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Resource Equivalency Analysis (REA) implication environmental of groundwater in Kupang East Nusa Tenggara

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Abstract. *This study aims to conduct an environmental assessment caused by the commercial use of groundwater by the community as landowners in Kupang Province of East Nusa Tenggara, Indonesia. REA methodology to assess and compensate for environmental damage. This method, developed by the National Oceanographic and Atmospheric Administration (NOAA), uses the scale of remediation required to compensate for past, current, and future damage. Therefore, the objective of this study was to design compensation approaches are the services approach (or the resources approach) and the valuation approach (the value-to-value and value-to-cost approach). The results show that the change in residential land is 0.16% or 25 ha. The total area of changed settlement/land built up has decreased the function of land, which was originally secondary/logged-over dry land forest to become settlement/land built up. Furthermore, there was a decrease in secondary/logged-over dry land forest to open field of 0.03% or 3.1 ha, so the total area of secondary/logged-over dry land forest decreased by 0.19% or 28.1 ha. The total present value is 149.54 DShaYs (Ha year's discount service). The value of this credit amount of compensation can be calculated at 246.89 ha. This means that it is sufficient for the restoration of 246.89 ha in 50 years with a recovery time of 10 years so that it is sufficient to restore the community for the loss of 247 ha. The cost per hectare is IDR 5,000,000.00. The compensation fee is IDR 1,235,000,000.00.*

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INTRODUCTION

The World Health Organization (WHO) has also published a book entitled "The Right To Water" which puts the task of each country's government on the right to water. There are three main tasks for the government of each country regarding the right to water, namely "duty to respect, duty to protect, and duty to fulfill" so that the use of ground water does not interfere with groundwater supplies, or does not damage the quality of water that has been provided by nature (Budds and Sultana 2013; Cleaver 2018). The government of East Nusa Tenggara implements it through the East Nusa Tenggara Provincial Regulation Number 11 of 2018 concerning groundwater management. The average infiltrated water potential and utilized water directly by the people amounted to 18%, and the remaining 82% is lost water potential. The results of the rainfall characterization in the study area have implications in water resources management (Messakh et al. 2015)

However, to overcome the difficulty of clean water for residents, the Government of Kupang City has issued a policy of distributing water through tanks taken from drilled well to a number of villages that were considered to be most in need. Through the Kupang City Disaster Management Agency (BPBD), the government provided 500 water tanks and proposed funding worth one billion to the parliament. Furthermore, permits for groundwater utilization are given to individuals to be commercialized at prices ranging from IDR 60,000.00 to IDR 70,000.00 per 5,000 liters and become a source of regional income or become one of the tax objects that can increase the original regional income of Kupang City. On the other hand, the NTT forum for the environment (Walhi) urged the government not to rely on drilled wells as a source of raw water because it is a form of exploitation of groundwater. There is a gap between the government, which still grants the extent of permits for the use of groundwater resources in increasing the value of the economic sector and in the other hand, from the perspective of damage to groundwater resources.

Therefore, policymakers, in determining appropriate compensation for a certain amount of ecological damage, use monetary and environmental compensation to increase the total compensation cost but reduce individual gains and losses arising from the trade-off between income and environmental quality (Bas et al. 2013; Mishan and Quah 2020). Resource Equivalency Analysis (REA) is a study of environmental damage that must be considered as the basis for compensation for losses. Conceptually, the determination of compensation for damage to natural resources uses a demand-side approach with replacement cost (Fauzi 2006; McCay et al. 2004; Zafonte and Hampton 2007; Budds and Sultana 2013; Wakefield and Davis 2017; Evers et al. 2019).

The objective of this study was to analyze a comprehensive implication for environmental problems using a Resource Equivalency Analysis. First, the credit calculation by estimating the restoration project needed to restore resource services through the restoration scenario. Second, the scenario of the percentage of natural resource services recovered and the time for recovery and benefits is needed. The third is information on the size of the restoration through the calculation of discounted debit and discounted credit.

METHOD

Location and Research Time

This research was conducted on the commercial groundwater of Kupang City, Province of East Nusa Tenggara, Indonesia. The supplies are from groundwater and Tilong Dam. Furthermore, the drinking water treatment plant by Municipal Waterworks (PDAM) and commercial groundwater locations where groundwater supplies water to several sub-districts in Kupang city, As shown in Figure 1.

