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Implementation of Soil Productivity Index for Estimating Yields of Rice, Soybean and Tobacco in Lombok

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Abstract: *A quantitative assessment of Soil productivity has been done for tobacco plantation area in Lombok. The output of this assessment is called soil productivity index (SPI) which is a percentage of crop yields obtained under actual soil and climatic conditions in the field, relative to potential yield under ideal condition. The aim of this study was to develop a robust soil productivity index for rice, tobacco and soybean. Data required were soil properties, namely: physical properties, chemical and fertility. of soils. Climate data included monthly precipitation (minimum 30 years) and daily rainfall data (minimum 10 years). The SPI was calculated using Normalized Storie Index Rating (NSIR) and Normalized Square Root Index (NQSRI). The results showed that Normalized Square Root Index gave greater output and better correlation value compared to Normalized Storie Index Rating. The SPI of rice ranged from 50 to 88 with average of 67. The SPI tend to increase when year was wet..The SPI for soybean ranged from 54 to 78 with average of 66. There was a little effect of year type on yield of soybean. The SPI of tobacco ranged from 30 to 84 with average of 61. Tobacco base -SPI tended to decrease when year was wet. Validation with RMSE showed that there was no significant different between actual (measured yield) with predicted yield. This means that the SPI values can be used as a better predictor of actual yield estimation in the fields.*

Keywords: *Soil productivity index, Normalized Storie Index Rating, Normalized Square Root Index (NSRI), .*

I. Introduction

Soil Productivity Index (SPI) is becoming an important method for increasing farming efficiency and sustainability.[1];,[2]. The SPI is a conceptual frame work for assessing crop performance in responding to soil-water and plant relationship [3]**,**[4];. Various methods for assessing land suitability have been widely developed for land evaluation [5]; [6], They were developed based on an empirical relationship between crop performance and diagnostic criteria [7] [8]. The output of land evaluation mode base on SPI is becoming more interpretable along with progress in computer science and geographic information system (GIS) which enable to convert numerical data into geospatial representing soil productivity [9]; 10];11];[12]). Bouma [13] stated that rapid change in land use must be accompanied by regular-evaluation -of updated soil survey data. The updating soil data is prescribed for a proper land use planning using modern technology [4], which requires better quality input data [6], and to incorporate more detailed climate information and soil moisture regimes and state of soil fertility and organic matter [14];.[15].)

Early attempt to apply quantitative methods in Indonesia was commenced in 1950s [7], to investigate productivity of irrigated rice fields in a period of 1950 to 1954 1950 to 1954 in Central Java**.** It was concluded from results of the investigation that soil characteristics played a major role in land productivity. .Riqiuer *et al* [16] applied a multiplication method to assess soil productivity in Java island. Parameters included in the model were effective soil depth, texture or structure of top soil horizon, cation status or soluble salt, organic matter, mineral content of B horizon, drainage and soil moisture content. However, this method was less adopted because of its inconsistency and difficulty in interpretation. Land Suitability Rating (LSR) was developed by University of Iowa for indexing suitability of land for field crops, such as corn and soybean in IOWA State, USA [17]. Storie [18] developed the Storie Index Rating (SIR) which multiplies rating of land characteristics for land evaluation in California, USA. Square root method was tested in Middle East by Khiddir [19]. Both methods are currently widely used in the middle East countries [14]

Sys *et al* [20] suggested that there are few modification on criteria and parameters required in using the Storie rating and the Root Square method. Adjustment subjected to change depending on seasonal crop variety, crop breeding, soil characteristics, and climate condition. Darvishi-Foshtomi *et al.* [21] stated that indices of >70, 50 – 75, 25 to 50, and <25 are equivalent to S, S2, S3 dan N for land suitability classification respectively.

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A quantitative method for soil productivity assessment has many advantages, mainly: quantitative criteria can be more flexible, reliable, objective and reproducible [17], Mustafa et al, [22]. However, it requires an extra effort to test its correlation with actual crop yields in different climate and soil regimes. Many worldwide experiments have been conducted for that purposes. Sys and Frankfart [23] found a strong correlation between land productivity index and yield of cacao (r=0.98), cotton (r=0.93) in Congo basin. Sys and Verheye [24] found correlation coefficient of 0.93 for rice in Thailand. Christianto and Hernusya [25] found that correlation coefficient ranged from 0.63 to 0.93 for several estate crops in Indonesia.

Land evaluation seeks to predict -behavior of land for a particular use. Land evaluation assesses all land indicators including indicators of soil quality, landscape, water, climate, and land use. Soil properties were assessed namely soil physical and chemical characteristic such as soil depth, texture, soil density, infiltration rate, soil moisture holding capacity, pH, carbonate concentration. Main inputs in land evaluation are parameters which are assumed as permanent and constant over time [3], while in fact soil parameters are varied spatially and temporally depending on various factors, namely climate variability and human intervention on land system [26]. It is no doubt that human role in land management could be positive, but over exploitation of land beyond its capacity results in negative impact to soil productivity [27]). In other word, land undergoes a dynamic change from time to time due to differences in the way of land management practiced, e.g. land use intensity, different types of plants introduced, as well as variations in landscape [26]. Karlen *et al.* [28] [29]; Doran et al [30] [31] found that quality of soil changing because of decreasing organic matter and soil erosion. Dilkova [32] stated that human aggressiveness in land utilization is a major factor for decreasing level of soil organic matter leading to degradation of soil quality. Therefore, quantitative models enable scientists to cove with such dynamic change of land characteristic, climate variability and plant species.

