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Development Strategy of Post-Coal Mine Area in Kutai Kartanegara Regency, East Kalimantan Province, Indonesia

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1. Relevance to the environmental science and engineering	[✓ A]	B	C	D
2. Justification for the study	A	[✓ B]	C	D
3. Subject mastery (Manuscript demonstrates depth of knowledge and presents ideas in a new way.)	A	[✓ B]	C	D

B. Writing styles

1. Technical mastery	A	[✓ B]	C	D
2. Logical organization	A	[✓ B]	C	D
3. Appropriate documentation	A	[✓ B]	C	D
4. STM format	A	[✓ B]	C	D

C. Acceptance:

1. In the paper, development strategy of post-coal mine area in Kutai Kartanegara regency, east Kalimantan province, Indonesia was studied in detail. Research results make it possible to provide solutions to problems in the region, to identify the characteristics of the land, as well as other potential resources. Authors have done a lot of research work. And authors have drawn some meaningful conclusions.
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[3] Greenberg, J., ed. 2008. *Of Prairie, Woods, and Water: Two Centuries of Chicago Nature Writing.* Chicago: University of Chicago Press.

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[5] Reed, B. W., Semmens, M. J., and Cussler, E. L. 1995. “Membrane Contactors.” In *Membrane Separation Technology, Principles and Application*, edited by Noble, R. D., and Stern, S. A. Amesterdam: Elsevier.

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Selection of a Subset of Meteorological Variables for Ozone Analysis: Case Study of Pedregal Station in Mexico City

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Abstract: In this paper, we describe how we carried out a research using the methodology Extreme Value Theory to model a problem of environmental pollution. Through the likelihood ratio test, we selected the best subset of environmental variables. The procedure was applied to data of Pedregal Station, which belongs to the atmospheric monitoring system of Mexico City, managing the maximums of each three days in the period from 1990 to 2009. The importance of these studies on ozone concentrations is that exposures for a long period of time may cause health damage to alive/living beings, in short and long terms, mainly for people living in megacities. The environmental variables considered in this analysis are: wind, temperature and relative humidity. The chemical variables that we took are: carbon monoxide, nitrogen dioxide and sulfur dioxide. Although we did not examine all possible subsets, we took the most important ones by nested subsets, comparing them using the deviance statistic. Finally, we observed that the best subsets were those involving the time variable and, the one that contained all variables except sulfur dioxide, which lead us to think that explaining the ozone concentration evolutions through these variables, is still a complicated case, since more accurate methodologies are discovering new associations that are related with its creation and evolution. Environmental pollution is a very difficult problem that requires to carry out new researches, measurements and interactions, that help to put forth the acquired knowledge into new models.

Key words: Generalized extreme value distribution, ozone, selection of variables.

1. Introduction

The Extreme Value Theory is an area of statistics dedicated to develop models and techniques that estimate the behavior of rare events that in some cases have catastrophic results. These belong to the long-tailed of a distribution and are far from central statistics. These events exceed a threshold (maximum or minimum value) in a fixed time period and use the asymptotic distribution of the maximums properly normalized by sequences of random variables [1-3]. Extensions on this theory exist for the case of extreme modeling; one is in a continuous time [4] and the other uses Bayesian methods as it has been done by some researchers [1, 5, 6].

Ozone is the most harmful oxidant for life on earth that is produced by human activities. For this reason, the specialists, in conjunction with public institutions, have been carrying on investigations in areas related to ozone and health, to measure the resistance of individuals living in urban zones, in according with interesting variable, like age orthe exposure time, among others [7, 8]. Several statistical methodologies have been applied, for example multivariate models, non linear regressions, time series, non parametric models, Bayesian and neuronal networks, copula and spatial models [9-15].

Mexico city is a mega city since it has more than ten million people, who suffer of a deficiency of oxygen in

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Corresponding author: Sara Rodríguez, master, main research field: statistics. E-mail: rguez.sara@gmail.com.

their lungs of less than 23%, in comparison with people living in other places at sea level [16]. There are geographical conditions in this city (a place enclosed by mountains) that favor photochemical processes in the atmospheric stability, causing constant thermal inversions. Industry is located in the northern part of the city, and winds blow from north to south, leading to dispersion of pollutants (nitrous oxides, volatile organic compounds, among others), and also are dragged to the south, where complex chemical processes occur by sunlight, which gives raise to ozone creation [17].

Mexico City's authorities issued environmental controls. One of them is the standard of air quality which can not exceed 0.11 parts per million of ozone, and that a person should not be exposed to this level for more than an hour [18]. The Atmospheric Monitoring System of Mexico City [19] as one of its policieshas to verify the validity of the information and constantly carries on analysis of its data. These information bases are the most used in Mexico due to their reliability and facility to obtain the data, which is available for the any user that in turn helps diverse pollution researchers, belonging to diverse fields on this matter like the statistics area, or others to the environmental physical chemistry and/or photochemical. Some of the works in the Bayesian statistics estimate the probability that a standard in air quality could be exceeded for a number of times within a time interval. Assigning a non informative initial distribution, researchers use a non homogenous Poisson distribution with multiple change-points and note that changes that occur in the data are reflections of environmental actions that have been taken by the inhabitants of Mexico City valley, and by the Mexican government in two different years in 2000 [20]. Another work on this Bayesian approach is the proposal for temporary space model in the interpolation and prediction of hourly ozone concentrations. Temperature was taken as covariate in some SIMAT stations, and was interpolated when data was missing. The model incorporates spatial covariance structure for observations and parameters that define the harmonic components, using a dynamic linear model. This model yields good results for short time prognostics, but it does not incorporate transport of pollutants, also does not respond to physical relations and, neither involves chemical reactions that occur at different atmospheric levels [6]. Subsequently, the authors propose a new approach assuming that the empirical distribution of ozone can be approximated by a Generalized Extreme Values type distribution, whose parameters define a time and space structure. The location parameter has a dynamic linear model and parameters of scale and form are depending on time. In the analysis of Mexico City data, an example is given in a flexible form to capture short and long term tendencies, also depending on time. The research that that was presented is a challenge to try variations in time lengths or the selection of a threshold. It was observed in the analysis that optimal selection of thresholds depended on neighboring stations [21]. Another article that uses the classic Extreme Generalized Values Distribution proposes a simple model to estimate trends in time series, that fits the ozone as the classic linear regressions models do, from the convergence of the quantile function to a standardized normal distribution, which allows to do hypothesis tests and confidence interval in the parameters of interest. The reported results confirm that the series of data presents two change points, one increasing before 1996 and another decreasing after this time [22].