Method of Collecting Data

Analysis land use change was using intersect method and ArcGIS. Furthermore, in the initial discharge calculation, related information to damaged natural resources and the degree of damage is needed and information on the estimated duration of damage and metric size using hectares (ha). Rehabilitation costs per hectare are generally IDR 5,000,000.00. Depending on the resource, rehabilitation costs per hectare range from US$ 43 to US$ 15,221 per hectare (Nawir et al. 2008). The increase human needs will be directly proportional to the increasing need for land that will be used to meet their needs (Marshall et al. 2011). There are many study cases on the factors that influence land use change: distance to the city Centre, population growth, economic facilities growth, social facilities growth and the determination of regional spatial plans (Sitorus and Aprilian 2018). The increase in built-up land is a consequence of an increase in population and an increase in the economic sector (Nugroho et al. 2018).

Data Analysis Method

The research dissects three processes to assess environmental assessment:

1) Calculating the debit amount's total present value
   $PVD = \Sigma L(1r)\ P - trt = 0$
   Lt: internym loss, r: discount rate, P: At the initial time of the incident, the environment was undamaged
2) Calculate the credit's total amount and present value.
   $PVC = \Sigma S\ (1{+}r)\ P - trt = 0$
   St: during this time t service was restored.
3) Scale and cost estimates for the rehabilitation
   $S = \Sigma PVDtrt = 0\ \Sigma PVCtrt = 0$
   PVD: *present value debit;* PVC: *present value credit*