Furthermore, progress in modeling and computer application make it easy -to resolve -a complex formula being applied,[9], [33].[34], [35]. Analysis of land suitability with more parameters being included in the model could produce a simple indices which is getting close to real and actual land suitability. The aim of this study was to develop land suitability indices for rice, soybean, and tobacco-in Lombok under three climatic scenarios, namely dry, average or normal and wet conditions. The output of model are presented as SPI maps for five soil types in the study areas.

II. Materials and Methods

2.1. Research Location

This research was carried out in rice fields which are a center for tobacco plantation in dry season in Lombok. Cropping pattern in irrigated area was paddy in rainy season followed by second paddy in early dry season or tobacco, or secondary crops such as soybean, peanut and corn in late dry season. In semi irrigated area and rainfed area, cropping pattern were rice in rainy season followed by secondary crops including tobacco in dry season. Secondary crop in this research was focused on soybean and tobacco. Area of semi irrigated and rain-fed were situated in south part of Lombok where climate is drier (D4 and E4 [36]. Here, water availability is one of the most limiting factor for dry season crops.

Total area of tobacco plantation in The study location is 63117 ha [37]. This was divided into three categories based on historical background of tobacco plantation, namely main area (about 22974 ha or 36%), extended area (about 35326 ha or 56%) and potential area of tobacco (about 4817 ha or 7%). Main area refers to the area where tobacco has been subsequently planted after rice since 1960s. Currently about 70% or or about 15.000 to18000 ha of this area is planted with tobacco yearly. Soil type of this area mostly Inceptisols and Alfisols which are distributed at Sub District of Terare,. Sikur, Montong Gading and Sakra, East Sakra, West Sakra and Keruak in East Lombok. Sub District of Kopang and Batukliang in Central Lombok. Extended area refers to less irrigated area where climate is dryer and water is limited. About 15% to 20% of total extended area was planted tobacco yearly. This area is mostly dominated by heavy clay soils, Vertisols located in southern subdistricts of Lombok including West Praya, Southwest Praya, East Praya and Pujut in Central Lombok, and Sub District of Keruak and Jerowaru in East Lombok. Potential area refers area which was historically area of dark tobacco (chopped tobacco) and farmers are starting to grow *virginian* tobacco under supervision of tobacco companies in Lombok. This area is dominated by Entisols equipped -with good irrigation system, under climate type D3 and D4. This site is located at Sub District of Kuripan, Gerung and Kediri, southern part of West Lombok (Figure 1).

2.2. Source of Data

Most of climate data for this study were obtained from Research Center for Water Resources and Agroclimate, State University of Mataram. Period of climate data collected was ≥ 50 years of monthly rainfall data (from 1950 to 2007). Later data were obtained from BMKG dan BPTPH of Province of West Nusa Tenggara.Climate data were collected from stations that are close to study sites , namely: station Bebuak, sub District of Kopang, station DasanLekong (East Lombok), station Keruak East Lombok) , station Sengkol, and

Pelambik (Central Lombok), station Narmada (West Lombok) and BKMG of Mataram (City of Mataram). Of the seven weather station data logger is then retrieved a data while irradiation (radiation).

