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Village Level Food Insecurity Index and Regional Clustering in Muna District, Southeast Sulawesi Province, Indonesia

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Abstract

Based on Food Security and Vulnerability Atlas (FSVA) 2015, Muna District is classified as a food insecure area with a priority level of vulnerability 3 which means it tends to be high as well as being ranked 190 according to the distribution of food insecure areas in Indonesia. This study aims to (1) Compile food insecurity index for each village in Muna District, (2) Classify villages based on regional characteristics in Muna District. Data were analyzed using principal component analysis and cluster analysis. The results of the calculation of the food insecurity index showed there were 4 villages (2.6%) included in the food insecurity category (priority 1), 33 villages (21.7%) were classified as quite vulnerable (priority 2), 94 villages (61.8%) were included the category is quite resistant (priority 3), and 21 villages (13.8%) fall into the food security category (priority 4). Villages with food insecure status (priority 1) and moderately vulnerable (priority 2) mostly have low population welfare characteristics, a high ratio of non-working population, a high ratio of residents without clean water access, and a ratio of households with no waste facilities high bowel water. As a whole, Muna District tends to be food security, as seen from the number of villages in priority 3 and 4, which are greater than 50%.

Keywords: *cluster, food insecurity, principal component analysis*

1. Introduction

The problem of food security is a global problem that is closely related to human survival. The 1996 World Food Summit in Rome, Italy, stated unequivocally that food security is a condition where all people, at all times, have access to adequate and safe food, as well as nutritious food sources to meet life's needs and support health (Gibson 2012). Famine levels around the world have risen for the first time in a decade. In 2016, as many as 815 million people suffered from hunger, an increase of 38 million compared to 2015, which is equal to 11 percent of the world's population (FAO *et al.* 2017).

Based on the Global Hunger Index score, in 2018, the level of hunger in Indonesia is still at a serious level. Indonesia for 17 years (2000-2017) showed a static development and is expected to reach the level of hunger in developed countries within 80 years (Pakpahan 2018).

Food insecurity is a condition of the inability of individuals or groups of individuals in an area to obtain adequate and suitable food for a healthy and active life. Food insecurity can also be interpreted as the condition of an area, community or household whose level of availability and food safety is not sufficient to meet the physiological needs for the growth and health of some people (Kementan 2010).

To overcome the problem of hunger, Indonesia is guided by the SDGs the second goal of which is to eliminate hunger, achieve food security and good nutrition, and improve sustainable agriculture. The Government of Indonesia cooperates with the World Food Program (WFP), compiling a comprehensive geographical profile related to food and nutrition insecurity in all regions. This preparation is used to improve the accuracy of targeting, provide information for policy makers so as to improve the

quality of plans and programs in reducing food and nutrition insecurity. The collaboration resulted in a Food Security and Vulnerability Atlas (FSVA).

Based on the 2015 FSVA, Muna District is included in priority group 3, which means the level of food insecurity tends to be high as well as being ranked 190 according to the distribution of food insecure areas in Indonesia. BPS data states that in 2015 the number of poor people in Muna District reached 44,430 people (15.45%), higher than other districts in Southeast Sulawesi Province. In addition, in Muna District there were still cases of malnutrition with a total of 26 cases (in 2017), 31 cases (in 2016), and 45 cases (in 2015).

Food security at one level does not reflect food security at another level such as the national level with households. A district that is identified as relatively more food security does not mean that all sub-districts, villages and the population in it are also food security. Likewise, in regencies classified as food insecure, this does not mean that all sub-districts, villages and their populations are food insecure (Dewan Ketahanan Pangan 2015).

The embodiment of national food security starts from the fulfillment of food in the smallest region, namely rural areas as the basis of agricultural activities. The village is an entry point for the inclusion of various programs that support the realization of food security (Hanani *et al.* 2011). So information about the level of food insecurity at the village level is needed.

This study aims to determine the index of food insecurity in each village and village typology based on regional characteristics in Muna District.

2. Research Methods

2.1 Time and Location

This research was conducted in Muna District, Southeast Sulawesi Province which covered 22 Subdistricts and 152 Villages. Muna District is located in the southeastern part of the island of Sulawesi (Figure 1). Astronomically located in the southern part of the Equator, extending from North to South between 04 ° 15 '- 05 ° 15' south latitude and stretching from west to east between 122 ° 30 '- 123 ° 15' east longitude. The study was conducted from January to June 2019.

