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THE USR INTERNATIONAL SEMINAR ON FOOD SECURITY

"Improving Food Security : The Challenges for Enhancing Resilience to Climate Change"

Volume I

The University of Lampung

Indonesian SEARCA Fellow Association

Southeast Asian Regional Center for Graduate Study and Research in Agriculture

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USR INTERNATIONAL SEMINAR ON FOOD SECURITY

Improving Food Security : The Challenges for Enhancing Resilience to Climate Change

Emersia Hotel and Resort, Bandar Lampung, Lampung, Indonesia

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Volume 1

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SEARCA

2016

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Preface
COMMITTEE CHAIR

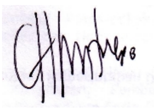
Recently, there are many discussions about food security as a complex issue of sustainable development. One of important topics is will the food needs in the future be met by the current production levels? In addition, the future production faces another sustainable development issues, one of which climate change that affects all four food security dimensions: food availability, food accessibility, food utilization and food systems stability. Improving food security, therefore whilst reconciling demands on the environment conditions which becoming the greatest challenges.

To response that challenges, The University of Lampung collaborated with ISFA (Indonesia SEARCA Fellow Association) and SEAMEO-SEARCA conduct an International Seminar on "Improving Food Security: The Challenges for Enhancing Resilience to Climate Change" in Bandar Lampung, Indonesia on August 23-24, 2016. There are 4 topics are offered as follows: (1.) Food Security and Food Production System, (2.) Food Security, Post Harvest Science and Technology, (3.) Food Security and Socio-Economic Environment Aspect and (4.) Ecological Perspectives on Food Security.

At this seminar, 111 research articles were submitted from 6 countries i.e. Indonesia, Lao, Malaysia, Myamar, Thailand, and Vietnam. The authors are researchers, practitioners included NGO, policy makers, academics as well as industrial professionals. The ultimate aim of this seminar is to deliver state-of-the-art analysis, inspiring visions and innovative methods arising from research in a wide range of disciplines. Through this activity, it is expected that research articles in all aspects related to food security can be documented, rapidly spread, communicated and discussed throughout the countries.

Thank you for your participation and looking forward to having productive discussion among participants.

Sincerely yours,



Christine Wulandari, Ph.D

Preface
The University of Lampung Rector

Many Asian countries face serious challenges on their food security due to changing consumption patterns including the demographics, declining of agriculture productivity, degradation of natural resources, rising input costs as well as cost for transportation of supply chains. All of these, need various trends anticipation of short to medium term, and this is clearly becomes efforts focused on mitigating towards the challenges. Together with SEAMEO-SEARCA and Indonesian Searca Fellows Association (ISFA), the University of Lampung (Unila) collaborated to conduct an international seminar with theme in "Improving Food Security: The Challenges for Enhancing Resilience to Climate Change" on 23-24 August 2016 in Emersia Hotel, Bandarlampung. From this international seminar, 111 research articles from six countries in Southeast Asia were compiled and expected to be used as a stepping stone for preparation of development strategies in Indonesia country or other Asian countries resolving the issues of Food Security.

This cooperation among Unila with ISFA and SEARCA in accordance with the Unila statement mission for Unila goals of 2005-2025, one of which Unila is able to build joint effort in many development aspects within various parties, including governments, publics, businesses, non-governmental organizations either national and overseas, with mutual benefit basis in sustainable frame for natural resources conservation in supporting Food Security. The other Unila goals related to the Food Security is the community welfare, in which Unila become the agent of changes and maintain the certainty and justice for the community benefits.

My very sincere appreciation to invited speakers and participants for their great contributions, to all advisory boards SEAMEO-SEARCA and Indonesian Searca Fellows Association (ISFA), reviewers, colleagues and staffs for putting remarkable efforts and their contribution to the organization of this seminar. Finally, I just hope that this seminar is able to inspire and deliver benefits to all participants, in which together we are able contribute to development of Food Security in our countries as well as to global.

We look forward to working with you and getting to know you in years ahead.
Thank You.

Your sincerely,

Prof. Dr. Hasriadi Mat Akin

Preface
SEARCA DIRECTOR

MESSAGE

The Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) is pleased to support the Indonesian SEARCA Fellows Association (ISFA) in organizing this *International Seminar on Improving Food Security: The Challenges for Enhancing Resilience to Climate Change.*

SEARCA's support to this event and many similar others is a testament of our commitment to promote food and nutrition security via the route of Inclusive and Sustainable Agricultural and Rural Development (ISARD). Food and nutrition security continues to be a major problem in the region and in the rest of the world in varying degrees and complexities. This is further exacerbated by the impacts of climate change on agriculture which not only serves as the backbone of the economy but is also key to feeding a growing population that continues to struggle with poverty and hunger.