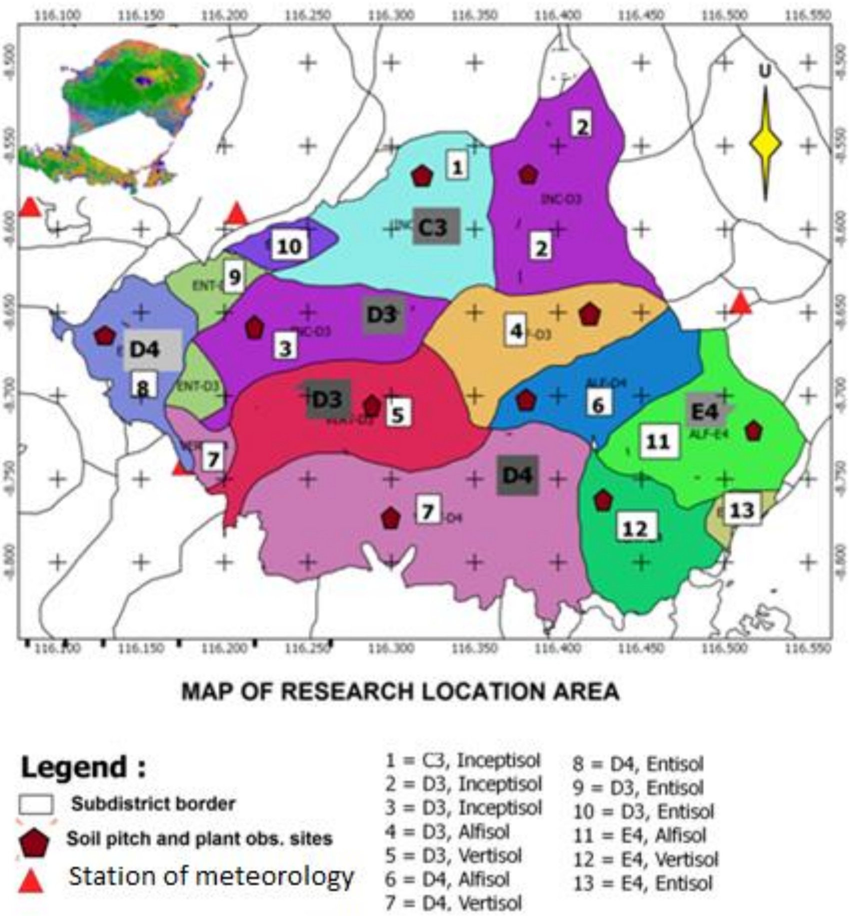

Figure 1. Study Sites in Lombok -

Primary soil data were collected in 2012 representing -four soil types. Each soil type was represented by providing proportional numbers of soil profile or mini pit. The four soil types were -Alfisols (3 pits), Entisols (1 pit), Inceptisols (3 pits) and Vertisols (3 pits). Soil properties were directly observed in *situ*, and soil samples were collected from the pits for laboratory analyses. Collected soil samples were analyzed in Laboratory of Soil Physics and Soil Chemistry, Faculty of Agriculture, State University of Mataram. Soil parameters were: soil texture (percentage of clay, silt and sand), fragmentation (percent gravel and stone content in soil matrix), soil organic matter, cation exchange capacity, base (alkaline) cation, base saturation (percent of base cations contributing to CEC), pH and salinity. Other soil characteristic and land characteristics were also directly identified in *situ*, namely: soil depth, soil layers (horizons) land slope, and drainage.

Field plant observation was carried in 10 sites not far from soil observation sites. Plant growth and crop parameters were measured at maturity phases during field survey. Crop parameters were measured were dry rice grain, dry soybean seeds, and dry tobacco leaves. The observation plots were proportionally distributed in four soil types representing three targeted area, namely: 3 observation plot on Alfisols, 3 observation plot on Inceptisols, and 3 observation plots on Vertisols and 1 observation plot on Entisols. Parameters for rice and soybean were observed in sampling plot of 5 m^2, while for tobacco was measured as systematic random sampling within 2 x10 m of crop line containing 32 plants. All plants in the 10 m length with five replication were sampled for estimating yield of tobacco.

Total number of respondents reviewed in this research was 180 farmers selected by means of purposive sampling to represent total tobacco farmers in targeted area. Criteria for selected respondents was: (i) respondent has experience in tobacco plantation more than 10 years, (ii) growing tobacco in area of more than 1 hectare per season and (iii) growing a similar variety i.e. virginia within main area, potential area or extended area. Respondents were proportionally determined base on population size, namely 60 farmers (main area), 30 farmers (extended area) and 10 farmers (potential area).

III. Model Description

SPI is used to estimate the potential productivity of the land that is reflected from the environmental carrying capacity of the soil, soil quality (physical properties and soil fertility). SPI expressed as a percentage which is the yield on actual conditions in the field relative to the maximum yield that may be obtained crop. Computation the value of SPI adopts the methods described Sys et al.[38]. Initial procedure is assigning ratingof characteristics of the soil and climate. Rating value is determined by comparing the actual properties of soil and climate with the desired or favorable properties of them for optimal growth crops. In this case Sys et al [20] has given explanation of land characteristics required for various types of plants. Rating value of 100 was given if the condition or nature of soils and climate are favorable or within a range of desired condition for particular crops. The rating value gradually decrease when quality of soils was lower than the desired condition. SPI was calculated by using Storie's Index rating [18] and Khiddir's Square Root Index (Khiddir,[19]. We normalize both original formula by means of giving inverse power to multiplication under bracket. The value of denominator was equal to the number of variables used in the formula. for example, if it is used eight variables, then the power was one eighth (1/8 or 0,25). The normalized formula of Strorie's and Khiddir's are presented as follows:

Storie formula (Storie, [18]:

$$NSIR = R_{\min}\left(\frac{CF}{100}x\frac{DRG}{100}x\frac{D}{100}x\frac{TXT}{100}x\frac{SOM}{100}x\frac{CEC}{100}x\frac{BS}{100}x\frac{TOC}{100}\right)^{0,125}, \quad (1)$$

Khiddir formula (Khiddir, [38]:

$$NSQRI = Rmin\sqrt{\left(\frac{CF}{100}x\frac{DRG}{100}x\frac{D}{100}x\frac{TXT}{100}x\frac{SOM}{100}x\frac{CEC}{100}x\frac{BS}{100}x\frac{TOC}{100}\right)^{0,125}}, \quad (2)$$

Where NSIR and NSQRI stand for Normalized Srorie Index Rating and Normalized Squar Root Index, CF, DRG, D, TXT, SOM, CEC, BS and TOC consecutively are: climate factor or rainfall, relative humidity, sunshine duration (solar radiation and average temperatures), drainage, soil texture, soil organic matter, CEC, base saturation, toxicity (average rating of pH and salinity). $R\text{-}_{min}$ is the smallest rating among all variables.

2.3. Data source: Raw data analyses

Period of data was minimum of ten years. Components of climate data were air temperature, humidity and radiation throughout the dry season starting from April to October. Data for study area with no climatology station were interpolated from the closest station nearby. Seasonal rainfall forecast in condition of either El Nino, La Nina or Normal used rainfall event with probability of 60%.