In the field of environmental chemistry and physics, at the Atmosphere Science Center of the UNAM, researchers analyze the non lineal behavior among the precursors and ozone production in the city. They also inquire into the causes of the rising of high levels of ozone on a specific time. Their motivation was based on knowing why on a weekend, that are days off, pollution increased so much. They proposed hypothesis, and simulated real data bases, ozone creation through nitrous oxides, volatile organic compounds and climatic conditions on those days. This work got to demonstrate that strong winds carried pollution from Toluca metropolitan zone to the Valley [23, 24].

2. Material and Methods

Extreme Value Theory is based on Asymptotic Theory, derived from Fisher and Tippet principle [25], which establishes that there are only three types of distributions which are reached on the limit of maximums of stationary sequences. Fisher and Tippet found that distributions are unified in the Generalized Extreme Value Distribution, which has three parameters $(\mu, \sigma, \ \epsilon)$ of location, scale and shaped, respectively.

$$G_{\mu, \sigma, \epsilon}(\mu) = \exp\left\{-\left[1+\epsilon\frac{z-\mu}{\sigma}\right]^{-\frac{1}{\epsilon}}\right\} \quad if 1+\epsilon\frac{z-\mu}{\sigma} > 0 \qquad (1)$$

$$G_{\mu, \sigma, 0}(\mu) = exp\left\{-exp^{-\frac{z-\mu}{\sigma}}\right\} \qquad if \epsilon = 0$$

Eq. (1) is generalized extreme value distribution with $\theta = (\mu, \sigma, \epsilon) \in (R \times R^{+} \times R)$.

Reiss and Thomaset al. [1, 3] established that the values of the shape parameter determine the distribution type. If $\epsilon > 0$ then a Fréchet distribution type is obtained, if $\epsilon < 0$ then a Weibull distribution type is obtained, in the case $\epsilon = 0$ a Gumbel distribution is obtained. The results given in Ref. [22] allow us to use a linear regression model in order to analyze ozone concentrations through environmental and chemical variables. To accomplish this, Cox's idea [26] was used, who employed the regression model in a Generalized Pareto. In our case, we took a X^t covariates vector, the unknown parameter vector β was expressed into $\sigma = \sigma(x^t\beta) = \exp(x^t\beta) > 0$. In this last expression, we introduced the maximums of the standardized covariates to avoid scale problems in the fixed time period. The likelihood function is given by:

$$L(Y; \mu, \beta, \epsilon) = \prod_{i=1}^{n} g(y_i; \mu, \beta, \epsilon) =$$

$$\exp\,[-\sum_{i=1}^{n}\left(1+\frac{\epsilon(y_i-\mu)}{\exp\left[\beta_0+\sum_{j=1}^{k}\beta_j\, x_{ij}\right]}\right)^{-\frac{1}{\epsilon}}] \quad \exp(\beta_0$$

$$+\sum_{j=1}^{k}\beta_j x_{ij})^{-\mathrm{n}}$$

$$\cdot\left\{[\prod_{i=1}^{n}\left(1+\frac{\epsilon(y_i-\mu)}{\exp\left[\beta_0+\sum_{j=1}^{k}\beta_j x_{ij}\right]}\right)]^{-\frac{1}{\epsilon}-1}\right\} \qquad (2)$$

The maximum likelihood estimators of the parameters are obtained by maximizing the likelihood given by Eq. (2), using numerical methods.

3. Procedure for Selecting the Best Model

Taking the information about observations and k covariates, hypothesis tests are done on the covariates coefficients to know if any of them influences the trend of ozone maximums concentrations. This was achieved by observing the estimator sign of the covariate coefficient, namely we need to contrast the hypothesis

$$H_0: \beta_j = 0 \quad vs\, H_1: \beta_j \neq 0$$

Eq. (3) is test hypothesis for covariates.

where β_j represents the parameter associated with time, it's associated to the trend(j = 1,..,k), if $\beta_j < 0$ there will be an decreasing trend, if $\beta_j > 0$ there will be an increasing trend and in the last case, there will be no tendency.

The test consists in rejecting H_0 if $\left|\frac{\widehat{\beta_j}}{\sqrt{v_{jj}}}\right| > z_{\alpha/2}$ where α is the significance level and v_{jj} is the *i-th* term of the diagonal matrix $\left|E(-\frac{\partial^2 \log L}{\partial\beta_i\partial\beta_j}|_{\beta_j=\widehat{\beta_j}})\right|^{-1}$, for this, variances are obtained by using the observed Fisher information matrix.

In the event that the null hypothesis is rejected with significance level α, it is evident that it exists a trend in the observations of Y. If all covariates estimators were zero, this would indicate that these are not influencing to explain the trend of Y.

Using Coles procedure of selecting nested models [1] that supposes a model M_1 with θ a parametric vector and M_0 a subset vector $M_1(M_0 \subset M_1)$ that is obtained by restricting k components to a value, let us say they take zero value. This implies to partition vector $\theta = (\theta^{(1)}, \theta^{(2)})$ where the sub-vector k-dimensional fulfills that $\theta^{(1)} = 0$. The test involves to obtain the estimators $l_o(M_0)$ and $l_o(M_1)$ to prove the validity of the model using the relation of M_0 with M_1 to a significance level α. From where, the hypothesis test is expressed as follows:

$$H_0: \theta_0 = \theta^{(1)}\ vs\ H_a: \theta_0 \neq \theta^{(1)} \qquad (4)$$

Eq. (4) is test hypothesis for better model.