Addressing multi-faceted concerns such as food security and climate change requires collaborative efforts among various stakeholders across the region. That is why SEARCA has developed umbrella programs on food and nutrition security, and climate change adaptation and mitigation which identifies areas for cooperation in research, capacity building, and knowledge management in these two related concerns.

In all these, we are glad to have the cooperation of SEARCA's graduate alumni spread across the region. They have organized themselves into the Regional SEARCA Fellows Association, with at least 8 country chapters including ISFA. The country associations have conducted various knowledge sharing activities such as this International Seminar and plans are also underway for collaborative research projects in the regional alumni organization. By working in synergy, we have seen how the modest contributions of our graduate alumni can make a big difference to agricultural and rural development in the region – truly making them SEARCA's ambassadors in Southeast Asia and beyond.

I congratulate ISFA headed by Dr. Sugeng Prayitno Harianto for organizing this International Seminar which serves as a platform for knowledge sharing on various researches and development activities that contribute to food and nutrition security amidst the detrimental effects of climate change.

Finally, I also thank all our keynote speakers and delegates for their participation in this event and hope to see all of you again in future knowledge sharing events important to the development of the region.

Gil C. Saguiguit, Jr.
Director

KEYNOTES SPEECH

Dr. Siti Nurbaya Bakar
(Minister of Environment and Forestry, Republic Indonesia)

KEYNOTES SPEAKERS

Dr. Ageng S. Herianto, FAO Representative

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Prof. Dr. Buhri Arifin, Prince of Songkla University - Thailand

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ESTIMATION OF METHANE(CH_4) EMISSION BASED ON PADDY HARVEST AREA IN LAMPUNG PROVINCE, INDONESIA

ONNYCHRISNA P. PRADANA[1],TUMIAR K. MANIK[2] AND WARSONO[3]

ABSTRACT

Contribution of greenhouse gas (GHG) emissions from agriculture sector comes from paddy cultivation system, flooded paddy field is one source of methanee emissions.Severalresearchs related to greenhouse gas emissions from agriculture (paddy field) by direct measurements have been done in plot scale. This research aimed to predict methane annual emissions from paddy field in regional scale (province) based on paddy harvest area. Method that used in this research are IPCC model to estimate the emission and time series method (ARIMA) to forecast the emission in next five years. The result of this research shows: (1) methane emissions from paddy field are predicted to decline in the next five years, the number will be 232.703 Gg (2013); 229.113 Gg (2014); 225.877 Gg (2015); 222.961 (2016) and 220.333 (2017) for methanee emissions; (2) comparing the result from other country with similar area, it can be concluded that IPCC model could be applied to estimate methane emissions in Lampung; and (3) the amount of methane annual emissions from paddy field is effected by annual cultivated area/harvested area and cultivation period.

Key words:emission, methane,ARIMA, paddy field, IPCC.

INTRODUCTION

Climate change phenomenon as a result of global warming is a real earth problem that affects people life. The global average surface temperature of the Earth has increased by 0.6± 0.2 ºC since 1900 and it is likely that the rate and duration of the warming are greater than at any time in the past 1000 years (IPCC, 2001).Earth temperature rise because the longwave radiation emits by the earth surface is trapped by certain gasses known as greenhouse gasses.

Global warming will affect climate processes and feedbacks and result in changes of mean temperature and precipitationdistributions and is also expected to affect interannual and longer time-scale of precipitation (Boer, 2009). For instance monsoon rainfall over South Asia has decreased during the last 5 to 6 decadesaccording to several sets of observations (Annamalai *et al.*, 2013). Global warming induces increased frequency orintensity of typhoons; for that reason, coastal zones and riversides are considered to be the residential areas that are most likely to be influenced by global warming (Yasuhara*et al.*, 2010).

One of the greenhouse gases that play a role in global warming is methane. Methane (CH_4) has Global Warming Potential (GWP) value 21 times greater than CO_2 (ASA et al., 2010). Concentration level of methane has reportedly increased from 700 ppb in 1750 became 1774 ppb in 2005 (Hidore et al., 2010).

Methane is producedin an anaerobic environment such as rice paddies, swamps, sludge digester, rumens and sediments (Yang and Chang, 2001). Rice paddies have been identified as a major source of atmospheric CH_4. Global annual methane emission from rice fields were estimated to range from 25—100Tg which contributed to 10—30% of global methane emission (Yang and Chang, 2001).Various researches related to direct measurement of greenhouse gass emossion from paddy field have been done in plot scale.Next step is toupscale the results to for example city or regional scale. Since direct measurements might not available in this scale, models could be used to for this purpose usingdata from direct measurements from the plot scale.

Model is a development of equations that describe the relationship between certain variable, parameters, management or control input and environment input (Jones and Boote, 2007). IPCC (*International Panel for Climate Change*) has developed some mathematics models to predictmethane gas emission from paddy field(IPCC, 2006).