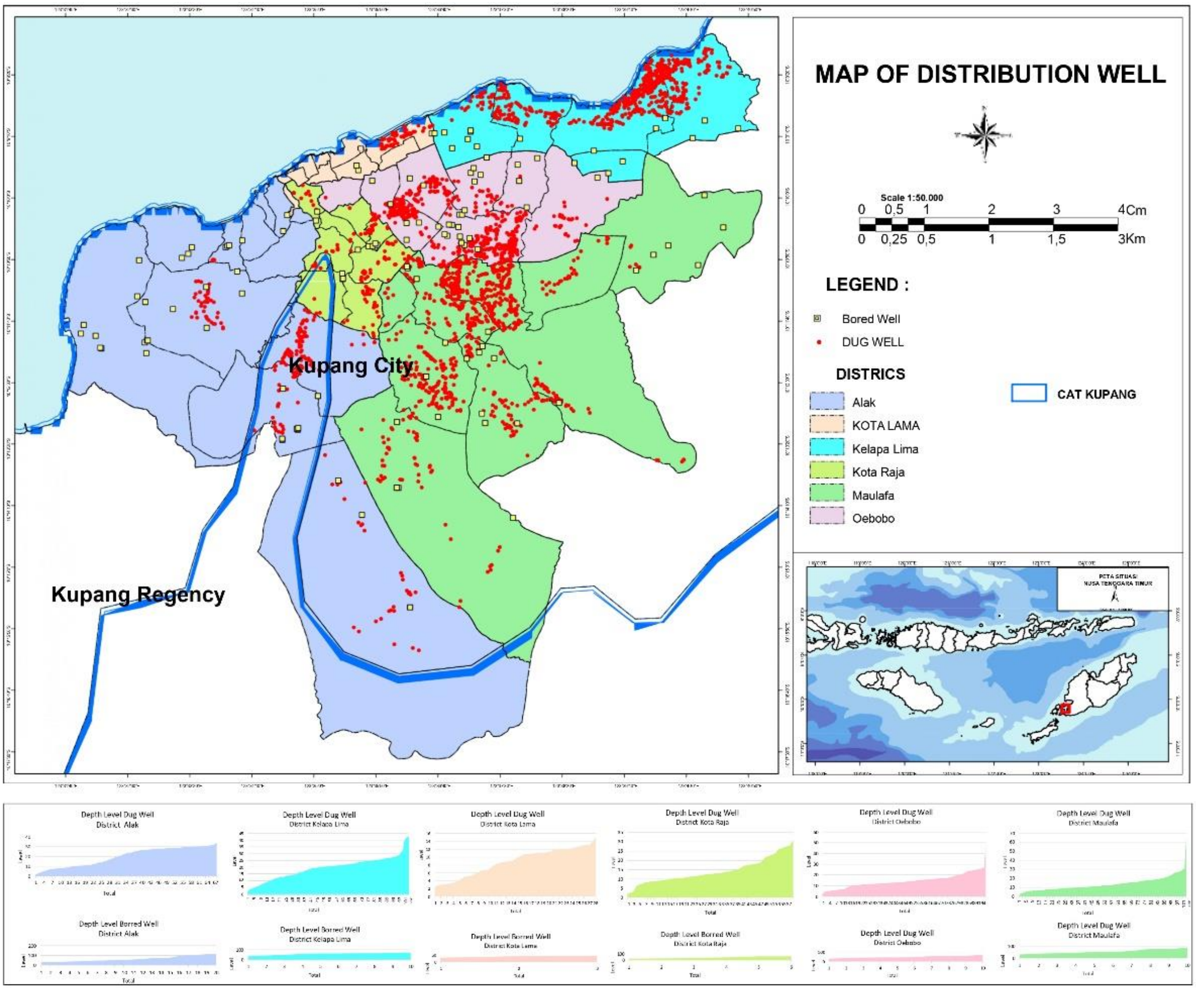

Figure 1 Map of study area

RESULT AND DISCUSSION

When interpreting an image, one examines the fundamental qualities of how each land use appears in the image with the use of interpretive factors. According to the results of image analysis (Figure 2) for the years 2019 – 2020 water bodies, secondary/logged-over dry land forests, settlement/land built up, shrubs, open fields, savannas, dry land agriculture, dry land mixed agriculture, wet paddy field, pond, airport/harbor, mining makes up most of the land use in Kupang City. The way that land was used in 2019 – 2020 has altered.

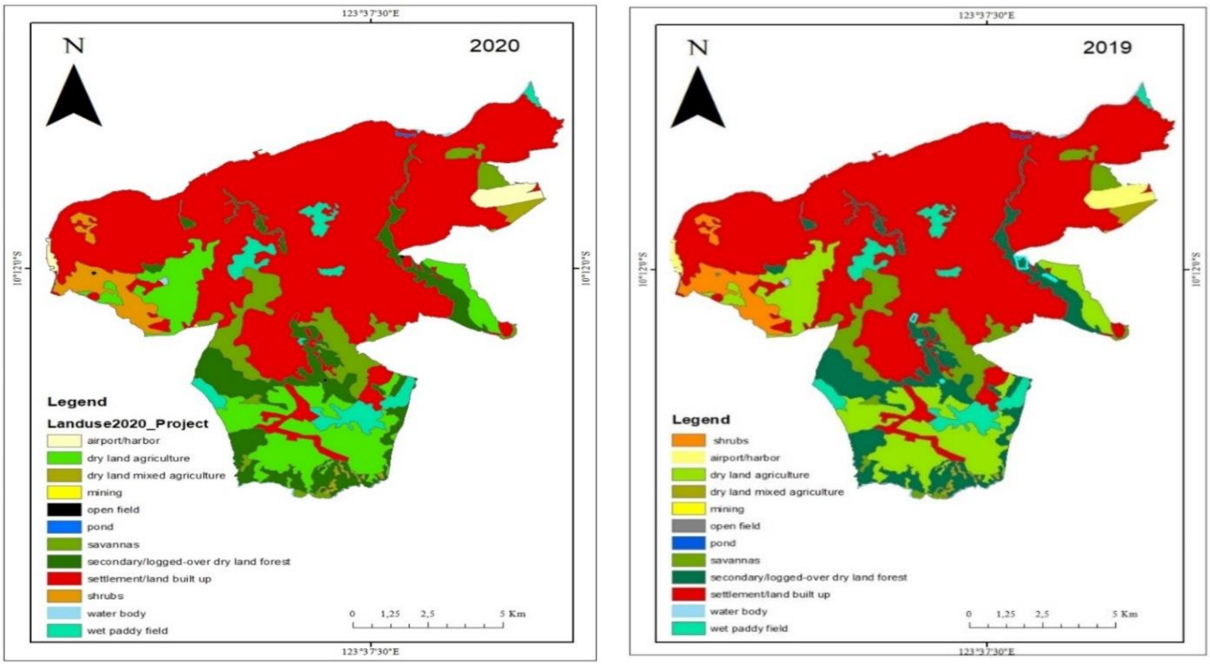

Figure 2 Land use map of Kupang City in 2019 and 2020

Table 1 Changes in land use area

Land Use	2019		2020		Changes of 2019-2020	
	Ha	**%**	**Ha**	**%**	**Ha**	**%**
5001 water body	42.1	0.27	42.1	0.27	0	0
2002 secondary/logged-over dry land forest	1,624.9	10.64	1,596.8	10.46	–28.1	–1.73
2012 settlement/land built up	9,145.6	2.89	9,170.6	60.09	25	0.27
2007 shrubs	442.3	59.93	442.3	0.03	0	0
2014 open field	1.7	0.01	4.73	2.89	3.1	186.7
3000 savannas	996.79	6.53	996.8	6.53	0	0
20091 dry land agriculture	2,067	13.54	2,067	13.54	0	0
20092 dry land mixed agriculture	116.2	0.76	116.2	0.76	0	0
20093 wet paddy field	605.8	3.97	605.8	3.97	0	0
20094 pond	9.2	0.06	9.2	0.06	0	0
20121 airport/harbor	206.6	1.35	206.6	1.35	0	0
20141 mining	1.7	0.01	1.7	0.01	0	0
Grand total	15,259.9	100	15,259.9	100		

