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Preface

We would like to present, with great pleasure, the inaugural volume-9, Issue-1, January 2023, of a scholarly journal, *International Journal of Environmental & Agriculture Research*. This journal is part of the AD Publications series *in the field of Environmental & Agriculture Research Development*, and is devoted to the gamut of Environmental & Agriculture issues, from theoretical aspects to application-dependent studies and the validation of emerging technologies.

This journal was envisioned and founded to represent the growing needs of Environmental & Agriculture as an emerging and increasingly vital field, now widely recognized as an integral part of scientific and technical investigations. Its mission is to become a voice of the Environmental & Agriculture community, addressing researchers and practitioners in below areas.

Environmental Research:

Environmental science and regulation, Ecotoxicology, Environmental health issues, Atmosphere and climate, Terrestric ecosystems, Aquatic ecosystems, Energy and environment, Marine research, Biodiversity, Pharmaceuticals in the environment, Genetically modified organisms, Biotechnology, Risk assessment, Environment society, Agricultural engineering, Animal science, Agronomy, including plant science, theoretical production ecology, horticulture, plant, breeding, plant fertilization, soil science and all field related to Environmental Research.

Agriculture Research:

Agriculture, Biological engineering, including genetic engineering, microbiology, Environmental impacts of agriculture, forestry, Food science, Husbandry, Irrigation and water management, Land use, Waste management and all fields related to Agriculture.

Each article in this issue provides an example of a concrete industrial application or a case study of the presented methodology to amplify the impact of the contribution. We are very thankful to everybody within that community who supported the idea of creating a new Research with *IJOEAR*. We are certain that this issue will be followed by many others, reporting new developments in the Environment and Agriculture Research Science field. This issue would not have been possible without the great support of the Reviewer, Editorial Board members and also with our Advisory Board Members, and we would like to express our sincere thanks to all of them. We would also like to express our gratitude to the editorial staff of AD Publications, who supported us at every stage of the project. It is our hope that this fine collection of articles will be a valuable resource for *IJOEAR* readers and will stimulate further research into the vibrant area of Environmental & Agriculture Research.

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(Managing Editor)

Dr. Bhagawan Bharali
(Chief Editor)

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Agricultural Sciences	
Soil Science	Plant Science
Animal Science	Agricultural Economics
Agricultural Chemistry	Basic biology concepts
Sustainable Natural Resource Utilisation	Management of the Environment
Agricultural Management Practices	Agricultural Technology
Natural Resources	Basic Horticulture
Food System	Irrigation and water management
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Cereals or Basic Grains: Oats, Wheat, Barley, Rye, Triticale, Corn, Sorghum, Millet, Quinoa and Amaranth	Oilseeds: Canola, Rapeseed, Flax, Sunflowers, Corn and Hempseed
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Vegetable crops or Olericulture: Crops utilized fresh or whole (wholefood crop, no or limited processing, i.e., fresh cut salad); (Lettuce, Cabbage, Carrots, Potatoes, Tomatoes, Herbs, etc.)	Tree Fruit crops: apples, oranges, stone fruit (i.e., peaches, plums, cherries)
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Table of Contents

Volume-9, Issue-1, January 2023

Phenotypic characterization of linear body measurements of Guinea pigs (*Cavia porcellus*) in the middle belt of Ghana

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Abstract— *The study was carried out to investigate the phenotypic characteristics, relationship between body weight and linear body measurements of Guinea pigs in the middle belt of Ghana. A total number of 367 Guinea pigs of about four weeks old were used for the study. The study was conducted in two phases. In the first phase, 310 Guinea pigs were sampled using snowball sampling method. Fifty four Guinea pigs were reared for four months in the second phase. Simple linear regression equation was used for body weight and linear body measurements. All the data were analyzed by using R statistical software version 4.2.1 and SPSS version 21.0. The effects of location had significant ($p \leq 0.01$) variation effect on Guinea pigs whilst sex did not have significant effect ($p > 0.05$) on Cavies. The highest correlation value (0.91) was between body length and heart girth. The least correlation value (0.21) was found between body weight and fore leg length. The simple linear regression equation: $Y= -214.69+5.51BL+10.11HG+15.74HW+18.16HL-7.74HLL-5.34FLL$, body length (BL), heart girth (HG), height-at-withers (HW) and head length (HL) were the best predictor of body weight in Guinea pigs with R^2 of 0.80. The best time to predict the body weight of Guinea pig was in week 2. However, it was concluded that the linear body measurements of Guinea pigs in the middle belt of Ghana serve as good indicators to predict live body weight which breeders can use for breeding purposes.*

Keywords— Cavia porcellus, characterization, correlation, phenotypic, regression.

I. INTRODUCTION

Characterizing indigenous breeds are very essential because they are well adapted to the local environment and require very little economic inputs for their sustenance (APD, 2003). Characterization is paramount for conservation and sustainable utilization of farm animal genetic resources, especially local breeds that are often less envisaged due to their relatively low production potential (Adjei *et al.*, 2015).