Besides upscalling the direct measurement to larger scale, it is also needed to forecast the methane emission in the future years. There are two methods in forecasting: qualitative and quantitative. In quantitative there are causal/regresion method and timeseries methods. Time series method is used when the intention is only to forecast future results without analyzing the process. In time series, Box Jekinsmethod could be a main alternative if inside the data exists some complicated data pattern(Makridakis*et al.*, 1999).In Indonesia, Box Jenkin method for agriculture application has been done to forecast sugar cane production Kristyawan (2003) and Istiqomah (2006).In Climatology, Box Jenkin has been used to forecast rainfall anomaly based on monsoon index and El Nino event (Edwuard, 2013).

Because rice is the main staple food in Indonesia and methane emission is crucial related to global warming, it is necessary to forecast its future emission using a suitable model based on paddy harvest area in Lampung Province, Indonesia.The objectives on this research is to forecast annual methane emission in five years period (2013—2017)in

Lampung Province based on paddy field area in the last 20 years (1993—2012). From this research it is expected that methane emission in this province could be quantified that agriculture project plan should consider mitigation effort and techniques.

METHODS

This research used exisiting data which are: (1) direct observation of methane emission in Lampung Province from Nugroho*et al.* (1994),and (2) data of paddy field harvest in Lampung from Indonesia Statistical Bureau (2012).

Estimation of annual methane emission.

Methane emissionfrom paddy field was calculated based on mathematical model released by IPCC(2006). This model has been applied by some researchers such as Gupta *et al.* (2008) and BPPT (2009). In this research different ecosystem of the paddy field was ignored since the observation data came from an experiment in one paddy field area, so it is assumed having the same ecosystem.

$$CH_4 Rice = \sum_{i,j,k} \left(EF_{i,j,k} \, x \, t_{i,j,k} \, x \, A_{i,j,k} \, x10^{-6} \right) \quad (1)$$

CH_4 Rice = annual methane emission from paddy field area ($GgCH_4$/year).
EF*ijk* = daily emission factors for i, j, andkconditions($kgCH_4$/ha/day).
t*ijk* = paddy time periodfor i, j, and k conditions (day).
A*ijk* = annual paddy harvest area for i, j, and k conditions(ha/year).
i, *j*, and*k* = represent different ecosystem, water rezym, changes in type and amount of organic matter and other paddy field condition which is possible to have different CH_4 emission.

Forecasting annual emission.

Paddy field area in Lampung was applied on mathematical model in order to get annual methane emission in Lampung Province. Data from the estimation would be used as databaseto forecast methane emission for next 5 years period using Box-Jekinsmethod (ARIMA model).

Box-Jekinsmethod (ARIMA model) was developed through identification and estimation steps (Makridakis, 1999). In identification, model is tentatively categorized; from this stage data could be identified whether it is random, stationer or seasonal, and whether there is AR (*auto regressive*), MA (*moving average*), or both ARMA(*auto regressive moving average*)proceses. Next step is estimating parameters of the tentative model. This step includes non linier estimation, parameter test and model fitness. With those approaching the best ARIMA model for the forecasing would be achieved.

Eventually, this research will be come up with a graph that shows the tendency of the methanee emission from paddy field area in Lampung Province in the near future (up to 2017).

RESULTS AND DISCUSSIONS

Direct observation of methane emission from Paddy field had been done in Lampung (Nugroho *et al*., 1994a and 1994b), the result is presented in Table 1.

Table 1.Methane emission from paddy field in Lampung Province.

Season	Month	Week	Emission (mg $CH_4m^{-2}h^{-1}$)
Rain (wet)	December	4	10
	January	1	18
		2	25
		3	22
		4	25
	February	1	20
		2	25
		3	19
		4	18
	March	1	9
		2	7
Dry Season	May	1	15
		2	30
		3	18
		4	24
	June	1	40
		2	42
		3	20
		4	27
	July	1	17
		2	19

The result of applying equation 1 using data from direct observation of methane emission and data of paddy harvest area is presented in Table 2 and Figure1.

Table2.Paddy harvest area and estimated methane emission in Lampung Province, Indonesia.

Year	Area (ha)	Methane emissions Gg/year	Year	Area (ha)	Methane emissions Gg/year
1993	433,078	163,703	2003	472,635	178,656
1994	425,940	161,005	2004	495,519	187,306
1995	514,363	194,429	2005	496,538	187,691
1996	515,192	171,645	2006	494,102	186,771
1997	454,087	197,155	2007	524,955	198,433
1998	521,575	180,268	2008	506,547	191,475
1999	476,899	187,820	2009	570,417	215,618
2000	496,879	189,423	2010	590,608	223,250
2001	501,119	179,724	2011	606,973	229.436
2002	475,461	178,656	2012	626,158	236,688

Source of paddy harvest area: Badan Pusat Statistik(2012)