Cross-tabulation was used to assess land use changes in the Table 2. The matrix displays the rate of transition between various land uses. The row portion displays the transition to land use changes that take place in the Table 1, while the column section displays the growth in the pace of land use change. The results show that the change in residential land is 0.16%, or 25 ha. The total area of changed settlement/land built up has decreased the function of land, which was originally secondary/logged-over dry land forest to become settlement/land built up. Furthermore, there was a decrease in secondary/logged-over dry land forest to open field of 0.03% or 3.1 ha, so that the total area of secondary/logged-over dry land forest decreased by 0.19% or 28.1 ha. This reduction occurs because residents' secondary/logged-over dry land forest areas are converted into settlements/land built up with an increase in population needs, which is directly proportional to the increase in the need for land used to meet needs. The reduction in secondary/logged-over dry land forest is also caused by forest encroachment on the planned dam.

Table 2 Record land use change matrix

Land Use	**Land use change 2019–2020**												**Grand Total**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	
(1)	206.6												206.6
(2)		2,067											2,067
(3)			116.2										116.2
(4)				1.7									1.7
(5)					1.7								1.7
(6)						9.2							9.2
(7)							996.8						996.8
(8)					3.1			1,596.8	25				1,624.9
(9)									9,145.6				9,145.6
(10)										442.3			442.3
(11)											42.1		42.1
c (12)												605.8	605.8
Grand Total	206.6	2,067	116.2	1.7	4.8	9.2	996.8	1,596.8	9,170.6	442.3	42.1	605.8	15,259.9

airport/harbor(1), dry land agriculture(2), dry land mixed agriculture(3), mining(4), open field(5), pond(6), savannas(7), secondary/logged-over dry land forest(8), settlement/land built up(9), shrubs(10), water body(11), wet paddy field(12).

Debit Amount's Total Present Value

Secondary/logged-over dry land forest of 28.1 ha, which is damaged due to settlement/land built up and forest encroachment into open fields, causing a decrease in forest services, such as groundwater, by 50% from the initial condition. The restoration program is carried out as an effort to restore or replace the same area with a gradual linear recovery every year, recovering 5% until the 10th year. After the 10th year, the restoration project will last up to 50 years, and the restoration will return to the baseline position (up 50%) as shown in Figure 3. The discount factor is 3%, as recommended by experts, namely using a low discount rate because a high discount rate will reduce the value in the future very significantly. Table 3 shows the discharge of this case. The value of PV damaged in column 4 is the result of the multiplication of the damaged ha discount factor.