2.4. Estimation of Potential Yield of Crops

Agricultural Research Development of Ministry of Agriculture [39] reported that potential yield of rice variety INPARI 1-8 ranged from 7 -10 tons/ha. In this research, potential yield for the variety was 8 tons per ha, while on farm level, actual yield was 4-6 tons in paddy fields with S2 class. National Statistics Bureau (BPS, 2013) reported that production for rice in moderately suitable irrigated land (S2) ranged from 4.5 to 5.5 per ha on average. Potential yield for soybean was 2.4 tons /ha of dry beans. Soybean under proper cropping management with a raw space of 0.2 x 0.3 m could produce 2.0 per ha on average. Actual yield at farm level with broadcast seed ranged from 0.7 - 1.3 tones/ha. BPS (37] reported that actual yield for soybean ranged from 1.1 -1.3 ton. Actual yield for soybean observed from sampled plot under good cropping management in this study ranged from 1,7 to 2,0 ha. Litbang Pertnian (2008) reported the highest of soybean was 2,4 ton/ha. Potential yield for tobacco var. *Virginia* was 2,8 tons/ha cured leave, while actual yield at farm level ranged from 1,5 ton 2,3 tons/ha dry leave. This actual yield was recorded from sampling plot at seven locations in 2012 and 2013. Based on those study the potential yield of rice, soybean and tobacco are 7,5 ton/ha unhulled dry grain, 2,4 ton/ha dry seed and 2,8 ton/ha cured leave respectively.

2.5. Model Validation

Model was validated by means of Root Mean squared Error (RMSE) [40]; [41] [42] . Validation of model is comparison between simulated results of model and field observations to determines whether output of model matches with its intended purposes. This process aims to ensure that output of model accurately represent actual system. Process of model validation was done before the model used for simulation or estimation purposes in research activities or operations services [4]'[43].en [26];. Validation was also carried out by evaluating correlation between predicted yield (soil productivity index) and average actual yields for

rice, soybean or tobacco recoded from selected farmers' crops. Data of actual yields for model validation were derived from sampling plots grown by farmers at the study sites. Data were collected in 2012 and 2013 from ten locations for each crop being considered in this research. The sampling plots sites were at Batukliang, Sikur, Jonggat, and Terare to represent main area, Janapria, East Sakra, Jerowaru, Pujut), Batujai West Praya), to represent extended area, and Gerung, West Lombok) to represent potential area.
Furthermore the closeness of predicted yield and actual yield of field observation and recorded yiled [37] can be analyzed using Pearson correlation [44] expressed follows:

$$r = \frac{(n\sum_{i=1}^{n} X_i Y_i) - (\sum_{i=1}^{n} X_i)(\sum_{i=1}^{n} Y_i)}{\left(\sqrt{n\sum_{i=1}^{n} X_i^2 - (\sum_{i=1}^{n} X_i)^2}\right)\left(\sqrt{n\sum_{i=1}^{n} Y_i^2 - (\sum_{i=1}^{n} Y_i)^2}\right)}$$

value of r expresses the closeness of X and Y relationship. If r is squared (R^2) then the value expresses the portion of X causing Y value. Example R^2=60% means 60% of Y value is really due to X factor. The rest 40% is due unknown factors.

IV. Results and Discussion

3.1. Soil and Climate properties

Study area comprised of 39.% Inceptisols at northern part with relatively high rainfall (Fig. 1:1,2 and 3), 37% Vertisols at southern part with dry climate (Fig1: 5, 7 and 12), 9% Alfisol at eastern part extending from wet to dry climate (Fig 1: 4,6 and 11), and 5% Entisols at western part with relive wet (Fig 1: 8,9 and 13).The properties of soil in the study area were given in Table 1.- It is clearly indicated from Table 1 that the properties of soils were mostly -different in clay content, CEC, soil depth, drainage,-ca andMg concentration -. In general, all parameters were higher at Vertisols than others soils, e.g. Entisols, Inceptisols, and Alfisols.-. Cation exchange capacity (CEC) was the highest in Vertisols with average value of 32.08 cmol/kg. It was merely due to high clay content of 52.58%, though organic matter was the lowest among five soil types, i.e. Inceptisols 1.63%, Alfisols 1.34%, Entisol 1.33% and Vertisols 1.22%,Drainage was bad in Vertisols, while Inceptisols and Entisols were well drainage soils. Drainage in Alfisols was between Vertisols and Entisols
Crops responses to climate and soil properties varied in accordance to level of crop tolerance -to climate and soil characteristics. -. For example, rice is less sensitive to texture and soil drainage. It means that rice could reach its optimum yield in heavy clay soils with poor drainage. However, soybean and tobacco are verysensitive to the both parameters soil drainage.

Table 1. The properties of soil in the center of tobacco plantation area in Lombok