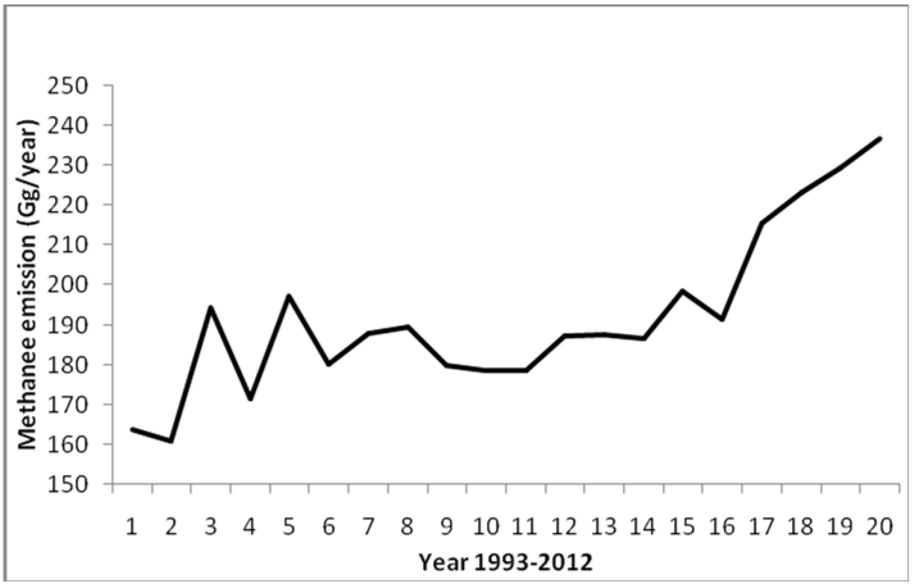

Figure 1.Estimated methanee emission from paddy field area in Lampung Province, Indonesia (1993-2012)

Next step is to calculate autocorrelation and partial autocorrelation; the resuts are presented in Figure 2 and 3.

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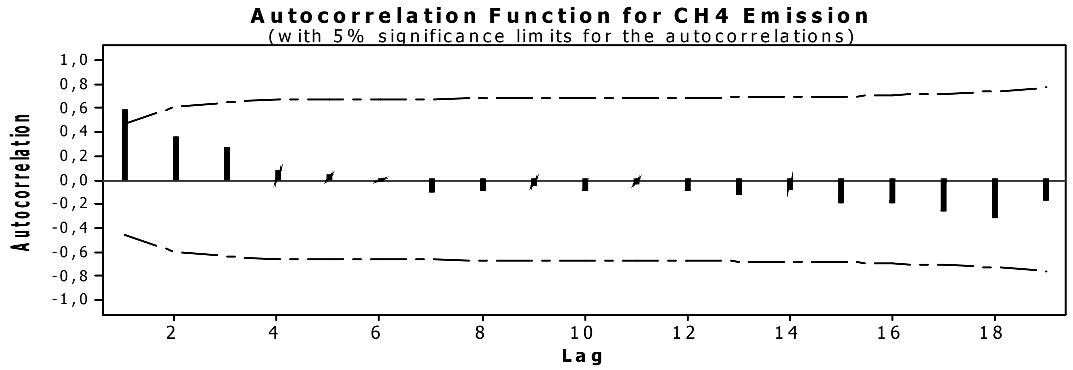
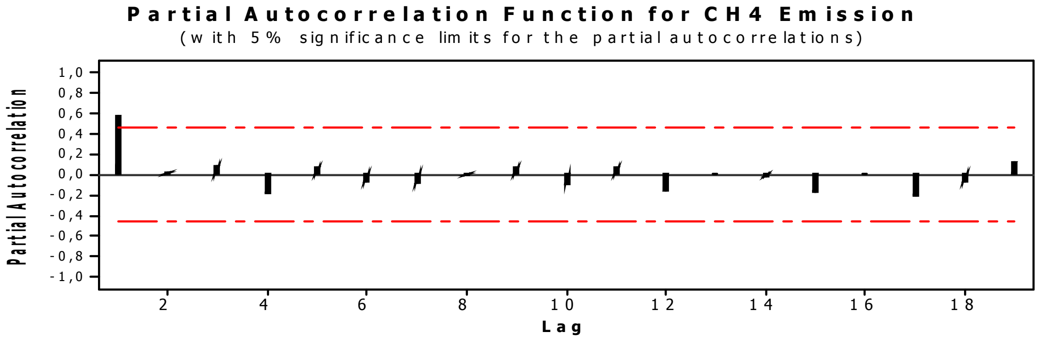


Lag	ACF	T	Lag	ACF	T	Lag	ACF	T	Lag	ACF	T
1	0,57	2,59	6	-0,01	-0,03	11	-0,03	-0,10	16	-0,19	-0,57
2	0,34	1,20	7	-0,10	-0,32	12	-0,08	-0,27	17	-0,25	-0,75
3	0,26	0,86	8	-0,09	-0,30	13	-0,12	-0,39	18	-0,31	-0,91
4	0,06	0,22	9	-0,04	-0,13	14	-0,07	-0,24	19	-0,16	-0,45
5	0,03	0,11	10	-0,08	-0,28	15	-0,19	-0,58			

Figure2. Autocorrelation function (ACF) of estimated methane emission from paddy field Lampung Province from 1993 to 2012.