The decision rule is to reject the null hypothesis if $D = 2\{l_1(M_1) - l_o(M_0)\} > c_\alpha$ when c_α is the quantile $(1-\alpha)$ of the distribution $\boldsymbol{\chi}_k^2$, $k =$ is the difference of model dimensions M_1 and M_0. Large values of D indicate that model M_1 explains better data variations than model M_0, but if D is small, it is not worth to incorporate more variables because the model has no improvements. The estimations with maximum likelihood using nested models lead to carry out pairwise testing [27, 28]. Akaike's information criterion (AIC) [29]is given by Eq. (5):

$$AIC = 2k - 2\log(M) \qquad (5)$$

where k is the number of parameters estimated in the model M, and $log(M)$ is the value of the log-likelihood function for the set M with estimated parameters. This criterion helps us to solve the problem of choosing between rival models that are non-nested in terms of their functional forms. For a given data set, several models can be fitted; according to the *AIC* criterion the model with smallest *AIC* is the best (more negative *AIC* value).

4. Applications

Mexico city was considered as the city with the hardest environmental problems in the worlda few years ago, since there were motor vehicles that circulated daily with no restrictions at all and there were not regulations on industries located in the city, whereby there was frequently maximum levels at 0.11 ppm with the most harmful variable, the ozone [30]. Currently, some situations have been controlled with the collaboration of everybody and nowadays, so it is no longer the most polluted in the world [31, 32].

The Sistema de MonitoreoAtmosférico (SIMAT) [33] of Mexico City began to operate in 1986. It is integrated by the Red Automática de Monitoreo Atmosférico (RAMA), the Red manual de Monitoreo Atmosférico (REDMA), the Red de Depósito Atmosférico (REDDA), and the Red de Parámetros Meteorológicos (REDMET), located in different places on the valley. Their geographic locations are: northwest (NW) which has 17 stations, southwest (SW) with 6 stations, northeast (NE) with 4 stations, in the southeast (SE) there are 5 stations and in the center (C) there are 3 stations. We chose Pedregal Station which is one of the SW stations, since it presents the highest levels of ozone in all the valley, its location is indicated in Fig. 1.

In all valleies, thermal inversions constantly occur, the station to be analyzed belongs to Alvaro Obregón delegation, with a population of 729,193 and 198,647 housing [34]. The reduction on very extreme pollution levels has been achieved through time [35], with efforts form the inhabitants as well as restrictions on daily movement of motor vehicles, accessible costs in public transportation and relocation of some polluting industries, like the refinery of Azcapozalco [36]. Unfortunately, the city grows by giant leaps that causes accumulation of atmospheric pollutants, this aggravates with more than 18 million people that inhabit in Mexico City and vehicle parking [37, 38]. There are frequent thermal inversions in more than 70 percent of the year, due to a natural phenomenon of air stagnation, this gets dispersed in a gradual way in the course of the day and breaks due to atmospheric warming (Table 1).

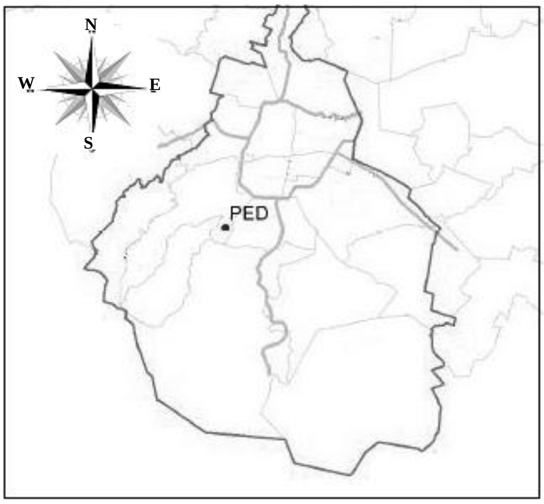


Fig. 1 Geographic location of Pedregal station (PED) which is placed in the southwest of Mexico City that belongs to the Alvaro Obregón delegation [33].

Table 1 Summarized descriptive information about Pedregal Station (PED) of 1990-2009, n = 2073 [33].

Summary of ozone	Value
Minimum	0.029
1st quantile	0.129
Median	0.169
Mean	0.174
3rd quantile	0.215
4th quantile	0.404
Maximum	2.073

Table 2 Names of covariates with its units of measurement and their respective codes, in Pedregal Station.

Variable code	Measurementunit	Renamed
Ozone (O_3)	ppm	
Time (t)	hours	X_1
Temperature (tmp)	DegreeCelcius (°C)	X_2
Windspeed (wsp)	m/s	X_4
Relative humidity (hr)	%	X_3
Carbonmonoxide (CO)	ppm	X_5
Nitrogendioxide (NO_2)	ppm	X_6
Sulfurdioxide (SO_2)	ppm	X_7

We present a study to analyze the influence of 8 covariates (environmental and chemical) in ozone concentrations in Pedregal Station that belongs to the metropolitan zone of Mexico City. It shown the measurement unit and the variables code that wereused (Table 2).

Using a linear regression model in the scale parameter, for each group of 72 hour, we took the maximums of the 7 covariates.

Then, we present graphics of the 7 covariates measurements that have different measuring units and that were standardized to avoid scale problems (Fig. 2).

The maximum likelihood estimators for high and fixed p were obtained using a program written in Ref. [39]. Some nested models were estimated for various parameters $\beta_0, \ldots, \beta_7$ in

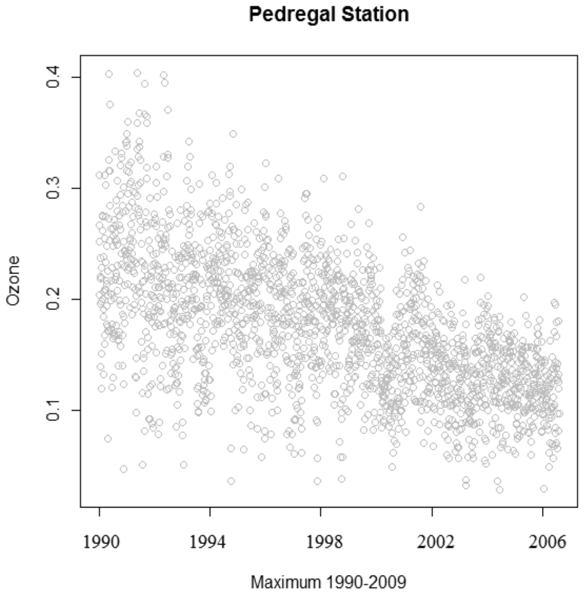
$$GEV(\widehat{\mu}, \widehat{\sigma} = exp(\widehat{\beta_0} + \widehat{\beta_1}x_1 + \cdots + \widehat{\beta_7}), \widehat{\epsilon}) \qquad (6)$$