Soil Properties	Study location									
	Bkling	Sikur	Jngat	Trare	Jnpri	Sakti	Jr Wru	Pujut	PRB	Grung
Name of Soil	Incept	Incpt	Incp	Incpt	Alf	Alf	Vert	Vert	Vert	Ent
Climate type	C3	D3	D3	D4	D4	E4	E4	D4	D3	D4
pH_H_2O	7,11	6,79	6,53	7,23	7,53	6,92	7,49	7,23	7,43	6,58
EC(mmhos)	0,19	0,21	0,65	0,50	0,35	0,77	0,36	0,74	0,71	0,29
K(cmol)/kg	1,35	1,34	1,65	1,66	2,12	1,33	2,50	1,52	1,58	1,65
Na(cmol)/kg	1,65	1,24	1,18	1,27	1,24	2,26	4,73	3,60	2,70	1,24
Ca(cmol)/kg	10,90	11,25	9,78	9,63	12,98	10,5	12,80	14,6	16,0	9,46
Mg(cmol)/kg	0,98	1,12	0,88	2,01	1,07	2,56	6,85	5,50	5,99	1,03
CEC(cmol)/kg	17,96	18,64	17,95	19,50	19,45	20,4	30,74	32,9	32,6	17,70
BS(%)	0,83	0,80	0,75	0,75	0,90	0,82	0,87	0,77	0,80	0,76
SOM(%)	1,31	2,82	1,09	1,31	1,37	1,32	1,29	1,30	1,07	1,33
Silt(%)	34,43	32,33	22,98	36,07	27,30	28,0	23,80	25,0	30,7	39,19
Clay(%)	12,77	41,03	39,5	42,81	38,00	42,0	58,65	51,3	47,8	20,30
Soil BD	1,17	1,15	1,10	1,10	1,17	1,10	1,22	1,22	1,15	1,07
Depth	0,82	0,81	0,78	0,97	0,99	1,22	1,16	1,20	0,97	0,75
Permeabilty (.)	17,47	14,78	5,39	5,46	2,61	1,49	0,33	0,12	0,45	12,46
Drainage	Well	Well	Well	SW	SW	SW	Bad	Bad	Bad	Well
Slope (…)	5,00	4,86	5,00	4,12	4,96	5,00	3,08	3,01	3,61	3,60

Effect of seasonal temperatures, or monthly average temperature were different at every stage of -crop development. Spatial distribution of temperature in study area was presented in Figure 2. Temperature gradually decreased from south to north part along with increase in altitude. Maximum temperature ranged from 25^o to 25.8^o(with minimum temperature 20.4^o C at high land of north region, while maximum temperature at low land of south region ranged from 26.4^o C to 26.8^{o}C with minimum temperature 20.3^{o}C

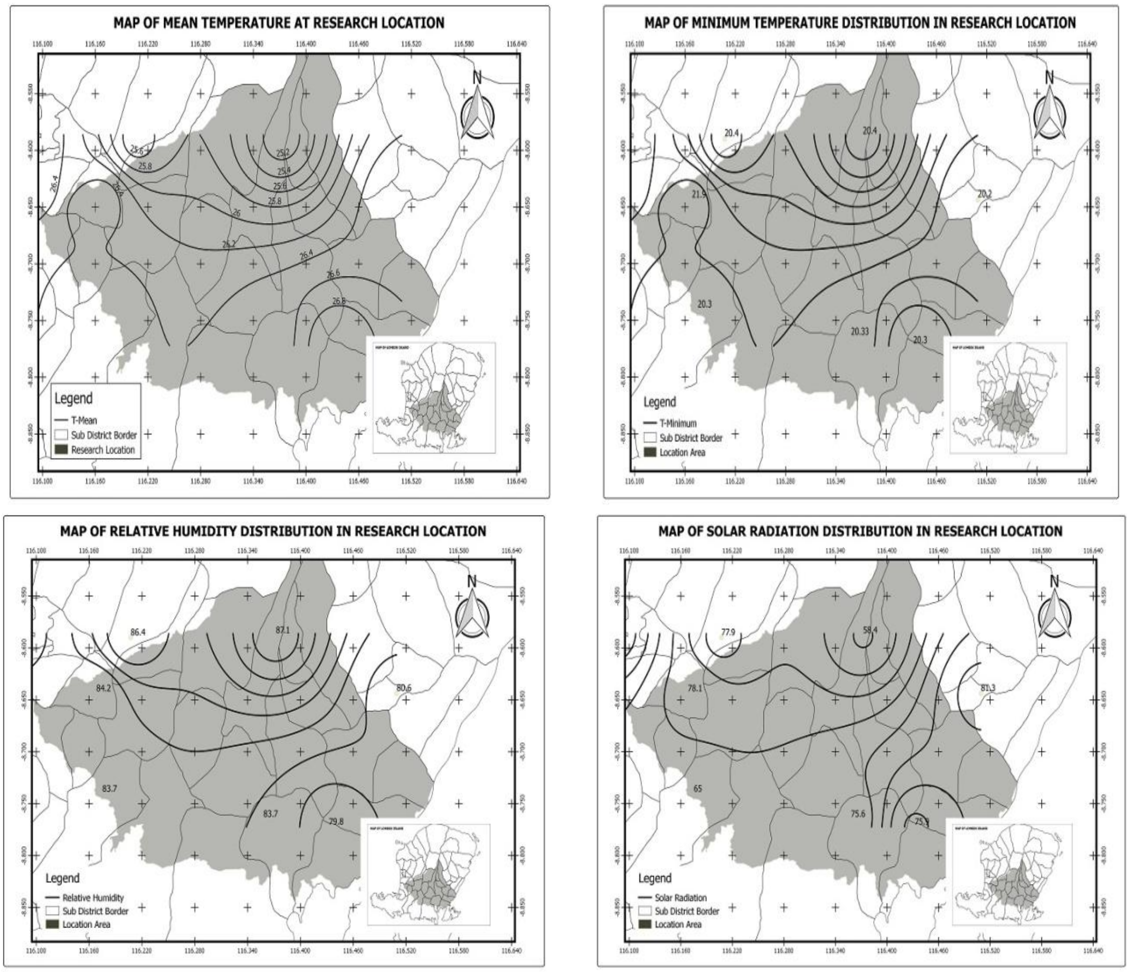

Figure 2. Interpolation weather data of 7 meteorological stations in or nearby study area. The stations includes BMKG Mataram, SMPK Narmada, SMPK Sengkol, SMPK Dasan Lekong, Stasiun Meterologi Plambik, dan Keruak (DPU)

There was a gradient of relative humidity from north to south and from west to east of study area. Northern part was mostly high humidity with average of 87.1%, and south part was relative low humidity of 83 4%. It was getting lower at further south. Relative humidity was gradually decrease from average 84% at west to 80.6% at east part of study area.