Lag	PACF	T	Lag	PACF	T	Lag	PACF	T	Lag	PACF	T
1	0,57	2,59	6	-0,06	-0,31	11	0,07	0,32	16	0,00	0,02
2	0,01	0,07	7	-0,07	-0,34	12	-0,15	-0,69	17	-0,21	-0,96
3	0,08	0,40	8	-0,00	-0,02	13	0,00	0,00	18	-0,06	-0,28
4	-0,18	-0,82	9	0,06	0,31	14	-0,01	-0,08	19	0,12	0,56
5	0,07	0,32	10	-0,09	-0,42	15	-0,17	-0,78			

Figure 3.Partial autocorrelation function (PACF) of estimated methane emission from paddy field Lampung Province from 1993 to 2012.

Both graphs could be indicators whether the data is random, stationer or seasonal, or having AR, MA, or ARMA processes. The stricked dotted line shows the upper and lower border of the coefficient values.

Determination of random pattern

The data is considered random when the coeficient value is inside the borders. The ACF, showsr_1 = 0,579 bigger than 0,438 (the upper border). It means autocorrelation coefficient when k = 1 significantly different from zero. When k> 1, allautocorrelation coefficients do not significantly different from zero. The same result is showed by the PACF, when*k* = 1,*r* = 0,579 bigger than 0,438. It means autocorrelation coefficient when *k* = 1 significantly different from zero. When *k*> 1, allautocorrelation coefficients do not significantly different from zero. Therefore, it can be concluded that the data series are random.

Determination of Stationary

The ACF did not show a diagonal trend from left to right as the time lags increases (Figure 2); this proved that the data is stationer; therefore, no data differentiation is necessary. Stationer data has constant mean and varian, there is no up and down pattern. With this result prediction of methane emission the ordo is 0 (*d* = 0) since no data differentiation is needed.

Determination of Seasonal Trend

The autocorrelation on the ACF did not show a repetition; it means on the ACF no identification that the coefficient on two or three time lags significantly different from zero; therefore, it can be concluded that no seasonal influence on the data series.

Identification of AR (*autoregressive*) processes

The ACF shows autocorrelation values which decreases exponentially (r_1 = 0,579 >r_2 = 0,346 >r_3 = 0,266 >r_4 = 0,069 >r_5 = 0,036), until reach zero after 2 and 3 time lags; that shows the existence of AR proceses. The ordo of AR processes could be determined from the numbers of partial coefficients in PACF that is significantly different from zero, in this study the ordo is one *p*= 1. The existence of AR process shows that the last data has a correlation with the previous data series and the correlation decreases with further time lags.

Identification of MA (*moving average*) processes

MA processes could be identified from the value of partial autocerrelation in PACF that decreases exponentially. Since there is no indicator of that pattern in this data series; it can be concluded that MA processes did not exist, or the ordo is zero (*q* = 0). Moving average exists when data has connection with previous data in short time (having short memory)

From those identification steps eventually the ARIMA model which is tentatively suitable for the data series is ARIMA (1,0,0) model. However to determine the ordo for that model, besides the identification steps, it is also necessary to do the “trial and error” steps to obtain ordo comparisons in order to achieve better model. In this study ARIMA (0,0,1) model is chosen as the alternative model, then parameter estimation would be done for those two tentative models. The model analysis for ARIMA (0,0,1) and ARIMA (1,0,0) are presented in Table 3.

Table3.Statistic analysis model ARIMA (0,0,1) and ARIMA (1,0,0)

Type	Coef	SE Coef	T	p	MSE
MA 1	-0,6985	0,1671	-4,18	0,001	267.68
AR 1	0,9012	0,1773	5,08	0,000	195,91

For α = 0,05; |*t*|value for MA(1) parameter (4,18)washigher than $t_{0,025(24)}$ = 2,064. This shows that parameter estimation value of those models were significantly different from zero (reject H_0). Value of *p* parameter of MA (1) was 0,001; much lower than significant level 0,05; means reject H_0. Therefore, the MA (1) model could be accepted.

For α = 0,05; |*t*|value for AR(1) parameter (5,08)was higher than $t_{0,025(24)}$ = 2,064. This shows that parameter estimation value of this model were significantly different from zero (reject H_0). Value of *p* parameter of AR (1) was 0,000; much lower than significant level 0,05; means reject H_0. Therefore, the AR (1) model could also be accepted.

Both of the models could be used for methane emission forecasting, the results are shown in Figure 4 and 5.