Phenotypic characterization generally refers to the process of identifying distinct breed populations and describing their external and production characteristics within a given production environment (Karnuah *et al.*, 2018). Phenotypic characterization describes how to conduct a study on a specific animal population and its production environment which includes; details of what to measure, how to take these measurements and how to interpret them (FAO, 2012). It provides the prerequisite information and guidelines on genetic and molecular characterization (FAO, 2011).

Guinea pigs are widely reared for meat in Latin America and many African countries but their production has received virtually no attention from government institutions and agricultural sector policy makers (AU-IBAR, 2019). Ghana has various breeds of domestic animal species that contribute to agriculture and food security, but there is little knowledge on the characteristics of some of the breeds (APD, 2003). Micro livestock are likely to become increasingly important as a result of rapid increase in human population and urbanization (Assan, 2014). Guinea pigs appear to be cheaper and achievable solution that can be used to supplement and compensate for the protein insufficiency in rural areas for many reasons (Handlos, 2018). However, characterizing indigenous breeds and their subsequent description would assist in the development of economically low esteemed areas of every region through the evaluation of local breeds and thereby promoting conservation of local breeds and preservation of biodiversity (De Marchi *et al.*, 2003).

Ayagirwe *et al.* (2019) indicated that Guinea pigs can be phenotypically characterized based on their observable quantitative traits such as; body weight, head length, body length, heart girth and height.

In accordance with Animal Production Directorate (2003) stated that Ghana Animal Genetic Diversity must conserve indigenous breeds and improve upon their sustainability. Now, it is imperative to characterize these wonderful animals (Guinea pigs) for food, income, multiplication and research.

II. MATERIALS AND METHODS

2.1 Study area and data collection

The research was carried out in the middle belt of Ghana (Ahafo, Ashanti, Bono and Bono East regions). The data collection was obtained from September, 2019 to February, 2021. Ashanti region lies between longitudes 0.15 – 2.25ºW and latitudes 5.50 – 7.46ºN and Bono Ahafo region is located within longitude 0.15ºE and latitudes 8.45ºN and 7.30ºS of Ghana. These regions have annual rainfall between 1,088 mm – 1,800 mm from the beginning of March to end of September and a mean temperature range of 23.9ºC to 32ºC and humidity between 65% - 85% throughout the year (MoFA, 2021ab).

Two studies were conducted. For the phase one, a twelve - month survey was performed. Fifty four (54) Guinea pigs farmers were interviewed using a semi-structured interview and questionnaire and 310 Guinea pigs were sampled in middle belt of Ghana using snowball sampling method. In the phase two (field experiment), fifty four (54) Guinea pigs of about four (4) weeks old were reared for four (4) months in Goaso, Ahafo region. Three hundred and sixty-seven (367) Guinea pigs about a month old from the four regions (Ahafo, Ashanti, Bono and Bono East) were sampled for the study.

The data obtained were on the relationship between body weight and linear body measurements of Guinea pigs breeds in the middle belt of Ghana. The linear body measurements of Guinea pigs were recorded using a digital kitchen precision scale and a tape measure. Measurements were recorded in grams (g) and centimeters (cm).

Primary characterization and longitudinal type of design were used for both survey and field experiment.

FIGURE 1: Taking linear body measurements of Guinea pigs in the middle belt of Ghana

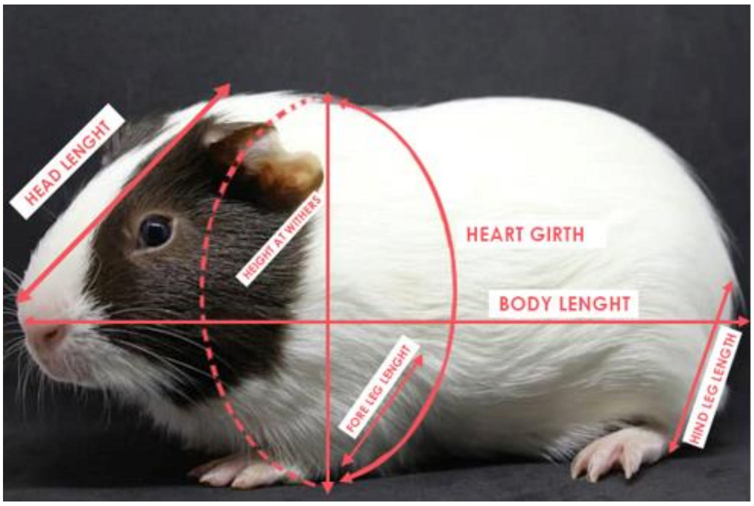

FIGURE 2: Showing linear body measurements of Guinea pigs in the middle belt of Ghana

Body weight (WT): The animals were weighed on a scale and their weights read and recorded.