3.2. Crop Yield

Yield of rice, soybean and tobacco at 10 land map units from field observation and BPS is presented at Table 2.

Table2. Average yield of rice, soybean and tobacco in year of 2012 (normal year) year of 2013 (wet year) obtained from BPS and field observation

			Regency in figure (BPS, 2013, 2014)					
Lokasi	Tipe	Jenis	Dry season 2012 (normal year)			Dry season 2013 (wet year)		
	Iklim	Tanah	Rice	Soy	Tbc	Rice	Soy	Tbc
Batukliang	C3	Inceptisols	5,32	1,37	1,90	5,50	1,38	1,28
Sikur	D3	Inceptisols	5,33	1,29	1,87	5,33	1,05	1,39
Jonggat	D3	Inceptisols	5,44	1,36	1,93	5,74	1,12	1,62
Terara	D4	Alfisols	5,23	1,18	1,79	5,13	1,06	1,43
Janapria	D4	Alfisols	4,96	1,35	1,92	5,02	1,15	1,62
East Sakra	E4	Alfisols	4,99	1,04	1,62	4,74	1,04	1,08
Jeruwaru	E4	Vertisols	5,13	1,13	1,64	4,72	1,05	1,23
Pujut	D4	Vertisols	4,72	1,03	1,91	4,93	1,07	1,49
West Praya	D3	Vertisols	4,86	1,12	1,90	5,00	1,31	1,47
Gerung	D4	Entisols	5,45	1,26	1,45	5,50	1,16	1,56
			Data from filed observation (OBS)					
Batukliang	C3	Inceptisols	5,32	1,30	1,79	6,40	1,29	1,70

Sikur	D3	Inceptisols	4,72	1,32	1,77	5,59	1,21	1,64
Jonggat	D3	Inceptisols	5,47	1,28	1,83	6,49	1,30	1,66
Terara	D4	Alfisols	4,72	1,30	1,76	5,43	1,20	1,54
Janapria	D4	Alfisols	4,39	1,33	1,69	5,34	1,22	1,39
East Sakra	E4	Alfisols	4,42	1,07	1,68	4,71	1,03	1,18
Jeruwaru	E4	Vertisols	4,47	1,12	1,73	4,88	1,04	1,40
Pujut	D4	Vertisols	5,74	1,28	1,71	5,75	1,24	1,51
West Praya	D3	Vertisols	5,08	1,26	1,71	5,29	1,33	1,53
Gerung	D4	Entisols	5,38	1,31	1,88	6,26	1,31	1,60

The SPI value for tobacco, soybeans and tobacco in 10 land map unit (LMU) were presented at table. The SPI of rice ranged 52 to 88 with average of 67. The best SPI was found at rice in wet dry season and the worst was in dry season. Soil type showed inconsistent effects on the SPI, however the highest value generally found at Inceptisols and the worts one is at Vertisols.

3.3. Square Root Index (SQRI) and Storie Index Rating (SIR)

Soil productivity index (SPI) rice, soybeans and tobacco using NSRI (Khiddir, [19] were shown in Table 3. The SPI of rice ranged from 52 to 88 with average of 67 . the best SPI was obtained in a wet dry season conditions and the worst was at dry season conditions. The type of soil showed no consistent effects. The lowets value obtained in Vertisols and the highest at Inceptisols.

Table3. Soil Productivity Index (SPI) of rice (RC), soybean (SB) and tobacco (TB) based on NSRI formula

Research Location	Land	Wet Dry Season			Normal Dry Season			Dry Dry Season		
	MapUnit	RC	SB	TB	RC	SB	TB	RC	SB	TB
BatuKliang	Inc -C3	80	74	69	68	75	70	66	82	71
Sikur	Inc -D3	77	69	67	64	72	68	63	77	69
Jonggat	Inc-D3	83	74	72	71	75	74	68	84	74
Terare	Inc -D4	72	64	65	61	68	67	59	74	68
Janapria	Alf -D4	73	65	65	65	71	67	60	76	68
East Sakra	Alf -E4	59	55	59	44	58	60	50	64	62
Jerowaru	Vert-E4	63	55	60	52	61	62	52	66	63
Pujut	Vert-D4	66	61	66	63	61	71	65	65	67
West Praya	Vert-D3	76	74	71	67	70	72	64	75	72
Gerung	Ent-D4	85	73	74	72	74	77	69	85	76

Source :analysed from raw data of field plant observation and BPS

The SPI for soybean ranged from 54-78 with average of 68. There is -no effect of wetness of season on soybean. The different in SPI value was due to soil properties such as pH, SOM and relative humidity. It seems that soybean was suitable and more adaptive -under extreme weather events in Lombok compared to rice and tobacco.