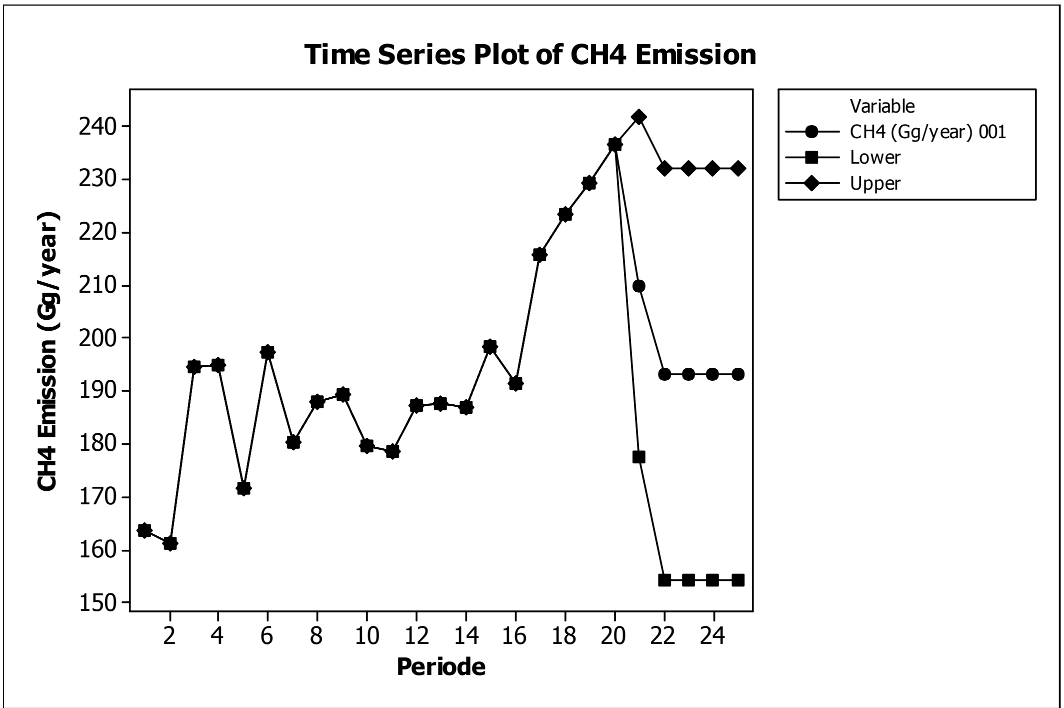


Figure 4.Forecasting of methanee emission using ARIMA (0,0,1) model.

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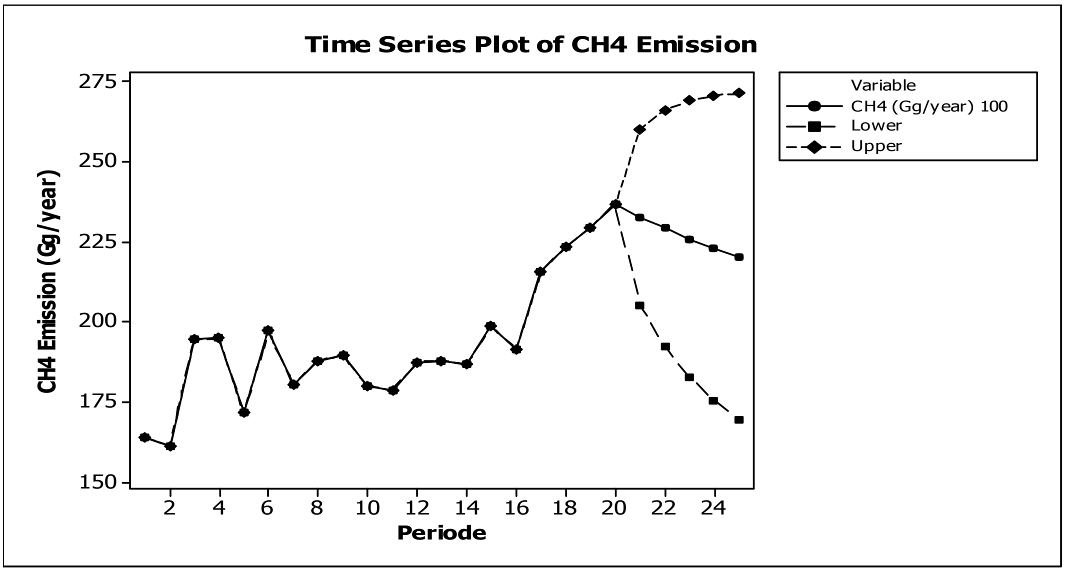

Figure 5.Forecasting methanee emission using ARIMA (1,0,0) model.

From those models, the most suitable model should be chosen. The criterias for chosing the model are: (1) should have less means square error (MSE) and (2) should have more simple equation (see Table 4).