Body length (BL): It was measured from the croup to the tail.

***Height at withers (HW)*:** Measured from ground to the highest point of the withers. This was done by keeping the tape measure tight, straight and perpendicular to the ground.

Heart girth (HG): Measured the circumference around the chest. It was done by placing the tape measure immediately behind the forelegs and pull the tape to fit snugly.

Head length (HL): It was measured from the nose to the neck bone.

Hind Leg length (HLL): It was measured from the socket joint to the highest point of the croup.

Fore Leg length (FLL): It was measured from the shoulder joint to the foot.

2.2 Statistical analysis

Evaluation of the effects of location (regions) and sex on body measurements data were analyzed by least squares analysis of variance using the General Linear Model (GLM) of R Statistical Software version 4.2.1 (R Core Team, 2021).

The model used was: $Y_{jk} = \mu + R_j + S_k + RS_{jk} + e_{jk}$, where Y_{jk} = body weight, body length, heart girth, height-at-weight, head length, hind leg length and fore leg length. μ = the overall mean, R_j = the effect of the j^th^ regions or location, j = 1…4 (1=Ashanti, 2=Ahafo, 3=Bono and 4=Bono East) S_k = the effect of the k^{th} sex of Guinea pigs, k= 1, 2 (1=male, 2=female) RS_{jk} = is the interaction effect between j^{th} location and the k^{th} sex e_{jk} = the random error term assumed normally and independently distributed, (0, σ2 e). Means were separated using LSD under the Post Hoc Multiple comparison.

Correlation coefficients among the various linear body measurements were estimated using the Pearson's correlation of SPSS 21.0 (SPSS, 2021).

The best prediction equation of the body weight and linear body measurements of Guinea pigs were analyzed using simple linear regression analysis with the aid of R Statistical Software version 4.2.1 (R Core Team, 2021).

The simple linear regression equation was: $Y= \alpha + \beta X$

Where Y is live body weight (BW) or dependent variable; α is the constant value of Y.

Where β is the slope of X defined as the change in Y resulting from a unit change in X.

X is the independent variable represented by BL, HW, HG, HL, HLL, FLL.

III. RESULTS

3.1 Survey results

3.1.1 Body weight and linear body measurement base on location (regions)

The mean body measurements for local Guinea pigs based on regions are indicated in Table 1. The regions were highly significant ($p < 0.01$) on body measurements (*BL, HG, HL, HLL* and *FLL)* of Guinea pigs except for the body weight ($p > 0.05$) and height-at-withers ($p > 0.05$) that did not have influence on the location (regions).

TABLE 1
EFFECTS OF LOCATION (REGIONS) ON BODY WEIGHT AND LINEAR BODY MEASUREMENTS OF GUINEA PIGS IN THE MIDDLE BELT OF GHANA

Variable	Region				Mean	*P Value*
	Ashanti	Bono	Ahafo	Bono East		
BW	378.88±20.58	429.84±23.35	418.65±12.93	357.86±35.57	405.19±151.90	0.06
BL	21.68±0.48^{b}	23.02±0.55^{ab}	23.67±0.30^{a}	21.76±0.83^{ab}	22.83±3.55	0.00
HG	17.01±0.35^{b}	18.58±0.39^{a}	17.05±0.22^{b}	16.81±0.60^{b}	17.32±2.55	0.00
HL	7.24±0.16	7.71±0.18	7.47±0.10	7.24±0.28	7.43±1.19	0.09
HW	6.77±0.15^{c}	7.73±0.17^{ab}	8.08±0.09^{a}	7.33±0.25^{bc}	7.58±1.09	0.00
HLL	6.19±0.12^{b}	6.41±0.14^{b}	6.95±0.08^{a}	6.42±0.21^{ab}	6.59±0.91	0.00
FLL	5.31±0.13^{b}	5.44±0.15^{b}	6.41±0.08^{a}	5.41±0.22^{b}	5.83±0.96	0.00
No.	89	60	18	143		

P-Value = probability value, BW= body weight, BL=body length, HG=heart girth, HW=height-at-weight, HL=head length, HLL=hind leg length, FLL=fore leg length

3.1.2 Body weight and linear body measurement base on sex

Mean body measurements for Guinea pigs based on sexes are found in Table 2. Both sexes had no influence ($p > 0.05$) on *BW, BL, HG, HW, HL, HLL* and *FLL*

TABLE 2
EFFECTS OF SEX ON BODY WEIGHT AND LINEAR BODY MEASUREMENTS OF GUINEA PIGS IN THE MIDDLE BELT OF GHANA

Variable	Sex		Mean	*P Value*
	Male	Female		
BW	399.76±17.97	408.43±10.99	405.19±153.10	0.63
BL	22.85±0.43	22.82±0.26	22.83±3.64	0.95
HG	17.29±0.31	17.34±0.19	17.32±2.62	0.85
HW	7.41±0.14	7.45±0.09	7.43±1.21	0.83
HL	7.64±0.14	7.54±0.09	7.58±1.22	0.51
HLL	6.56±0.11	6.60±0.07	6.59±0.96	0.68
FLL	5.77±0.13	5.87±0.09	5.83±1.09	0.46
No.	113	197		

