations showed that the average minimum and maximum temperature conditions around cayenne pepper (Rural Salut) were between 24^{o}C – 30^{o}C. This temperature is very suitable for growing cayenne pepper plants because the ideal temperature for chilli seed germination is 25-30oC. Cayenne pepper can adapt to temperatures of 24^{o}C – 27^{o}C with humidity that is not too high. The growth of hybrid chilli plants requires a temperature of 24^0-28^{o}C. Temperatures that are too low will inhibit plant growth. In addition, the growth and development of flowers and fruit is less than perfect.

Air humidity is the relative ratio between air and water vapor in an area. The higher the water vapor content, the higher the air humidity. In chili planting, environmental humidity becomes more important to note because it is related to the development of disturbing microorganisms. The relative humidity needed for the growth of chili plants is around 80% 10].

The results of the study illustrated that the application of drip irrigation water in the vegetative phase for the highest plant height parameters on average was at the age of 10 days given about 50% water, at the age of 20 days it was given 60% and at the age of 30 - 40 days it was given 75%, the primordia phase (40 -50 days) providing water that can produce an average maximum number of flowers is giving water 80% of the plant's water needs in the fertilization phase (45, 55 days) providing water that can produce an average maximum number of ovaries is 85%. At 55, the provision of water, which produces an average maximum interest, is 85%. In the chili fruit ripening phase at 70 days, the amount of water that can produce the maximum fruit weight is 85% of the plant's water requirement. Water use efficiency is the ratio of the average water supply to the average water use for each phase. The efficiency of water use with drip irrigation is at the age of plants 0-10 days = 50%, 10-20 days = 60%, 30-40 days = 75%. The percentage of water supply with the drip irrigation system illustrates that the provision of irrigation water for cayenne pepper plants does not have to be 100% full of the plant's needs, but depends on the plant growth phase (vegetative phase and generative phase) and when the rainy season starts.

Figure 1. Installing plastic mulch on the planting medium before setting the paralon drip irrigation pipes.

Figure 2. Initial setting of drip irrigation on the raised

 https://doi.org/10.29165/ajarcde.v8i2.422

bed

Figure 3. Cayenne pepper plants with drip irrigation aged 2 weeks and three weeks

Figure 4. Performance of cayenne chilli plants with drip irrigation during generative growth

Table 3. Observation of Land Area, Amount of Water and Number of Irrigation Workers in Chili Farming Way Before drip irrigation (Surface irrigation)

No	Observation items	Surface irrigation	Drip irrigation Technology
1	Land Area	1,000M^2 (Control)	1.000M^2
2	Water irrigation need	150.000 Liter/ 6 months	57.600 Liter/6 months
3	Total irrigation costs	IDR 900,000, -	IDR 440.000, -
4	Variable costs	IDR 650,000, -	IDR 650,000, -
	Total Cost (4 +5)	IDR 1,550,000	IDR 1,090,000
5	Total Revenue	IDR 6,730,000, -	IDR 9,050,000, -
6	Profits	IDR 5,180,000, -	IDR 7,960,000, -
7	Casual labor	5 Persons	1 Person
	R/C	4.34	8.30
	Profit margin) (%) = *(Profit / Total Profit) x 100%*	76.97%	87.96%

The results of the study illustrate that the actual amount of irrigation water needed in the application of drip irrigation systems in chilli farming during vegetative growth to generative growth is 57,600 litres for an area of 1,000M^2 at the cost of IDR 440,000 (diesel fuel). This amount was obtained from the suction from the Bore Well, which was then accommodated in a 3,300-liters volume tank as a reservoir. After six months, drip irrigation was not operated because the rainy season has arrived. At the same time, the volume of water for manual irrigation (surface flow), namely by channeling water from bore wells to the on-farming area through simple irrigation canals, is 150,000 liters per 1,000 M^2 for IDR 900, 000 (for 9 hours of irrigation for IDR 50,000 per hour). This proves that innovative drip irrigation systems could save water use and casual labor costs.

The main advantage and benefit of innovative drip irrigation on dry land is that farmers can grow vegetables outside the season and are not dependent on the rainy season. Chili harvest was carried out 11 times, and revenue was calculated for each harvest. Harvesting is done every week. Chili sales are done by weighing—total revenue of IDR 9,050,000. - was obtained from selling 526 kilograms of cayenne pepper. The average income per harvest was IDR 456,000.00, and the total profit was IDR 7.960.000. during one growing season for about 11 months. It was greater than the profits of surface irrigation (IDR 5.180.000). Chilli farming without drip irrigation with an area of 1,000M^2 produces 168 kg of fresh chilli with an average yield of 3.75 kilograms per plant. The average selling price of chilli was IDR 30,000. Per kilogram (the price rank IDR 20,000 to IDR 120,00). The farmers usually get pick season and high chilli prices from January to April yearly. Total Revenue earned in one growing season was IDR 6,730.00, and the profit was IDR 5.180.000. The greater profits of chilli farming by drip irrigation technology indicated that the innovative drip irrigation technology is more profitable than the surface irrigation system.