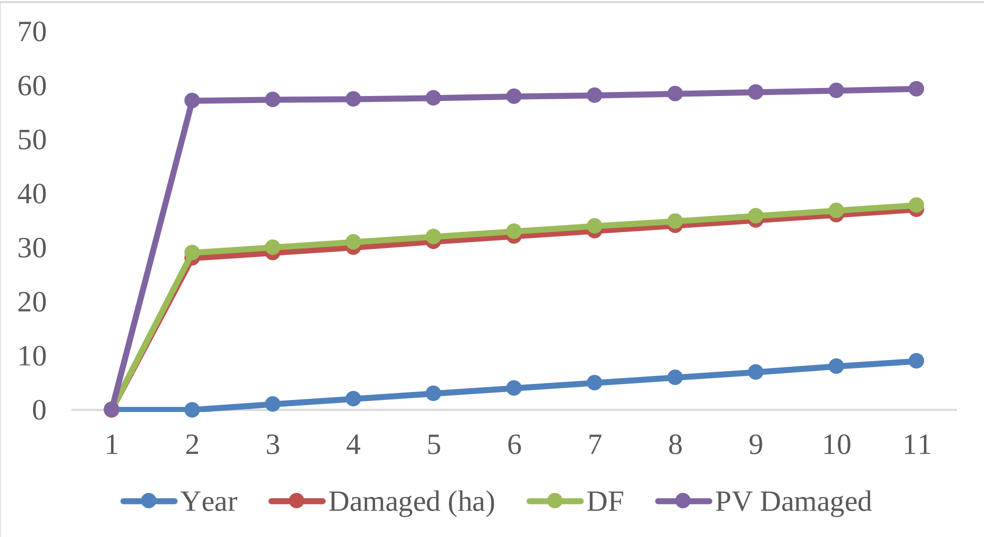

Figure 3 Credit changes linearly

Table 3 Discounted debit

Year	Damaged (ha)	DF[a] (3%)	PV[b] Damaged
0	28.1	1.00	28.10
1	28.1	0.97	27.28
2	28.1	0.94	26.49
3	28.1	0.92	25.72
4	28.1	0.89	24.97
5	28.1	0.86	24.24
6	28.1	0.84	23.53
7	28.1	0.81	22.85
8	28.1	0.79	22.18
9	28.1	0.77	21.54
Sum discounted PV services ha years (DShaYs)			246.89

[a)] discount factor DF = $1/(1+r)^t$, [b)] present value

Credit Amount's Total Present Value

Table 4 and Figure 4 showed that the calculation of the discounted present value credit for 50 years. Table 4 showed that the calculation of the discounted present value credit for 50 years. The total present value is 149.54 DShaYs (Ha year's discount service). The value of this credit amount of compensation can be calculated at 246.89 ha. This means that it is sufficient for the restoration of 246.89 ha in 50 years with a recovery time of 10 years so that it is sufficient to restore the community for the loss of 247 ha. The cost per hectare is IDR 5,000,000.00. The compensation fee is IDR 1,235,000,000.00.

Tabel 4 Discounted PV credit

Year	Service gain (%)	DF	PV credit
0	5	1.00	5.00
1	10	0.50	5.00
2	15	0.44	6.67
3	20	0.33	6.64
4	25	0.32	7.95
5	30	0.25	7.55
6	35	0.26	9.11
7	40	0.20	7.93
8	45	0.24	10.60
9	50	0.15	7.46
10	50	0.25	12.45
11	50	0.09	4.33
12	50	0.37	18.45
13	50	0.02	0.84
14	50	0.79	39.57
15	50	0.00	0.01
16	50	0.00	0.00
etc	50	etc	etc
49	50	etc	149.54

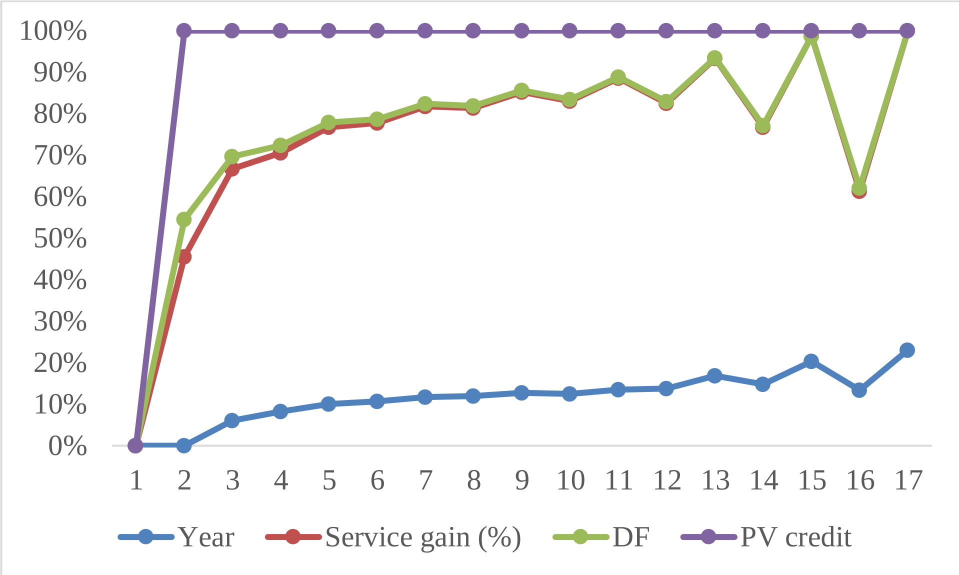

Figure 4 Discounted PV credit

CONCLUSION

The analysis shows that the current settlements/land built up have a preponderance of non-recommended allocation and are expected to grow. The area of anticipated settlements/land built up serves as a representation of the amount of land allocated for settlements/land built up development, which is sufficient to meet the demand. The distribution pattern, not a shortage of suitable locations for settlements/land built up development, is the issue. By controlling the distribution of settlements/land built up growth, the policy allocation matrix rule bridges the gap between policy advice and the planning control tools. The rule combines the effectiveness and conformance of the land allocation for settlements/land built up development that accommodates the idealist aspect and the existing and projected settlements/land built up that represents the reality aspect.

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