P-Value = probability value, BW= body weight, BL=body length, HG=heart girth, HW=height-at-weight, HL=head length, HLL=hind leg length, FLL=fore leg length

3.1.3 Correlation between body measurements of Guinea pigs from survey

The correlations coefficient between body weight and linear body measurements ranged from low (0.33) to high (0.87) are indicated in Table 3. The correlation was highly positive and significant ($p < 0.01$) between body measurements. The highest correlation figure was recorded between body weight and body length (0.87), hind leg length and fore leg length (0.87). The body weight and height-at-weigh had the second highest correlation figure (0.79). The least correlation value was found between heart-at-withers and fore leg length (0.33). There was no negative correlation among body measurements.

TABLE 3
CORRELATION OF BODY WEIGHT AMONG LINEAR BODY MEASUREMENTS OF GUINEA PIGS FROM SURVEY

	BW	BL	HG	HW	HL	HLL	FLL
BW	-						
BL	0.87**	-					
HG	0.64**	0.66**	-				
HW	0.79**	0.78**	0.51**	-			
HL	0.67**	0.73**	0.53**	0.55**	-		
HLL	0.60**	0.69**	0.51**	0.54**	0.71**	-	
FLL	0.45**	0.59**	0.49**	0.33**	0.67**	0.87**	-

***** Significant p < 0.01, BW= body weight, BL=body length, HG=heart girth, HW=height-at-weight, HL=head length, HLL=hind leg length, FLL=fore leg length***

3.2 Field experiment results

3.2.1 Body weight and linear body measurement base on location (regions)

Mean body measurements for Guinea pigs based on location (region) are presented in Table 4. The location did not have effects on most of the body measurements of Guinea pigs. The Guinea pigs had similar values ($p > 0.05$) for all the body measurements except for hind leg length that had some differences ($p < 0.01$) and fore leg length was highly significant ($p < 0.01$).

TABLE 4
EFFECTS OF LOCATION (REGIONS) ON BODY WEIGHT AND LINEAR BODY MEASUREMENTS OF GUINEA PIGS IN THE MIDDLE BELT OF GHANA

	BW	BL	HG	HW	HL	HLL	FLL
BW	-						
BL	0.87**	-					
HG	0.64**	0.66**	-				
HW	0.79**	0.78**	0.51**	-			
HL	0.67**	0.73**	0.53**	0.55**	-		
HLL	0.60**	0.69**	0.51**	0.54**	0.71**	-	
FLL	0.45**	0.59**	0.49**	0.33**	0.67**	0.87**	-

***** Significant p < 0.01, BW= body weight, BL=body length, HG=heart girth, HW=height-at-weight, HL=head length, HLL=hind leg length, FLL=fore leg length***

3.2.2 Body weight and linear body measurement base on sex

Table 5 shows the mean body measurements for Guinea pigs based on sexes. Both sexes had no effect (p > 0.05) on *BW, BL, HG, HW, HL, HLL* and *FLL*.

TABLE 5
EFFECTS OF SEX ON BODY WEIGHT AND LINEAR BODY MEASUREMENTS OF GUINEA PIGS IN THE MIDDLE BELT OF GHANA

Variable	Sex		Mean	*P value*
	Male	Female		
BW	272.18±17.19	264.34±10.98	267.54±62.10	0.65
BL	21.55±0.76	22.31±0.48	22.00±2.74	0.32
HG	16.91±0.66	17.66±0.42	17.35±2.37	0.26
HW	7.16±0.21	7.22±0.14	7.19±0.77	0.78
HL	7.23±0.19	7.08±0.13	7.14±0.71	0.45
HLL	6.48±0.24	6.36±0.15	6.41±0.86	0.62
FLL	6.21±0.28	6.29±0.18	6.26±1.01	0.74
No.	20	34		

P-Value = probability value, BW= body weight, BL=body length, HG=heart girth, HW=height-at-weight, HL=head length, HLL=hind leg length, FLL=fore leg length

3.2.3 Correlation between body measurements from field experiment

Table 6 to 9 showed the degree of correlation between body weight and linear body dimensions for the experimental animals in week; 0, 2, 4 and 8 respectively which ranged from low (0.33) to high (0.87). The correlation coefficients were positive and highly significant (p < 0.01: 0.05) between body measurements such as body length, heart girth, height-at-weight and head length. The body length highly correlated with heart girth (0.91) as in Table 7. The second high correlation was found between body length and heart girth (0.88) in Table 8. Body weight and fore leg length (0.21) had the least correlation value as indicated in Table 9. Tables 8 and 9 revealed that as Guinea pigs grow older their body weight became highly correlated with hind leg length The body weight did not correlate with fore leg length in the field experiment. There was no negative correlation among body measurements.