4. CONCLUSION

Developing innovative drip irrigation technology for fresh vegetable-based horticulture, such as cayenne pepper and seasonal dry fruits, proves efficient and water-saving. This technology reduces production costs, increasing total revenue and profits for farmers. The implementation of innovative drip irrigation in horticultural farming of seasonal vegetables and fruits demonstrates significant potential for enhancing household food security by boosting production and lowering farming costs, particularly those associated with irrigation and casual labor. This technology is especially beneficial for large-scale economic commodity farming, enabling farmers to grow fresh vegetables outside the traditional rainy season. Drip irrigation technology significantly reduces water usage, costs, and casual labor. For example, chilli cultivation using drip irrigation requires approximately 57,600 litres of water over six months per 1,000 square meters, costing IDR 440,000 for diesel fuel. In contrast, the manual surface flow method consumes 150,000 litres per 1,000 square meters, costing IDR 900,000. This demonstrates that drip irrigation is financially viable and more profitable than surface irrigation, as evidenced by the lower production costs and higher farming income and profits. Calculations indicate that chilli farming with drip irrigation yields a financial turnover of IDR 9,050,000 per 1,000 square meters, compared to IDR 6,730,000 per 1,000 square meters with surface irrigation.

To enhance dryland productivity, the development of innovative drip irrigation in seasonal vegetable and fruit farming should involve four key stakeholders: (1) Universities, as carriers of agricultural cultivation technology; (2) Government, as policymakers, facility providers, and supporters of agricultural facilities for farmers; (3) Agricultural Extension services, as transmitters of agricultural technology information; and (4) Entrepreneurs, as collectors and sellers of fresh vegetable and fruit commodities. Implementing innovative drip irrigation is crucial for accelerating the economic recovery of farmers post the 2018 earthquake and the COVID-19 pandemic. Feasibility analysis indicates that adopting a drip irrigation system is technically viable, financially feasible, and economically profitable, making it a promising alternative to enhance the productivity of dryland farming.

ACKNOWLEDGMENTS

This research was financially supported by the Institute for Research and Community Service, grant number 2751/UN18.1.1/PP/2021. Therefore, the authors thank the Head of the Institute for Research and Community Service, Mataram University, for the support during the fieldwork. The authors also thank the chairman and members of the farmer group of Pada Girang Salut village. They assisted us in setting up the drip irrigation network and observing and recording research data. Each research team member assisted with the data and review of the analysis results. We expect the farmer group would like to implement drip irrigation every planting season for chilli, tomato, long bean, watermelon and gold rock melon.

REFERENCES

[1] Halil; Sukartono; Saufi, A. 2017. Mempercepat Dan Memperkuat Keberdayaan Ekonomi Petani Pada Kawasan Penyangga Pariwisata Melalui Pengembangan Agrowisata Berbasis Agribisnis Hortikultura di Lahan Tadah Hujan Pulau Lombok Nusa Tenggara Barat. The Research Report of MP3EI.

[2] Halil, Sukartono, and Saufi. A, 2018; and Halil, Sukartono and Saufi, A. 2018. Mempercepat dan Memperkuat Keberdayaan Ekonomi Petani Pada Kawas, an Penyangga Pariwisata Melalui Pengembangan Agrowisata Berbasis Agribisnis Hortikultura Di Lahan Tadah Hujan Pulau Lombok Nusa Tenggara Barat. The Research Report of STRANAS (Institutional National Strategy Research).

[3] Ariana, A. N. T; Purnomo. R. H., Panggabean, T.; Juwita, R.. Aplikasi Irigasi Tetes (Drip Irrigation) dengan Berbagai Media Tanam pada Tanaman Pakcoy (Brassica rapa L.). Journal Keteknikan Pertanian, April 2018; Vol. 6 No. 1, p 93-100.

[4] Halil. H.; Taslim Sjah; Nurtaji W.; Sukartono; Saufi, A. 2022. Developing agribusiness vegetables and seasonal fruits for strengthening the economy of stallholder farmer households post the 2018 earthquakes and pandemic COVID-19 era in upland North Lombok West Nusa Tenggara. IOP Conference Series: Earth and Environmental Science 1107 (2022) 012092 2nd International Conference on Environmental Ecology of Food Security.

[5] urakhmad, W. 1990. *Pengantar Penelitian Ilmiah Dasar dan Metode Teknik Research*. Tarsito. Bandung.

[6] Nazir. 1988. Nazir, M. 1988. *Metode Penelitian*, Ghalia Indonesia. Jakarta.

[7] Keller, J and Bleisner, R.D. 1990. Sprinkle and Trickle Irrigation. AVI Publishing Company, Inc. New York, USA.

[8] Yotopolous, P.A. and Nugent, J.B. 1979. Economics of Development Empirical Investigations. Harper & Row, Publisher, New York, USA.

[9] Coelli, T. J. And Perelman, S. 1998. A Comparison of Parametric and Non-parametric distance Function: With Application to European Railways'. *European Journal of Operational Research*, Vol. 117: 326-339.

[10] Prayudi, B. 2010. Budidaya dan Pasca Panen Cabai Merah (Capsicum annum L). Badan Penelitian dan Pengembangan Pertanian, Balai Pengkajian Teknologi Pertanian, Jawa Tengah.

 https://doi.org/10.29165/ajarcde.v8i2.422