Table4.Level of MSE and model equations

Model	MSE (mean square error)	Equation
ARIMA (0,0,1)	267,68	$X_t = \mu + e_t - \theta_1 e_{t-1}$
ARIMA (1,0,0)	195,91	$X_t = \mu + \Phi_1 X_{t-1} + e_t$

Based on those criteriasARIMA (1,0,0)model was chosen to forecast methane emission from paddy harvest area in Lampung Province in near 5 years future (Figure 5 Table 5).In general from the data series can be concluded that paddy harvest area in Lampung Province is stationer, non seasonal and has strong correlation with the previous area.

Table 5.Forecasting of methane emission in 5 years near future based on ARIMA (1,0,0) model.

Period	Methane emission	Lower border	Upper border
21	232,703	205,264	260,143
22	229,113	192,175	266,050
23	225,877	182,739	269,015
24	222,961	175,378	270,544
25	220,333	169,425	271,241

The tabel shows the forecasting in 5 years of methane emission range from paddy harvest area in Lampung Province.The upper border might be reached if the harvest area and the planting intensity increases which is possible since Lampung province is one potential center of rice paddy production in Indonesia.Research of methane emission from paddy field in other province in Java Island, Indonesia from 2006—2008had been done (BPPT, 2009).

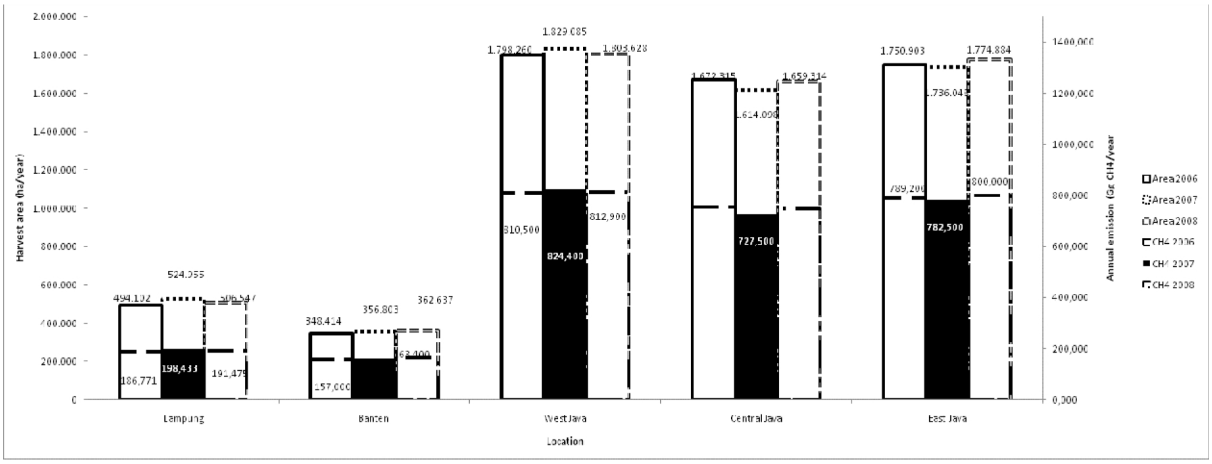

Figure 6.Methane emission from paddy field in provinces of Java Island, Indonesia (BPPT,2009).

Comparing the ratio of the area and methane emission in those provinces shows that in general the ratio was 1:2.000.In Lampung in 2007 the methane emission was 198,433 Ggand the area was 524.955 ha (1:2.645), while in Banten the emission was 160,800 Ggwith harvest area 356.803 ha (1:2.219). From the ratio, it can be concluded that the model in this study could be applied in forecasting methane emission from paddy field.

Comparing the results on this study with similar study conducted in Taiwan (Yang and Chang ,2001) is shown in Figure 7. In Lampung, the methane emission was about 0,161—0,236 Tg/year withpaddy field area was about 425.940—626.158 ha; while in Taiwan the emission was 0,032—0,062 Tg/year with the paddy area was 182.807—277.498 ha.

Similar results has also found in a research in some locations in India (Gupta *et al.*, 2008) see Figure 8.