TABLE 6
CORRELATION COEFFICIENTS BETWEEN BODY WEIGHT AND LINEAR BODY MEASUREMENTS IN WEEK 0

	BW	BL	HG	HW	HL	HLL	FLL
BW	-						
BL	0.84**	-					
HG	0.78**	0.76**	-				
HW	0.69**	0.69**	0.76**	-			
HL	0.68**	0.72**	0.73**	0.66**	-		
HLL	0.26	0.35*	0.54**	0.46**	0.51**	-	
FLL	0.23	0.32*	0.51**	0.39**	0.51**	0.83**	-

Significant (p < 0.05), ** significant (p < 0.01), BW= body weight, BL=body length, HG=heart girth, HW=height-at-weight, HL=head length, HLL=hind leg length, FLL=fore leg length.

TABLE 7
CORRELATION COEFFICIENTS BETWEEN BODY WEIGHT AND LINEAR BODY MEASUREMENTS IN WEEK 2

	BW	BL	HG	HW	HL	HLL	FLL
BW	-						
BL	0.82**	-					
HG	0.85**	0.91**	-				
HW	0.68**	0.56**	0.67**	-			
HL	0.67**	0.59**	0.62**	0.66**	-		
HLL	0.26	0.30*	0.35**	0.46**	0.51**	-	
FLL	0.23	0.25	0.32*	0.39**	0.51**	0.83**	-

Significant p < 0.05, **significant p < 0.01, BW= body weight, BL=body length, HG=heart girth, HW=height-at-weight, HL=head length, HLL=hind leg length, FLL=fore leg length

TABLE 8
CORRELATION COEFFICIENTS BETWEEN BODY WEIGHT AND LINEAR BODY MEASUREMENTS IN WEEK 4

	BW	BL	HG	HW	HL	HLL	FLL
BW	-						
BL	0.75**	-					
HG	0.83**	0.88**	-				
HW	0.55**	0.55**	0.60**	-			
HL	0.56**	0.59**	0.69**	0.62**	-		
HLL	0.49**	0.47**	0.46**	0.64**	0.53**	-	
FLL	0.25	0.42**	0.35**	0.57**	0.49**	0.81**	-

***** Significant p < 0.01, BW= body weight, BL=body length, HG=heart girth, HW=height-at-weight, HL=head length, HLL=hind leg length, FLL=fore leg length***

TABLE 9
CORRELATION COEFFICIENTS BETWEEN BODY WEIGHT AND LINEAR BODY MEASUREMENTS IN WEEK 8

	BW	BL	HG	HW	HL	HLL	FLL
BW	-						
BL	0.71**	-					
HG	0.81**	0.79**	-				
HW	0.41**	0.53**	0.47**	-			
HL	0.38**	0.33*	0.40**	0.27*	-		
HLL	0.39**	0.46**	0.38**	0.31*	0.45**	-	
FLL	0.21	0.32*	0.22	0.26	0.32*	0.82**	-

***** Significant p < 0.05, ** significant p < 0.01, BW= body weight, BL=body length, HG=heart girth, HW=height-at-weight, HL=head length, HLL=hind leg length, FLL=fore leg length***

3.2.4 Prediction of body weight from linear body measurements using simple regression

Simple linear regression equation among body weight and linear body measurements (BW, BL, HG, HW, HL, HLL and FLL) of Guinea pigs were presented in week; 0, 2, 4 and 8 respectively were significant ($p < 0.05$) as found in Table 10. The study revealed that the best time to predict Cavies body weight was in week 2. The best predictor of body weight in Guinea pigs were body length (BL), heart girth (HG), height-at-withers (HW) and head length (HL) with R^2 of 0.80 which shows that there was 80% of variations in live body weight and linear body measurements of the experimental Guinea pigs. The highest coefficient of determination figure ($R^2 = 0.80$) was found in week 2 which recorded low value of Standard error of means (SEM = 28.93). There was 80% variations in body weight (BW) of Guinea pigs between BL, HG, HW, HL, HLL and FLL in week 2 of the experiment. Week 0, reveals second highest coefficient of determination value ($R^2 = 0.78$ or 78%, SEM = 31.02) which begun with high in magnitude and direction. But the strength in coefficient of determination started declining in week 4 ($R^2 = 0.76$ or 76%, SEM = 29.65) and week 8 ($R^2 = 0.68$ or 68%, SEM = 37.60) in direction of the predictive equation. The best predictive equation to determine live body weight in Guinea pigs was:

Y= -214.69+5.51BL+10.11HG+15.74HW+18.16HL-7.74HLL-5.34FLL

Where Y= live body weight (BW), BL= body length, HG= heart girth, HW=height-at-weight, HL=head length, HLL=hind leg length and FLL= fore leg length respectively.