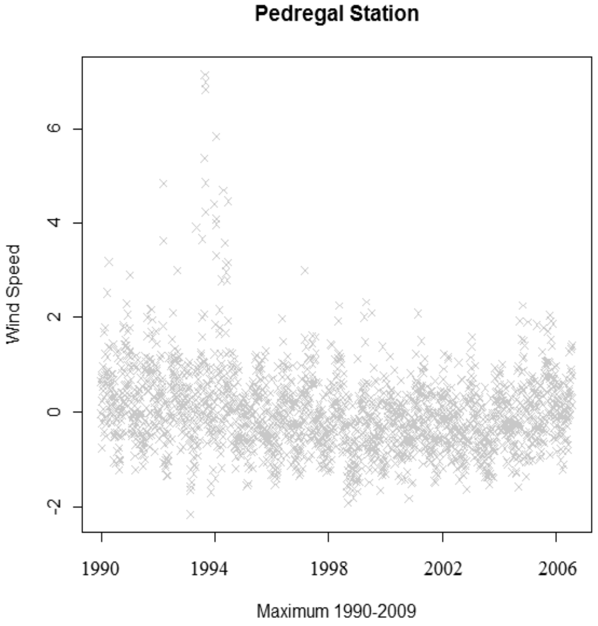
Eq. (6) is generalized extreme value distribution with covariates.

Based on this information hypothesis testing can be done about ozone concentrations trend, in order to know the way some covariates get involved in the model.

Fig. 3 shows probability plot, quantile plot, density plot for the ozone concentrations from 1990 to 2009. Theses graphics can be used to check the validity of distributional assumptions.

Table 3 shows the maximum likelihood estimator and standard deviation (SV) for the parameter associated to time. In this table, we show that the estimator of time parameter is negative. That is to say, ozone decreases over time.





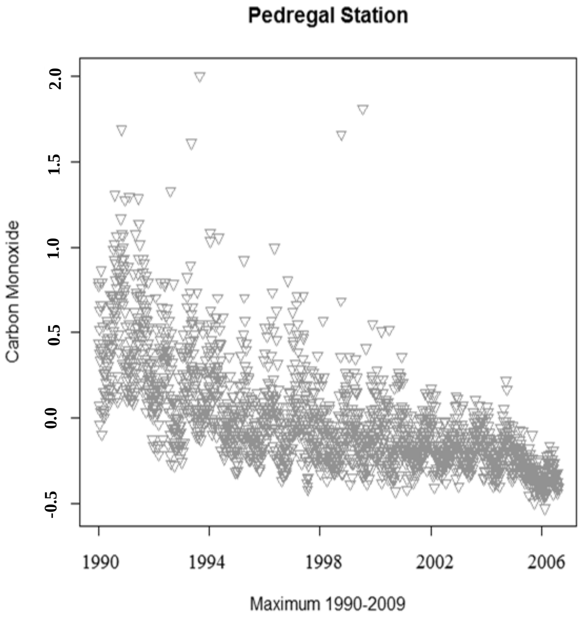


Fig. 2 Graphics of the 7 covariates that were related to the ozone variable at Pedregal station during the period from 1990 to 2009. These are O₃ (dependent variable), tmp, hr, wsp, CO, SO₂ and NO₂ (independent variables). Due to the limit of space in the text, we only present some graphics.

Another example with other model is as shown in Table 4, where we have a negative sign in the coefficients of time, wind speed and nitrous dioxide.

The remaining variables have opposite signs, indicating positive contribution for ozone creation.

Selection of the Best Subset of Variables: The number of models to be selected can be big if the number of variables is high, in our case, there are $2^6 = 64$ subsets to analyze. The models that will be analyzed are those ones nested in modelM_1, and that the biggest model contains the 6 covariates, whereby we present 6 models of interest (Table 5).

Table 6 shows the log-likelihood, deviance (with model M_1 as reference) and degrees of freedom for the tested models. The last column of this table shows the result of testing hypothesisthat a given model fits the data better than M_1 for different significance levels, $\alpha = 0.005, 0.01, 0.25$ and 0.1.