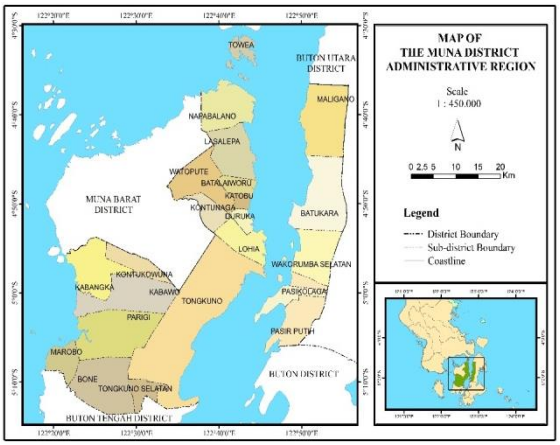

Figure 1. Map of the Study Area

2.2 Material

The data used in this study are secondary data that includes 2014 Village Potential data, the 2015 Geographic Difficulty Index, Regions in Numbers sourced from the Central Statistics Agency (BPS), the 2015 Integrated Database Update (PBDT) data sourced from the National Team for the Acceleration of Mitigation Poverty (TNP2K) and deforestation data from the Ministry of Environment and Forestry (KLHK). Processing data using ArcGis 10.4.1 and Statistica 10.

The variables used in this study include 4 dimensions of food security with a total of 17 variables (Table 1).

Table 1. Variables used

Variable	Information	Dimension
X_1	Market / household ratio	Food availability
X_2	Mini market / household ratio	
X_3	The ratio of stalls / households	
X_4	Store / household ratio	
X_5	Ratio of normative consumption to food availability (rice, corn, cassava, sweet potatoes)	
X_6	Ratio of population to welfare status lowest / total population	Food Accessibility
X_7	The ratio of households without access to electricity	
X_8	Population ratio not working	
X_9	Access road cannot be passed by 4 or more wheels	
X_{10}	Geographical difficulty index	
X_{11}	The ratio of households does not have access to clean water	Food utility
X_{12}	Ratio of number of health workers / total population	
X_{13}	Ratio of malnutrition population / population	
X_{14}	The ratio of households without bowel facilities	
X_{15}	Number of natural disasters	Food stability
X_{16}	Agricultural land conversion	
X_{17}	Deforestation of the forest	

2.3 Method

2.3.1 Forming Food Insecurity Index

Food Insecurity Index is a composite index obtained from the sum of all individual indices in each dimension. Village level food insecurity index in MunaDistrict was compiled using Principal Component Analysis (PCA).

The steps are as follows:

1. Standardize original variables to eliminate data variations between variables (Gujarati 2003)

$$y_{ij} = \frac{x_{ij} - \mu_j}{S_j} \quad (1)$$

y_{ij} : new simplified variable

x_{ij} : variable X value in region i variable j

μ_j : the average value of each variable

s_j : standard deviation of each variable

2. Orthogonalization of variables to create new variables Z_α (α = 1,2,...,q≤p) which have characteristics not correlated with each other, the average value of each remains equal to zero, and the value of each variance Z_α same with $\lambda_\alpha \geq 0$, where $\sum_\alpha \lambda_\alpha = p$
3. Simplifying the number of variables by ordering each of the main factors / components (F_α) resulting, which have *eigenvalue* (λ_α) highest to lowest.
4. Standardize factor scores ((Pravitasari *et al*. 2018):

$$Si(std) = (Si - Si(min)) * \frac{100}{Si(\max) - Si(min)} \quad (2)$$

Where :
S = factor scores
i = unit of analysis area
Si(max) = maximum factor score
Si(min) = minimum factor score

5. Normalization of weights. The weight used is the normalized eigenvalue value (Pravitasari *et al*. 2018).
6. Multiplication between standardized factor scores and normalized weights results in a weighted factor score throughout the analysis unit area and all components formed.
7. Food insecurity index (Pravitasari *et al*. 2018): $\sum_{i=1}^{4} S_{std_i} * B_i$

S_{std_i} = standardized score of the principal component
B = weight
i = principal component