TABLE 10
PREDICTION OF BODY WEIGHT FROM LINEAR BODY MEASUREMENTS USING SIMPLE REGRESSION

Week	Equation	SEM	R^2	Sig
0	Y= -281.99+15.99BL+11.68HG+7.60HW+8.96HL-7.99HLL-9.01FLL	31.02	0.78	*
2	Y= -214.69+5.51BL+10.11HG+15.74HW+18.16HL-7.74HLL-5.34FLL	28.93	0.8	*
4	Y= -104.52+3.01BL+15.06HG+5.21HW-2.27HL+27.98HLL-25.99FLL	29.65	0.76	*
8	Y= -151.87+4.21BL+15.85HG+0.01HW+3.47HL+12.69HLL-8.74FLL	37.6	0.68	*

Significant p < 0.05, Y= live body weight, BL=body length, HG=heart girth, HW=height-at-weight, HL=head length, HLL=hind leg length, FLL=fore leg length, R^2 = Coefficient of determination, SEM=Standard error of mean

IV. DISCUSSION

4.1 Body measurements of Guinea pigs

The mean body weight of the adult Ghanaian local Guinea pigs established in the middle belt of Ghana was 405.19 g. The average body weights for males and females were 399.76 ± 17.97g and 408.43 ± 10.99 g respectively from the farmers. The finding agrees with Ayagirwe *et al.* (2019) who reported that adult average body weight of Guinea pig was 562.77 g and obviously females were heavier (600.50 g) than males (525.04 g). Also, Mwalukasa (2009) stated that the mean live weight of mature Guinea pig was 530.40 g, whereas adult body weight of male and female Cavies above 6 months of age from farmers were 571.3 g and 548.9 g in the Njombe district, Tanzania differs from the current result. According to Egena *et al.* (2010) who revealed that mean weight of adult male and female Guinea pigs were 454.00 ± 14.69 g and 436.67 ± 6.52 g in Nigeria. In the present results, the average body weight of the local Cavy that was three months old found in the field experiment was 267.54 g where the mean body weights for males and females were 272.18 ± 17.19 g and 264.34 ± 10.98 g respectively.

Abossede *et al.* (2019) observed that live weight of male and female Cavies were 310.19 ± 132.75 g and 285.54 ± 106.29 g respectively in the southern part of Benin. This partly agrees with the present findings from the field experiment.

The adult males and females have live body weight ranging from 900 - 1200 g and 700 - 900 g for the exotic breeds of Cavies (Quesenberry *et al.,* 2012). The variations in the current findings and previous reports on the average body weight of male Guinea pigs from farmers could be attributed to the fact that most of the females Cavies were matured. Husein (2015) stated that most of the males rabbit used in his study were growing ones. Average body length, heart girth, height-at-weight, head length, hind leg length and fore leg length from the survey result were 22.83 cm, 17.32 cm, 7.43 cm, 7.54 cm, 6.59 cm and 5.83 cm respectively. Similar survey on adult Guinea pigs conducted by Egena (2010) was 25.20 cm, 16.87 cm, 5.36 cm, 4.56 cm and 2.53 cm respectively except for the body length that scored high value, the rest of the results were lower than the current study. The present research confirms that, an average body length, heart girth, height-at-weight, head length, hind leg length and fore leg length on experimental animals have the following values; 22.00 cm, 17.35 cm, 7.19 cm, 7.14 cm, 6.41 cm and 6.26 cm respectively. Abossede *et al.* (2019) obtained 24.94 cm, 14.14 cm and 3.89 cm for head-body length, chest circumference and Left hind foot length (FL) respectively which is lower than present study except for head-body length. The variations may be due to genetic and environmental effects carried out by selective breeding on the animals (Ayagiwe *et al.,* 2015; Najat, 2019). Sex did not have any tremendous influence ($p > 0.05$) on both sexes for the body measurements from survey result. Body measurements of female Guinea pigs were 408.43 ± 10.99 g, 22.82± 0.26 cm, 17.34 ± 0.19 cm, 7.45 ± 0.09 cm, 7.54 ± 0.09 cm, 6.60 ± 0.07 cm and 5.87 ± 0.09cm for body weight, body length, heart girth, height-at-weight, head length, hind leg length and fore leg length respectively.