Whereby, it can be observed that the best models M_A

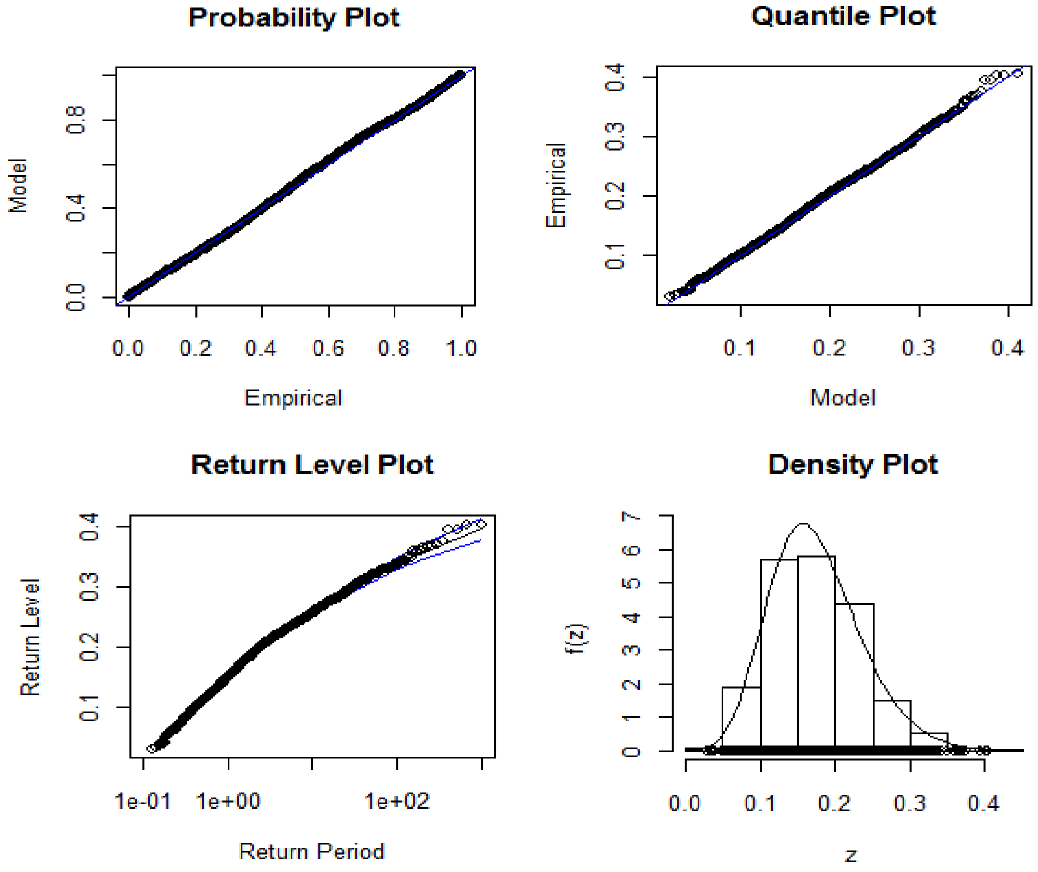


Fig. 3 Decriptive analysis of distributional assumptions of GEV at Pedregal Station.

Table 3 Model that uses ozone and time $GEV(\hat{\mu}, \hat{\sigma} = exp(\widehat{\beta_0} + \widehat{\beta_1}x_1),\ \hat{\epsilon})$ where MLE and SV are the maximum likelihood estimators and their standard deviation, repectively.

Parameter	MLE	Standard Deviation (SV)
$\widehat{\beta_0}$	-2.24470	1.699×10^{-2}
$\widehat{\beta_1}$	-0.00057	1.99×10^{-6}

Table 4 Model$GEV(\hat{\mu}, \hat{\sigma} = exp(\widehat{\beta_0} + \widehat{\beta_1}x_1 + \widehat{\beta_2}x_2 + \widehat{\beta_3}x_3 + \widehat{\beta_4}x_4 + \widehat{\beta_5}x_5 + \widehat{\beta_6}x_6 + \widehat{\beta_7}x_7),\ \hat{\epsilon})$ where MLE are maximum likelihood estimators, in brackets is the standard deviation with $\propto = 0.05$.

Parameter	MLE (Standard Deviation)
$\widehat{\beta_0}$	-1.9470 (1.83×10^{-2})
$\widehat{\beta_1}$	-0.0008 (1.99×10^{-6})
$\widehat{\beta_2}$	-0.1006 (6.59×10^{-2})
$\widehat{\beta_3}$	0.0045 (7.86×10^{-4})
$\widehat{\beta_4}$	-0.0514 (1.97×10^{-2})
$\widehat{\beta_5}$	2.6421 (9.36×10^{-1})
$\widehat{\beta_6}$	-1.2019 (1.26×10^{-1})
$\widehat{\beta_7}$	1.4989 (3.31×10^{-1})

Table 5 Nested models of interest with the covariates.

Models	Covariates
M_A	*t*
M_B	*t and tmp*
M_c	*t, tmp* and NO_2
M_D	*t, tmp*, NO_2 *and wsp*
M_E	*t, tmp*, NO_2, *wsp and* SO_2
M_G	*t, tmp*, NO_2, *wsp*, SO_2 and *CO*

and M_E are significant to $0.05 < \alpha < 0.1$; in the first case, the model is in terms of time and in the second one all variables are present, except sulfur dioxide. From Table 7 it can be concluded the models that best fits the data are M_1 and M_E, which agrees with the results obtained using the deviance criterion.

Fig. 4 shows the graphics of residuals of the model (residual probability plot). The residuals present a good behavior in general, since the residuals of the model follow a straight line tendency, but not all graphics are good, for example the residual quantile plot, we can see that the last real values were highly deviated with respect from the straight line. The central data of model $M_A$shows that is a little deviated from the estimated line (left figure), and in Model M_E the recent data is outside of the estimated line (right figure).

Table 6 Deviance function results (D), log-likelihood, degrees of freedom (*k*), for Pedregal Station.

Models	log-lik	$D = 2\{l\_1(M\_1)$ $-l\_i(M\_i)\}$	k		
M_1	2757.335				
M_A	3055.176	-595.682	7	$<\alpha$	M_A is better than M_1
M_B	2095.814	1323.042	6	$> \alpha$	Rejected that M_B is better than M_1
M_C	2351.725	811.22	5	$> \alpha$	Rejected that M_C is better than M_1
M_D	2463.099	588.472	4	$> \alpha$	Rejected that M_D is better than M_1
M_E	2806.472	-98.274	3	$< \alpha$	M_E is better than M_1
M_G	2167.648	1775.056	1	$> \alpha$	Rejected that M_G is better than M_1

Table 7 Results Akaike's criterion, for Pedregal Station.

Models	log-lik	k	$AIC = 2k - 2\log\,(M)$
M_1	2757.335	11	-5492.67
M_A	3055.176	4	-6102.352
M_B	2095.814	5	-4181.628
M_C	2351.725	6	-4691.45
M_D	2463.099	7	-4912.198
M_E	2806.472	8	-5596.944
M_G	2167.648	10	-4315.296