The SPI of tobacco ranged from 50-84with average of 61. The lowest SPI value was in wet dry season. Excessive rain decreasing tobacco yield that makes lower SPI. The soil types have a significant effect on the SPI of Tobacco. The higher value of SPI was found at Inceptisols and Entisols, while the lowest was found at Vertisols. High clay content of Vertisols may cause deteriorate effect on tobacco when heavy rainfall occurs.

3.4. Validation Model WithYield of Field Observations

Results of model crp was obtained from multiplication SPI and potential yield. In this case we multiply SPI with 7,5, for rice grain, 2,4 for soybean seed and 2,8 for cured tobacco. The multiplication number was approach from the potential yield crops as reported by Litbang pertanian [39].

Based on crop production data obtained from survey of farmer respondents and crop yield of field observation the production of rice in the MK-1 in 2012 is generally lower than the yield of rice MK-1/2013. This is due to the nature of the drought in 2012 was drier than in 2013. In contrast to the results of tobacco which opposite to rice, where the higher yield was obtained in dry years (2012) compared to yield in wet year (wet dry season of 2013). In soybean crop higher yield was obtained in dry years (2012). This demonstrates that soybean is more favorable to dry year than wet year. The Comparison of the results of the rice crop in four types of soil based on simulation models, field observation and crops were recorded in the district in Figures (BPS [37]

Table4. The comparation of predicted rice yield with actual rice yield obtained from BPS and field observation

Yera type	Dry year			Wet year		
Location	Predicted SPI	Obs-12	BPS	predicted SPI	Obs-13	BPS
Batukliang	5,44	5,32	5,50	6,38	6,40	5,32

Sikur	5,15	4,72	5,33	6,15	5,59	5,33
Jonggat	5,68	5,47	5,74	6,64	6,49	5,44
Terara	4,84	4,72	5,13	5,78	5,43	5,23
Janapria	5,21	4,39	5,02	5,85	5,34	4,96
East Sakra	3,52	4,42	4,74	4,72	4,71	4,99
Jeruwaru	4,16	4,47	4,72	5,04	4,88	4,86
Pujut	5,00	5,74	4,93	5,24	5,75	4,72
West Praya	5,39	5,08	5,00	6,10	5,29	5,13
Gerung	5,74	5,38	5,50	6,76	6,26	5,45
	RMSE	0,510	0,466	RMSE	0,436	0,859
	Ttable	2*0,30;9=0,54		Ttable	2*0,20;9=0,88	

Source of data: Raw data analyzed

From Table 4 it was obtained validation results that the yield estimation using SPI is quaite valid because the yield of predicted yield is very close to observed yield or recorded yield. For rice teh RMSE value was calculated and numbers as follow 0.51, 0,46, 0,43 and 0,85 which smaller with Ttest 2*0,20;9=0.88.

Table5. The comparison of predicted soybean yield with actual soybean yield obtained from BPS and field observation

Year type	Dry year			Wet year		
Location	Predicted SPI	Obs-12	BPS	Predicted SPI	Obs-13	BPS
Batukliang	1,50	1,29	1,38	1,47	1,30	1,37
Sikur	1,43	1,21	1,05	1,38	1,32	1,29
Jonggat	1,50	1,30	1,12	1,48	1,28	1,36
Terara	1,36	1,20	1,06	1,29	1,30	1,18
Janapria	1,42	1,22	1,15	1,30	1,33	1,35
SakraTimur	1,17	1,03	1,04	1,09	1,07	1,04
Jeruwaru	1,22	1,04	1,05	1,10	1,12	1,13
Pujut	1,21	1,24	1,07	1,21	1,28	1,03
Praya Barat	1,41	1,33	1,31	1,47	1,26	1,12
Gerung	1,49	1,31	1,16	1,47	1,31	1,26
	RMSE	0,171	0,256	RMSE	0,123	0,160
	Ttabel	2*0,40;9=0,26		Ttabel	2*0,40;9=0,26	

Source of data: Raw data analyzed

From Table 5 it was obtained that RMSE value of soybean were 0.51, 0,46, 0,43 and 0,85 The validation results was Tcalc. were smaller with Ttest 2*0,20;9=0.88. This means that predicted yield of soybean is very close to actual yield obtained from field observation and recorded data from BPS.

Table6. The comparation of predicted tobacco yield with actual tobacco yield obtained from BPS and field observation

Year type	Dry year			Wet year		
Location	SPI predicted	Obs-12	BPS	SPI predicted	Obs-13	BPS
Batu Kliang	1,96	1,70	1,90	1,93	1,79	1,48
Sikur	1,92	1,64	1,67	1,89	1,67	1,59
Jonggat	2,07	1,76	1,93	2,02	1,83	1,62
Terara	1,87	1,54	1,79	1,83	1,76	1,43
Janapria	1,88	1,59	1,62	1,82	1,69	1,62
East Sakrai	1,69	1,18	1,62	1,66	1,68	1,08
Jeruwaru	1,74	1,40	1,64	1,68	1,63	1,23
Pujut	1,99	1,51	1,91	1,83	1,71	1,49
West Barat	2,02	1,53	1,90	1,99	1,71	1,47
Gerung	2,16	1,70	1,95	2,08	1,88	1,56
	RMSE	0,39	0,15	RMSE	0,16	0,43
	Ttabel 2*0,30;9=0,54			Ttabel 2*0,30;9=0,54		

Source of data: Raw data analyzed

In the tobacco plant observation in the field is not much different from the results predicted by SPI. Statistical analysis with RMSE indicates homogeneity of the sample shown by Ttest at 30% degrees of freedom 9 (Ttabel 2*0,30;9=0,54) is greater Tcalc which were 0,39, 0,15, 0.16 and 0,43. Tcalc is smaller that 0,54 that means the value of predicted yield was relatively similar. (homogeneous).