The finding disagrees with Egena *et al.* (2010) and Abossede *et al.* (2019) who sited that Cavies males were heavier in body weight and body measurements ($p < 0.05$) than females. Therefore the heavy males could be used to mate with females in the flock because of their size. In terms of experimental animals, the sexes had no significant effect ($p > 0.05$) on body measurements (*BW, BL, HG, HW, HL, HLL* and *FLL*). The present report indicated that female Guinea pigs were heavier in most of the morphometric traits; *BL, HG, HW* and *FLL* (22.31± 0.48 cm, 17.66 ± 0.42 cm, 7.22 ± 0.14 cm and 6.29 ± 0.18 cm) respectively than their male counterpart except *BW, HL* and *HLL* (272.18 ± 17.19 g, 7.23 ± 0.19 cm and 6.48 ± 0.24 cm). Moreover, Hagan *et al.* (2016) also indicated that male grasscutters were heavier in body weight and body measurements than females. The higher body weight observed in females than males can be ascribed to the fact that many of the females were mature (Husein, 2015). This implies that the body measurements could be used for sexual dimorphism in Guinea pigs. Effect of location (regions) had significant influence ($p < 0.01$) on body measurements such as body length, heart girth, head length, hind leg length and fore leg length of Guinea pigs except for body weight and height-at-withers ($p > 0.05$) that did not have influence on the location (regions) in the survey result. Bono region scored highest; 429.84 ± 23.35 g, 18.58 ± 0.39 cm and 7.71 ± 0.18 cm for BW, HG and HW. Among all the regions that the study took place, Ahafo region recorded highest morphometric readings; BL (23.67 ± 0.30), HL (8.08 ± 0.09 cm), HLL (6.95 ± 0.08 cm) and FLL (6.41 ± 0.08 cm). Bono East region of Ghana had the least morphometric measurements in terms of body weight (357.86± 35.57 g).

The location did not have effect ($p > 0.05$) on most of the body measurements of Guinea pigs except hind leg length and fore leg length that had significant effect ($p < 0.01$) on the experimental animals. Ashanti region obtained the highest recordings for BW (281.58 ± 22.17 g), BL (22.83 ± 0.99 cm) and HG (18.33 ± 0.83 cm). Phenotypic measurement in the Ahafo region scored the highest figure in HL (7.30 ± 0.15 cm). Height-at-weight had 7.28 ± 0.24 cm, hind leg length (6.80 ± 0.25 cm) and fore leg length (6.93 ± 0.24 cm) respectively were the greatest in the Bono region. Notwithstanding, the region that had the least body weight (253.80 ± 19.09 g) was seen in Bono region. Variations in body measurements in all the regions may be ascribed to genetic make-up and change in environmental factors such as management, nutrition, climatic condition of the animals (Ayagiwe *et al.*, 2015; Baffour-Awuah *et al.,* 2005; Beffa *et al.,* 2009).

Various colours categories did not have influence ($p > 0.05$) on body measurements (BW, BL, HG, HW, HL and FLL) of Guinea pigs except HLL and FLL which were significant ($p < 0.01$ and 0.05).

4.2 Phenotypic correlations among body measurements of Guinea pigs

Pearson correlation coefficient between phenotypic measurements are profound to know in the present study of the body traits which are good determinant to show the magnitude and direction that change in one trait could influence the other. Generally, in this study the phenotypic correlation figures were superior ($p < 0.01$: 0.05) between weight and linear body measurements and ranged from low (0.21) to high (0.91).

The highest correlation figure (0.87) was found among body weight and body length and also hind leg length and fore leg length. Similar results have been reported by Ayagirwe *et al.* (2018) who reported strong and significant correlations between weight and body measurements except between body length (BL) and head length (HL) for the two sexes. The least correlation value was found between heart-at-withers and fore leg length (0.33) in the survey result. The high positive correlation was observed between body length and heart girth (0.91) in the field experiment is in line with the result of Egena *et al.* (2010) and Egena (2010) who indicated that strong and positive correlation among body weight and body length, heart girth and trunk length shows that the breeders could use any of these morphometric traits to predict live body weight of Guinea pigs. There was no negative correlation among the body measurements. However, Hagan *et al.* (2016) stated in their report that there was positive and significant correlation between live weight and all the linear body measurements of grasscutter for all the sexes. This means breeders could easily use low and high correlation values of the morphological measurements to predict body traits. It was revealed that as Guinea pigs grow older, their body weight becomes highly correlated with hind leg length.

4.3 Prediction of body weight using Linear body measurements of Guinea pigs

Generally, in this study, simple linear regression equations were significant ($p < 0.05$) on body weight and morphometric traits (body length, heart girth, height-at-weight and head length) of Guinea pigs. The best time to predict cavies' body weight was in week 2. The best predictor of body weight in Guinea pigs were body length (BL), heart girth (HG), height-at-withers (HW) and head length (HL) with R^2 of 0.80 which shows that there was 80% of variations in live body weight and linear body measurements of the experimental Guinea pigs. Abossede *et al.* (2019) reported similar finding that the body weight was significantly influenced by head body length, chest circumference, neck circumference and head circumference which were used to predict live body weight on Guinea pigs. The implication is that, increment of 1 kg of live weight of the animal will appreciate 5.51 cm in body length, heart girth (10.11 cm), height-at-weight (15.74 cm) and head length (18.16 cm) respectively in Guinea pigs. Moreover, Egena (2010) made similar observation that the $R^2 = 0.84$ (84%) variations of post weaned Guinea pigs for 10 weeks old were the best fit for body weight between body length, trunk length and heart girth. Linear body measurements have been used to predict live weight of many livestock species including grasscutters (Annor *et al.*, 2011), rabbits (Husein, 2015), cattle (Maylinda *et al.*, 2017), pigeons (Najat, 2019) and goats (Ofori *et al.*, 2021). According to Birteeb (2012) and Maylinda *et al.* (2017) who pointed out that despite the use of conventional weighing scales, predictive equation have been very useful determinant of live body weight of livestock. This shows that, the use of regression equation in the linear body measurements have become more powerful solution to estimate live body weight on Guinea pigs. Hence the live body weight of Guinea pigs is profound to predict the growth rate and economic value in livestock that most producers and animal meat processors look up for (Husein, 2015; Najat, 2019).