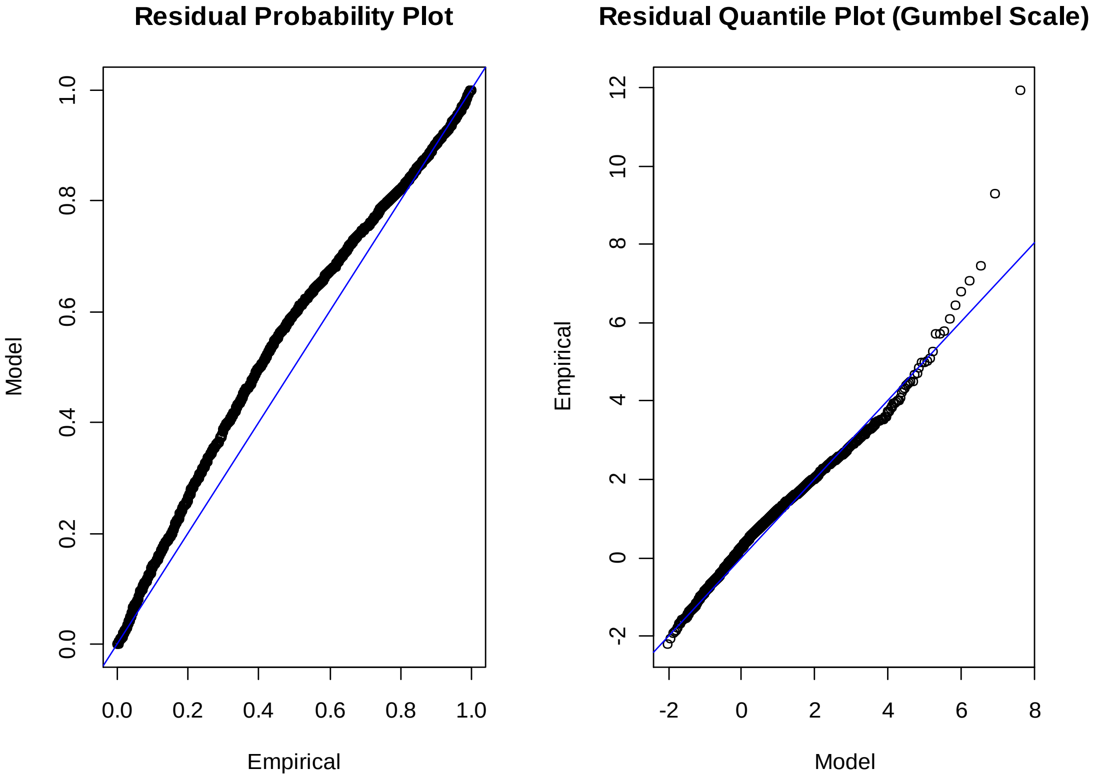


Fig. 4 Residuals probability plot forM_A and M_E models respectively.

5. Conclusions

The station with the higher records of pollution is Pedregal. Its geographical location is ideal for air flows to carry pollutants to the southeast zone and since air circulation is poor, due to that the valley is surrounded by mountains, this produces higher levels of ozone concentration, much above those health standards allowed by Mexico City authorities. The proposed methodology analyses the behavior of covariates included in the model. This supposes observations on Generalized Extreme Value distribution. It is important to observe the value of signs in the coefficients related with the increasing or decreasing tendency of the model. In the case of comparison of the proposed nested sub-models using chemical and environmental variables, it turns out that the models that explain better ozone concentration are two: one of them contains time variable and the other one contains all variables, except sulfur dioxide.

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Development Strategy of Post-Coal Mine Area in Kutai Kartanegara Regency, East Kalimantan Province, Indonesia

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Abstract: East Kalimantan province is one of the largest coal deposit reserve source, especially in the mining and quarrying sector. Mining sector is a strategic sector in East Kalimantan but post coal mining land has the problem for land using. The research method used survey method and laboratory test on 21 entities/companies with the status of cooperative and non-cooperative approach and land resource evaluation on 30 respondent keys (key informant). Analysis of data is using the evaluation of land potential: Analytical Hierarchy Process (AHP), IRR, NPV and BCR. The results showed that there are 2 scenarios decisions in the development of coal mining region that is the optimistic scenario on 2 aspects namely: (1) tourism (recreational parks and historical tours) and (2) aspects of the fishery (tilapia, goldfish, catfish). Then, in the moderate scenario, there are 3 aspects of development: (1) services (administration and housing); (2) fisheries (cork fish and damselfish) and (3) agriculture (guava, melinjo and dragon fruit). Optimizing the utilization of post-coal mining land in the regency of Kutai Kartanegara can be carried out with reference to these two types of scenarios as a manifestation of an engine of regional development.

Key words: Development strategy, post coal mine area, scenario decision.

1. Introduction

East Kalimantan province is one of the largest coal deposit reserve source of the 37.5 billion tons, or 35.7% of the total coal reserves in Indonesia [1]. Kutai Kartanegara is one of the districts with the largest number of mining and licensing in Indonesia, with economic growth areas of data measured GRDP. Mining and quarrying sector is a strategic sector or including the second contributor after the oil and gas sector, which in the period of 2000-2010 and 2010-2012, from the aspect of growth is steadily declining (Table 1).

Contribution of mining and quarrying sector from GRDP (Gross Regional Domestic Product) by industrial origin in years 2008-2012 showed average value of 65.54%, which suggests that this sector is the largest contributor to GRDP Kutai Kartanegara Regency, as presented in Table 2.

However, from the amount of points for results and acceptance of the budget contributed by the coal mining sector to local income was not directly proportional to the aspect of welfare. Kutai Kartanegara regency is a region with the number of poor people in east Kalimantan province of 112,560 in 2006 [2]. In addition to the year 2010, 40 villages in Kutai Kertanegara did not receive electricity. In year 2012, as a recipient of rice for the poor in the province of east Kalimantan which is about 2.200 tones for 30.095 household or 19% of the total 159,757 household [3], empirical issues above has been a gap in the aspect of economic growth at the macro level [4]. Strategy economic growth through industrialization is to create centers of economic growth in the region, but the micro aspects of

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Corresponding author: Nasruddin, Ph.D. candidate, research fields: geography and regional planning.

community level has not been reached [5]. Kutai Kartanegara regency is presented in Fig 1.

Until the year 2011, Kutai Kartanegara regency has been issued a mining production operations license (IUP), the highest in Indonesia is at 627 IUP or 61% of the 1.304 mining licenses in the east Kalimantan province [6, 7]. Coal mining data in Kutai Kartanegara regency has been collected from various sources. During the year 1996 and 2014, it has a trend of increasing activity of mining area (ha), especially on the type of exploitation. The exploitation area is reached about 642,068.05 ha or percentage ratio is about 23.55% of the total area regions of 2,726,310 million ha, as presented in Table 3 [6-10].