3.5. Soil Productivity Index relationship with Crop

SPI relationship with crop yields are predicted and the observation in the field showed a fairly close correlation. R^2 value of each crop figures show more than 80%, which means that the selection of the parameters used to develop the SPI has been quite accurate.

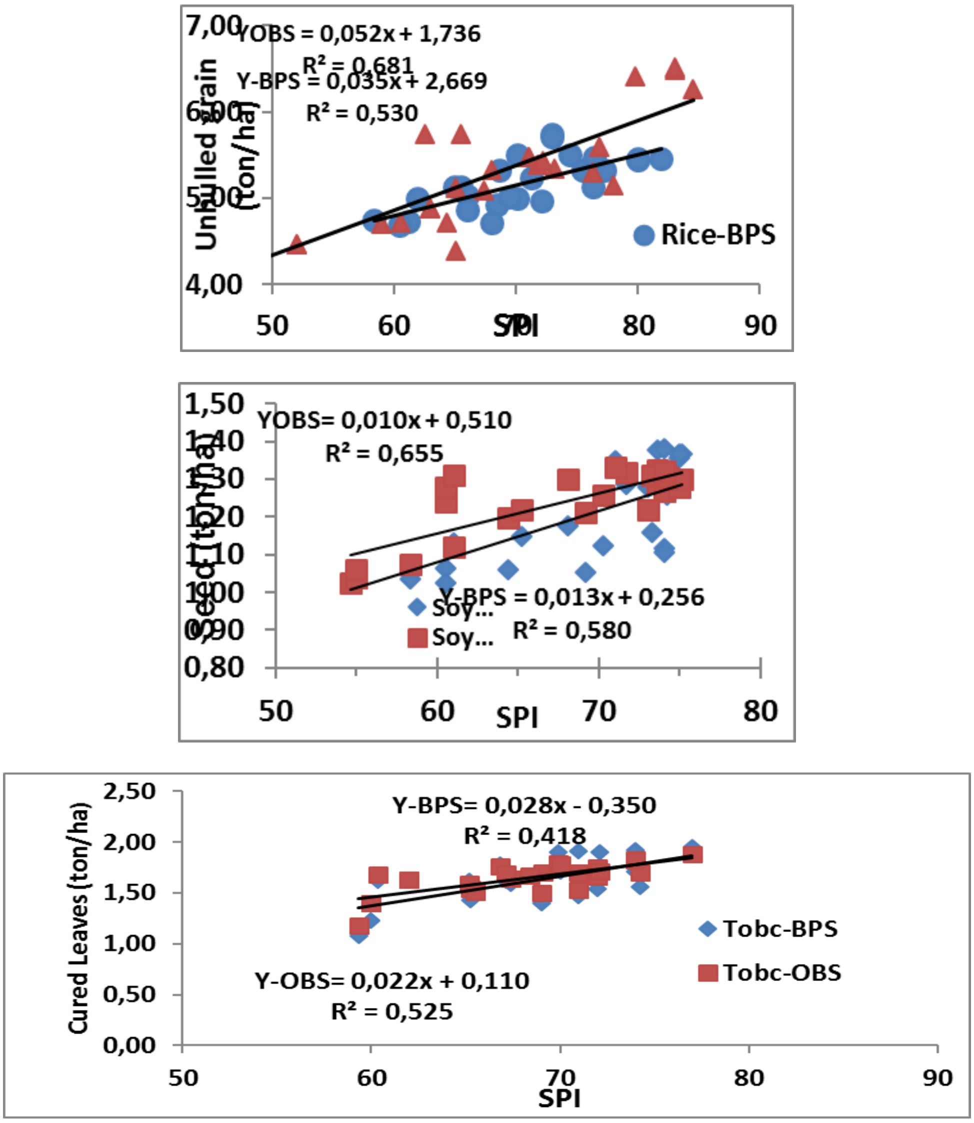

Figure3. The relationship between SPI and Observed and recorded yield of rice, soybean and tobacco

V. Conclusion

Based on the discussion above it can be concluded that: Normalized Square Root Index gave greater output and better correlation value compared to Normalized Storie Index Rating. The SPI of rice ranged from 50 to 88 with average of 67. The SPI tend to increase when year was wet..Rainfall during dry season tends to increase rice yield but iit it decrease tobacco yield. Soil types have inconsistent effect on rice yield. The SPI of soybean ranged from 54 to 78 with average of 66. There was little effect of year type on yield of soybean.The SPI of tobacco ranged from 30 to 84 with average of 61. The SPI tend to decrease when year was wet. Validation with RMSE showed that there was no significant between actual (measured yield) difference with predicted yield. This means that the SPI values can be better of actual yield estimation in the field. Testing the SPI value with actual observed aand recorded yields shows the coefficient determinant (R^2) of observed rice, soybean and tobacco yields were 0.68, 0,66 and 0,52 respectively and 0,53, 0,58, and 0,42 for recorded yield of rice, soybean and tobacco respectively.

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