2.3.2 Village Classification

The cluster analysis technique is one technique to limit the area based on the similarity of certain characteristics of an area. The areas contained in one cluster are more homogeneous compared to the regions that are in another cluster (Goswami *et al.* 2014). The region is described by a number of variables (Hair *et al.* 1998). This analysis aims to group a number of n observation areas into groups that have relatively similarities. The grouping is based on a measure of proximity between each region called distance. The measure of closeness used is the Euclidean Distance. Euclidean distance calculation equation between two points or two groups according to Panuju and Rustiadi (2013):

$$d_{12} = \sqrt{\sum_{i=1}^{p} (X_{1i} - X_{2i})^2}$$

Keterangan :
d_{12}= the distance between points 1 and 2 / cluster 1 and 2
i = 1,2,3, …
p = the number of variables that are characteristic of identifiers to determine the similarity between observation units 1 and 2.
The smaller the value of d the greater similarity of data 1 and 2
X_{1i} = coordinate of point 1 in the i-th variable

3. Result and Discussion

3.1 Village Level Food Insecurity Index

The initial stage of PCA is determining the number of main components to be used by looking at the eigenvalue and cumulative variance. Based on PCA results, there are 5 principal components that have an eigenvalue greater than 1 (Table 2). The cumulative value of the variants of the five principal components is already high, namely 73.971%. This means that the 5 principal components formed were able to explain the diversity of data from all variables by 73.971%.

Table 2.Eigenvalue andCumulative Variance

PC	Eigen value	% Total Variance	Cumulative Eigenvalue	Cumulative - %
1	2.731	27.305	2.731	27.305
2	1.392	13.920	4.123	41.225
3	1.196	11.960	5.319	53.185
4	1.073	10.726	6.391	63.911
5	1.006	10.060	7.397	73.971

After obtaining the number of principal components, then determine the forming variables of each principal component obtained from the loading factor value. The greater the loading factor indicates a strong correlation between the forming variables and the principal components. Based on varimax rotation, the loading factor values are presented in Table 3.

Table 3. Loading Factor with Varimax Rotation

Var	Component				
	1	2	3	4	5
X5	-0.027	0.022	0.103	0.019	**-0.939**
X6	**0.863**	0.016	0.160	0.042	0.040
X8	**0.692**	-0.235	0.344	-0.185	0.200
X9	0.046	0.051	**0.866**	-0.096	-0.196
X10	0.244	-0.011	**0.754**	0.221	0.079
X11	**0.739**	0.009	-0.150	-0.034	-0.272
X13	0.033	-0.005	0.057	**0.965**	-0.023
X14	**0.685**	0.114	0.249	0.268	0.159
X15	0.065	**0.768**	0.021	0.058	-0.126
X16	-0.074	**0.811**	0.008	-0.056	0.102

PCA reduced 17 initial variables to 10 food insecurity variables used for analysis. These variables are divided into five principal components :

1 Food accessibility in economic aspects
   a. The ratio of population to the lowest welfare status / total population.
   b. Population ratio not working.
   c. The ratio of households does not have access to clean water.
   d. The ratio of households without bowel facilities.
2. Food stability
   a. Number of natural disasters.
   b. Agricultural land conversion.
3. Physical aspects of food accessibility
   a. Access road cannot be passed by 4 or more wheels.
   b. Geographical difficulty index.

4. Food utility
   a. Ratio of malnutrition population / total population.
5. Food availability
   a. Ratio of normative consumption to food availability.

Next, factor scores from the PCA results are used to calculate the composite index for food insecurity for all villages in Muna District. The status of food insecurity in each village is needed in order to know which areas are experiencing food insecurity so that it can be prioritized in its handling. The status of food insecurity is grouped into four classes namely food secure, quite food resistant, quite food insecure and food insecure (Table 4). The greater the index value, the greater the vulnerability to food insecurity. Villages with food insecurity status are villages that get priority 1 to be handled by the local government, villages with insecure status become priority 2 to be dealt with immediately, while villages with sufficiently resistant status get priority 3 in food management and villages with food-secure status are handled in priority 4 (Figure 2).

Table 4. Number of Villages Based on Priority Handling in Muna District

Status	Priority	Number of Villages
Food insecure	1	4
Quite food insecure	2	33
Quite food resistant	3	94
Food secure	4	21