2. Methods

The research used survey method and laboratory test on 21 entities/companies with the status of cooperative and non-cooperative approach and land capability evaluation from FAO in 1976 [11] and 30 respondents key (key informant). Analysis of data using the evaluation of land capability, Analytical Hierarchy Process (AHP) and investment feasibility analysis (Internal rate of return, net present value and benefit cost ratio). Scenario decision formation development post-coal mine area include optimistic, moderate and pessimist. This scenario uses scoring technique analysis.

3. Results and Discussion

Results of the research study showed that a class of land capability using software Land Cover and Land Use Planning (LCLP) is gained 2 classes of land capability—class V and VI. Classes V and class VI has the status of reclamation land and non-reclamation land. Generally, there are no class distinctions among them. The distribution that the acquisition is not reclaimed shows that land capability class V and VI is higher (Table 4).

Furthermore, according to age of the post-coal mine, it also describes that there is no significant differences in the acquisition value of the land capability class. In the age distribution, it shows that the lower ages have the higher capability (Table 5).

Land capability class directives and other land potential parameters obtained land suitable classes on aspects of the fishery (33%), housing (43%), tourism (33%) and agriculture (0%) (Table 6). The next class

Table 1 Valid GRDP atcurrent prices distribution and at constant prices years of 2000-2012 [5].

GRDP	At current prices (million rupiah)			At constant prices (million rupiah)		
	2000	2010	2012	2000	2010	2012
With oil	19,450,109	84,313,364	110,901,152	19,450,109	22,576,925	23,042,710
r (%)	-	333%	32%	-	16%	2%
Without oil	805,677	20,623,188	44,540,752	805,677	3,914,775	7,439,785
r (%)	-	2,460%	116%	-	386%	90%

Table 2 Distribution of GRDP by industry (%) years of 2008-2012 [5].

No.	Business field	2008	2009	2010	2011	2012	Average
1	Agriculture	5.01	6.26	17.11	18.07	15.45	12.38
2	Mining and quarrying	87.87	84.63	56.36	43.66	50.18	64.54
3	Processing industry	1.08	1.3	3.44	6.05	5.13	3.40
4	Electricity, gas and water	0.04	0.05	0.13	0.25	0.25	0.15
5	Building	2.6	3.27	8.68	11.84	11.05	7.49
6	Trade, hotel and restaurants	1.99	2.66	7.72	12.31	10.73	7.08
7	Freight and communications	0.34	0.42	1.16	1.98	1.88	1.16
8	Finance, real estate and corporative services	0.31	0.38	1.03	1.95	1.83	1.10
9	Services	0.76	1.03	4.37	3.87	3.49	2.70

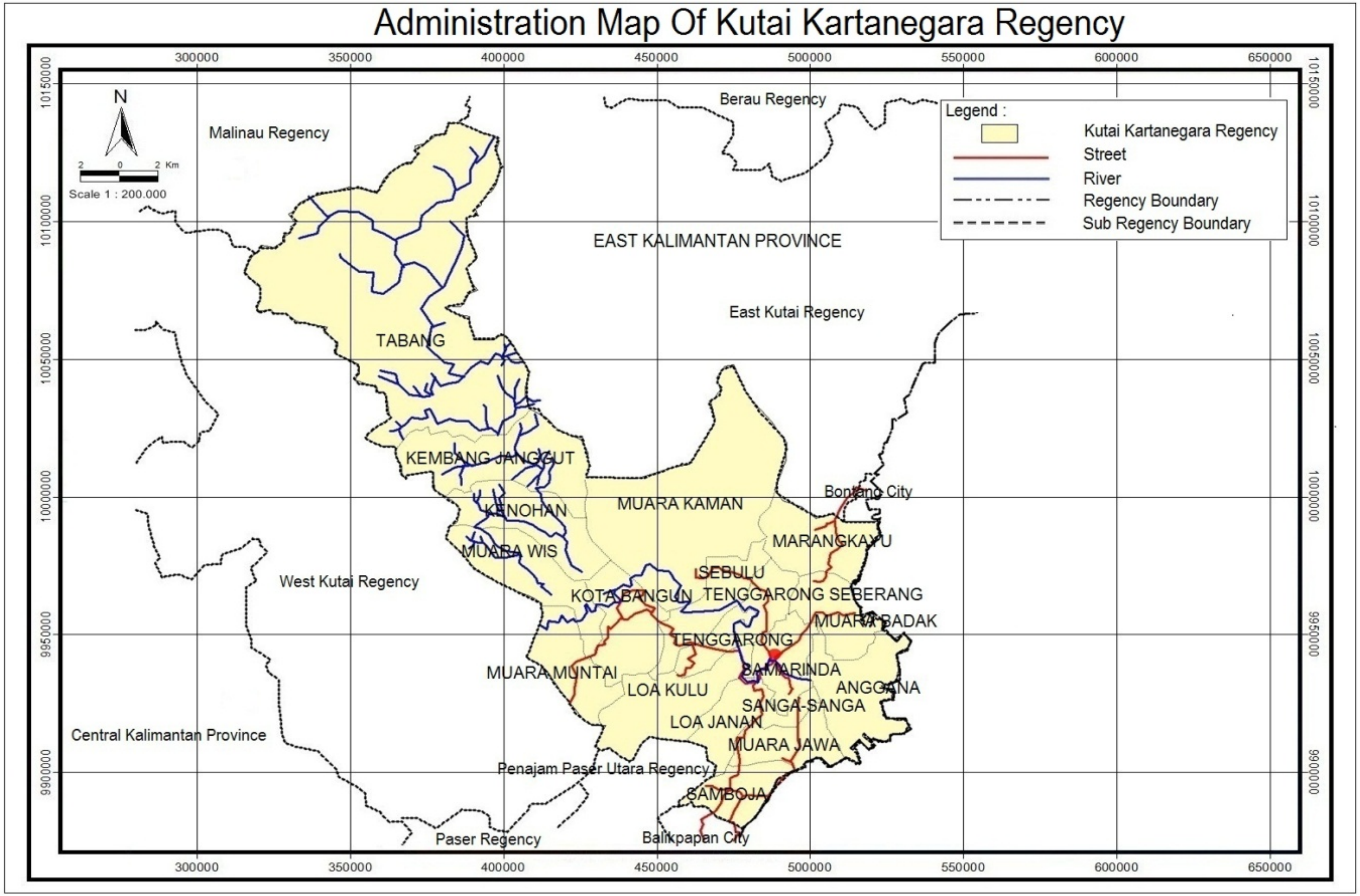

Fig. 1 **Kutai Kartanegara regency.**

Table 3 Overview of coal mining business area (Ha) in Kutai Kartanegara regency years of 1996-2011 [6-10].