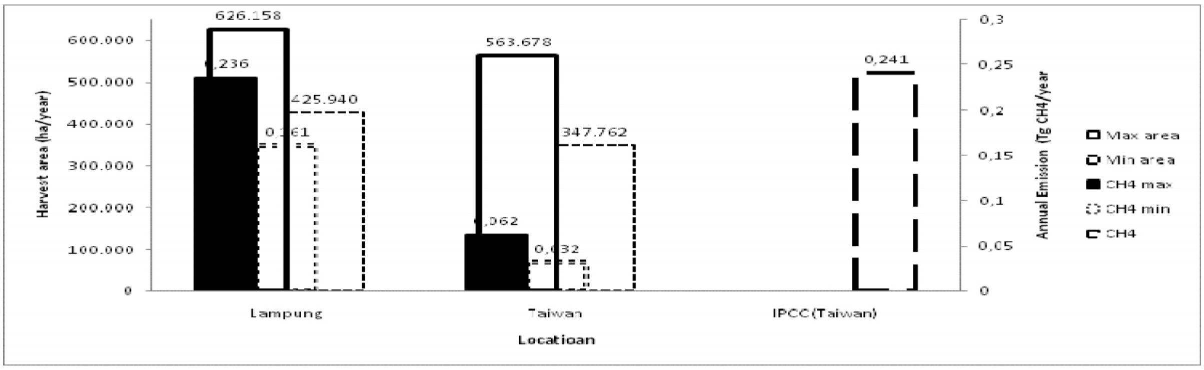

Figure 7.Comparison of methane emission from paddy filed area in Lampung and Taiwan.

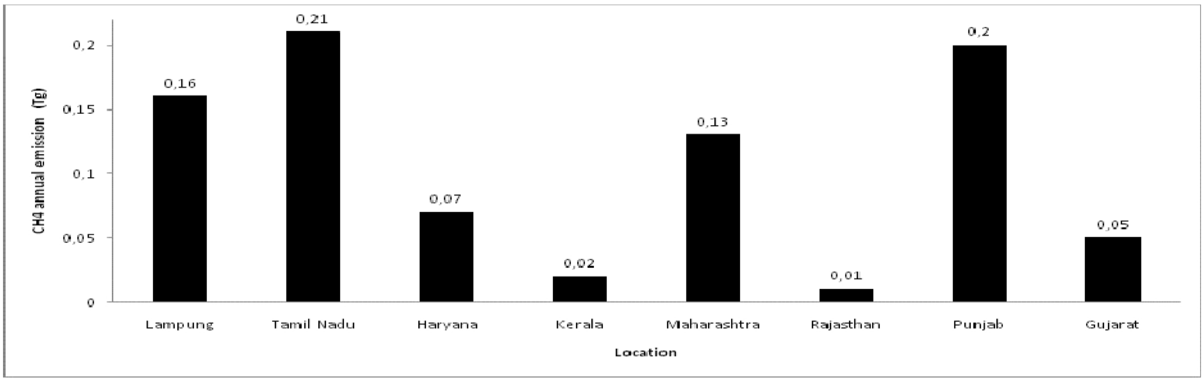

Figure 8. Comparison of methane emission of Lampung and some areas in India

This study showed the possibility of decreasing methane emission in Lampung Province due to decreasing paddy field area. Decreasing paddy field area could happen because of exchanging land use. Some factors influence exchanging land use in farmers level are (1) 97,5% because of no irrigation facilities, (2) 92,5% because the prize of other substitute commodities are higher, (3) 43,4%because of low rice prize, (4) 52,5% because planting paddy does not economically beneficial , (5) 32,5% because of labor scarcity (BPTP Lampung, 2011).

However, even with decreasing possibility of methane emission in Lampung Province, the emission itself is considered high. With long life stay in the atmosphere, increasing rate of methanee emission will significantly effect the climate change processes.

Based on data from Indonesian Statistic Bureau (BPS, 2012) paddy field area in Lampung Province does not always increase. In general, average increasing rate of paddy field area in Lampung Province from 2001 to 2009 was 1,57% per year or about 2.626 ha per year (BPTP Lampung, 2011). On national scale, in 2010 Indonesian government budgeted to develop 62.000 Ha new paddy field and 100.000 Ha in 2012 and plan to develop 100. 000 Ha every year (Dirjen Perluasan lahan, 2013).Badan Pusat Statistik (BPS, Indonesia Statistic

Bureau) predicts rice production in 2015 will increase 6,64 percentor 75,55 million tonscompares to the previous year; and this will be the highest in last 10 years; while the need is only 28 million tons.

Even though the need for rice is decreasing, rice will still be Indonesian staple food. Therefore, it is necessary to apply some mitigation techniques in paddy cultivation. Some of the possible cultivation techniques are: using paddy varieties with low emission, shorter growth time, drought tolerant,moderate fertilizer application, and manage the paddy field water regime.

This study has some limitations because data of direct methaneemission was observed once a week; it should be better if daily observation was available. However, the IPCC model was a common model used in many countries and the ARIMA model is also broadly used in forecasting future data based on previous time series data.

Applying IPCC mathematical model, methane emission from paddy planting area in Lampung Province, Indonesia on the period of 2013—2014were232,703 Gg (2013); 229,113 Gg (2014); and with applying ARIMA model the emission were predicted as 225,877 Gg (2015); 222,961 Gg (2016); and 220,333 Gg (2017).The combination of these models could describe in general the amount of regional methane emision with the assumptions that agriculture managements in paddy cultivation such as water regimes and fertilizer applications are remain the same.

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