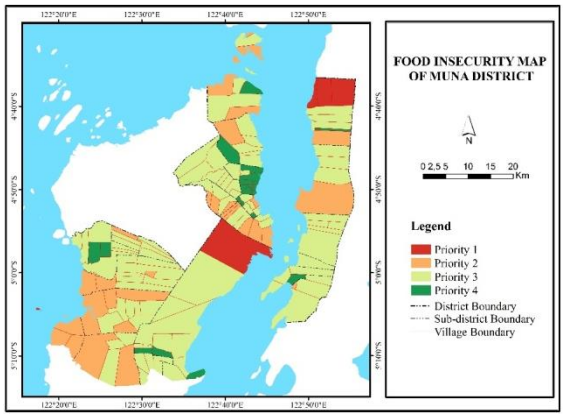

Fig 2. Food Insecurity Map of Muna District

The composite index calculation results indicate that four villages (2.6%) are in priority 1 with an index value ≥75. Priority 2 consists of 33 villages (21.7%) with an index value of 50 - <75. Priority 3 with an index value of 25 - <50 is 94 villages (61.8%), and the most food-resistant villages are in priority 4 with a total of 21 villages (13.8%) having an index value <25. The highest score is Langkoroni village in Maligano Sub-district with an index value of 100, while the lowest score is Laende Village in Katobu Sub-district with an index value of 0.

3.2 Village Classification Based on Regional Characteristics

Factor scores from the PCA results are not only used to calculate the composite index for food insecurity, but also for further data processing, namely village classification using Tree Clustering and K-Mean Cluster analysis. Based on the dendogram from the tree clustering results, villages in Muna District are grouped into 3 groups that have similar characteristics in each group. The characteristics of each group can be explained from Figure 3.

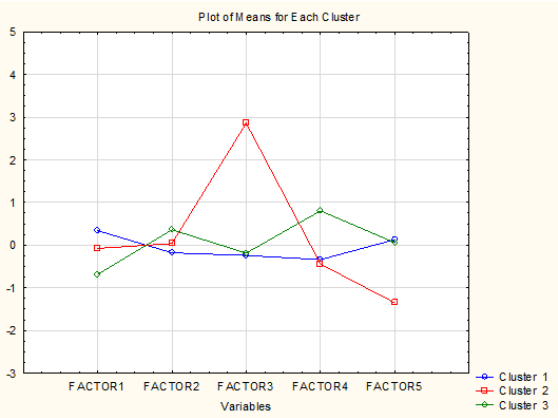

Fig 3. Graph of Means for Each Cluster

Cluster 1 members are villages that have high characteristics in the principal component (PC) 1 (the ratio of the lowest welfare population, the ratio of the population not working, the ratio of households without access to clean water, and the ratio of households without defecation facilities). A high PC 1 indicates that cluster 1 is a regional typology with low economic aspects of food accessibility. Most of the villages in Muna District belong to group 1, there are 95 villages (62.5%) out of 18 sub-districts that belong to group 1. The sub-district with the highest percentage of villages (reaching 100%) entering group 1 is Lohia Sub-district, Parigi, and South Tongkuno.

Cluster 2 consists of villages that have high characteristics on PC 3 (access road that cannot be passed by four or more wheels, geographical difficulty index) and PC 5 (ratio of per capita normative consumption). PC 3 represents the accessibility of physical aspects of food, while PC 5 represents the dimensions of food availability. The high PC 3 shows that the members of the cluster 2 have characteristics of areas that are difficult to reach physically using four-wheeled vehicles, almost all the area of cluster 2 can only be reached using sea transportation. Next, with the high characteristics of PC 5, it can be interpreted that cluster 2 is the region whose food consumption needs are higher than the food products produced in the region. There are 11 villages (7.2%) out of 6 sub-districts that are members of cluster 2, the most from Towea Sub-district with a total of 4 villages namely Renda, Bahari, Moasi, Wangkolabu. Marobo and Pasir Putih Sub-districts each have 2 villages that are members of 2 cluster, namely Pasikuta, Tapi-tapi,

Oenggumora, and Labulawa. The next cluster of 2 members comes from the sub-districts of Tongkuno, Katobu, and Wakorumba Selatan with a total of 1 village each, including the villages of Tanjung, Laende, and Bakealu.

Cluster 3 consists of villages with low characteristics at the lowest welfare ratio, the ratio of non-working population, the ratio of households with no access to clean water, and the ratio of households with no defecation facilities, while the number of natural disasters, land conversion, and the ratio of malnutrition population is high. There are 46 villages from 18 sub-districts that are members of cluster 3. Almost all village in Katobu Sub-district are members of cluster 3, this illustrates that cluster 3 is a more developed area compared to other regions in Muna District. The spatial distribution of members of each group can be seen in Figure 4.