Year	IUP sighting	IUP exploration	IUP exploitation	Total (ha)
1996-2006	-	-	39,105.56	39,105.56
2007	344,011.53	179,039.34	342,483.55	865,534.42
2009	532,369.00	319,507.00	116,352.00	968,228.00
2011	538,806.47	522,954.21	144,126.94	1,205,887.62
Total	1,415,187.00	1,021,500.55	642,068.05	3,078,755.60

Table 4 Distribution of land capability class with land status of coal mine closure (reclamation and not reclamation) [12].

No.	Land capability class	Amount (%)					
		Not reclamation	Reclamation	Total	Not reclamation	Reclamation	Total
1	V	6	6	12	50	50	100
2	VI	7	2	9	78	22	100
	Total	13	8	21	62	38	100

Table 5 Distribution of land capability classes with age of coal mine closure [11].

No.	Land capability class	After the age of coal mine (years)				Total
		0.25- <4	4- <7	7- <11	11-14	
1	V	6	4	1	1	12
2	VI	4	4	1	0	9
3	Total	10	8	2	1	21

Table 6 Distribution of land suitability classes (Ordos) for type development of coal mine closure region [12].

No.	Class (Ordos)	Type			
		Fishery	Settlement	Tourism	Agriculture
1	Not suitable	10	8	6	21
2	Moderate	4	4	8	0
3	Suitable	7	9	7	0
Total percentage (%)		21	21	21	21
1	Not suitable	48	38	29	100
2	Moderate	19	19	38	-
3	Suitable	33	43	33	-
Total		100	100	100	100

moderate land according to the aspects of the fishery (19%), housing (19%), tourism (38%) and agriculture (0%), while the class does not suitable the aspects of the fishery (48%), housing (38%), tourism (29%) and agriculture (100%), thus, the 4 aspects that do not have the potential for the development is agriculture.

Based on the above description, the post-coal mine majority are not in the suitable class. Each of risk in post coal mine area is land subsidence in the form of hollows or puddles, loss of topsoil containing humus/organic materials, and other forms of pollution, tend to be non-productive economically, so that sustainable development will be hampered. This statement is reinforced by several studies that the post mine coal area has much risk hence the land is limited for using [11, 13-17].

Therefore, the authors need a strategy that involves the development of aspects of the development actors (stakeholders), aspects of land potential and feasibility of investment in order to construct a coal policy post-mining land, as presented in Table 7.

Table 7 shows that there are 3 scenarios in the development of regional decision of the post-coal mine

Table 7 Scenario decision region coal mine closure [12].

No.	Type	Aspect	Score			Total score	Scenario decision
			Potential land	Expert choice	Investment feasibility		
1	Recreational park	Tourism	2	3	2	7	Optimistic
2	Historical tours	Tourism	2	2	2	6	Optimistic
3	Tilapia	Fishery	2	1	3	6	Optimistic
4	Goldfish	Fishery	2	1	3	6	Optimistic
5	Patin/Catfish	Fishery	2	1	3	6	Optimistic
6	Reign	Service	2	1	2	5	Moderate
7	Housing	Service	2	1	2	5	Moderate
8	Cork fish	Fishery	2	1	2	5	Moderate
9	Damselfish/Puyu	Fishery	2	1	2	5	Moderate
10	Guava	Agriculture	1	1	3	5	Moderate
11	Melinjo	Agriculture	1	1	3	5	Moderate
12	Dragon fruit	Agriculture	1	1	3	5	Moderate
13	Education	Service	2	1	1	4	Pessimist
14	Economics	Service	2	1	1	4	Pessimist
15	Catfish	Fishery	2	1	1	4	Pessimist
16	Galah Shrimp	Fishery	2	1	1	4	Pessimist
17	Durian	Agriculture	1	1	2	4	Pessimist
18	Rubber	Agriculture	1	1	2	4	Pessimist
19	Toothless gum	Agriculture	1	1	2	4	Pessimist
20	Sugar palm	Agriculture	1	1	2	4	Pessimist
21	Durian Lae	Agriculture	1	1	2	4	Pessimist
22	Palm oil	Agriculture	1	1	1	3	Pessimist
23	Cocoa	Agriculture	1	1	1	3	Pessimist
24	Candlenut	Agriculture	1	1	1	3	Pessimist
	Maximum		2	3	3	7	
	Minimum		1	1	1	3	

that is the optimistic scenario on 2 aspects, tourism (recreational parks and historical tours) and aspects of the fishery (tilapia, goldfish, catfish). Later in the moderate scenario, there are 3 aspects of the services (administration and housing), fisheries (cork fish and damselfish) and agriculture (guava, melinjo and dragon fruit), while, others are included in the criteria as a pessimistic scenario.

Therefore, the land use in post-coal mine area need the planning based on the capability of land and result of scenario. This is in line with the results of research [13, 16, 18-23]. Structuring the coal mining region becomes very important, especially, the post-coal mine region is expected to provide solutions to problems of the region, and identify the characteristics of the land as well as other potential resources [24].

4. Conclusions

The conclusion from this study is that the strategy of development at the post-coal mine area has 2 decision scenarios, which is the optimistic scenario on 2 aspects namely: (1) tourism (recreational parks and historical tours) and (2) aspects of the fishery (tilapia, goldfish and catfish). Later in the moderate scenario, there are 3 aspects of development: (1) services (administration and housing), (2) fisheries (cork fish and damselfish) and (3) agriculture (guava, melinjo and dragon fruit). Optimizing the utilization of post-mining land in the district of Kutai Kartanegara coal can be carried out with reference to these two types of scenarios as a manifestation of an engine of regional development.

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