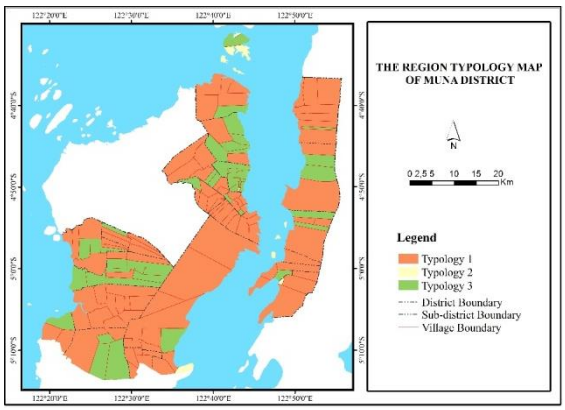

Fig 4. The Region Typology Map of Muna District

3.3 The Linkage of Food Insecurity Index to Regional Typology in Muna District

Different characteristics of village areas need to be followed by approaches to different development policy programs between regions. The development program will be more optimal if the policy package is rolled out in accordance with the characteristics and potential of each region.

Overlay analysis is carried out to determine the relationship between food insecurity index and regional characteristics in Muna District. Based on overlay analysis, it can be seen the distribution of each priority in handling food insecurity according to regional typology, as shown in Figure 5.

Areas that need major attention are villages with priority status 1 and 2 as the area most vulnerable to food insecurity (Table 5). The two priorities are mostly in typology 1 region with 3 villages (priority 1) and 21 villages (priority 2). This indicates that the population with the lowest welfare, the population does not work, households do not have access to clean water, and households without defecation facilities are the main characteristics of areas that are more vulnerable to food insecurity. These results are in line with research conducted by Nisa' *et al.* (2014) in Lumajang District which mentioned that poverty is an indicator that affects food vulnerability.

Table 5. Village Distribution Based on Priority Scale and Regional Typology

Priority	Typology		
	1	2	3
1	3 (1.97 %)	1 (0.66 %)	-
2	21 (13.82 %)	5 (3.29 %)	7 (4.61 %)
3	68 (44.74 %)	3 (1.97 %)	23 (15.13 %)
4	3 (1.97 %)	2 (1.32 %)	16 (10.53 %)

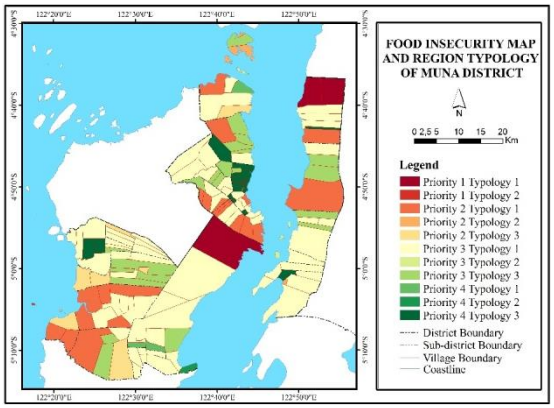

Fig 5.Food Insecurity Map and Region Typology of Muna District

The population with the lowest welfare and non-working population is related to the ability of the population to access food from an economic aspect, while households without access to clean water and households without defecation facilities are related to the ability of households to use food properly.The Muna District Government needs to strive to improve the welfare of the population and expand employment opportunities, in addition to the equitable development of basic service facilities in all rural areas is one of the priorities to be able to improve food security in all regions of Muna District.

4. Conclusion

Village-level food insecurity index in Muna District is divided into four priority scales. Priority 1 is the villages most vulnerable to food insecurity with 4 villages (2.6%) in 3 sub-districts. Priority 2 is somewhat better than priority 1 with the number of villages included in this category as many as 33 villages (21.7 percent) from 14 sub-districts. Priority 3 tends to be more food security with a number of members reaching 94 villages (61.8 percent) from 20 sub-districts. Priority 4 is the most food-resistant area, with 21 villages (13.8 percent) out of 9 sub-districts included in this category. Overall, Muna District tends to be food resistant, this can be seen from the number of villages that are in priority 3 and 4, greater than 50%.

Village area classification is formed into 3 typologies. Typology 1 with the characteristics of low economic aspect food accessibility has the largest membership of 95 villages (62.5%). Low physical aspect food accessibility and low food availability are characteristics of typology 2 with 11 village members (7.2%). The villages classified in typology 2 are mostly located in the archipelago. Typology 3 has characteristics of access to food in high economic

aspects, while food stability and food utilization are low. The number of villages entering typology 3 was 46 villages.

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