V. CONCLUSION

Basically indigenous Guinea pigs in the middle belt of Ghana were small in size with Ahafo region being superior in body weight and linear body measurements. Matured Guinea pigs had an average body weight of 405.19 g when they are about 90 days old and even more. The sexes did not have influence on Guinea pigs production. The body length highly correlated with heart girth (0.91), followed by body weight and body length; hind leg length and fore leg length (0.87). The least correlation value (0.21) was between body weight and fore leg length. The association between these body dimensions would be a good asset to estimate the carcass weight of the Guinea pigs in the middle belt of Ghana. Body length (BL), heart girth (HG), height-at-withers (HW) and head length (HL) were the best predictor of body weight in Guinea pigs. Predictive equation could be useful by farmers, researchers and animal processors to determine the body weight of Guinea pigs. Linear body measurements of Cavies could be used by breeders for breeding purposes to determine various body measurements in the areas where there is scarcity of weighing scale and tape measures.

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Analysis of Surface Flow Rate (Runoff) on Land Use Case Study in Loa Bakung Sub-District

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Abstract— *This study aimed to analyze the runoff rate on land use in the Loa Bakung Village. The results of this study are expected to be the basis for flood management in the region. The research was carried out from February - April 2021 at the Water and Soil Conservation Laboratory, Faculty of Agriculture, Mulawarman University. The object of this research is the land use of the Loa Bakung sub-district. The stages of conducting research are as follows: (1) preparation, (2) field observations, (3) data collection, (4) data processing, (5) interpretation, and (6) reporting. The data collected is in the form of; (1) an Administrative boundary map of the Loa Bakung sub-district, (2 Topographical maps, (3) Soil type maps, (4) Loa Bakung sub-watershed maps, and (5) Maximum rainfall data for the last ten years (2011-2020). This is done by calculating the surface flow rate using the rational method. The results showed that: (1) The results of the GIS analysis showed that there were five types of land use in Loa Bakung Village, namely shrubs, settlements, roads, mining, open land, and dry mixed agriculture. The use of shrubland has the largest area of 481.34 hectares, and the smallest is land without vegetation, namely 27.18 hectares; (2) The highest runoff coefficient (C) is in the use of shrubland, namely 0.13463. While the value of C or the smallest runoff coefficient is on the use of open land with a C value of 0.00493; and (3) The maximum runoff rate (Q) in the land use of Kelurahan Loa Bakung occurs in the 100-year return period (Q100) with a value of 157.4292 m3/sec and the lowest Q value appears in the five year return period (Q5) with a deal 86.1099 m3/sec*.

Keywords— Runoff, Land Use.

I. INTRODUCTION

Land use (land use) is an arrangement according to existing natural conditions. Its utilization requires interpretation, provision, and designation in a planned manner for use for the welfare of society.

Changes in the use of vegetation land to non-vegetative land are increasing in number in line with the increase in population, and the land is used for residential, office, industrial, and economic needs as well as other supporting facilities, which also have an impact both on the quantity of activity and the quality of the environment.

The transition of the function of an area that can absorb water into a watertight area will cause a hydrological imbalance and adversely affect the area. An area's changes will impact the time and volume of surface runoff. In densely vegetated land, rainwater that falls will be retained on the ground, cover plants and seep into the soil through the vegetation so that surface runoff is small. In open land (without vegetation), most of the rainwater that falls will become surface runoff towards the river, so the river flow increases very quickly. An increase in surface runoff volume will cause flooding problems in the downstream watershed (Laoh, 2002).

Surface runoff is rainwater that flows over the surface of the ground. The amount of water that becomes this flow depends on the amount of rainwater per unit of time (intensity), the state of the ground cover, topography (especially the slope of the soil slope), the type of soil, and whether or not rain occurs Rahim, 2003).

The amount and speed of surface runoff depend on the catchment area and, most importantly, on the runoff coefficient and maximum rainfall intensity. Surface runoff with a high amount and speed often causes the displacement or transportation of soil masses on a large scale, causing flooding.

The amount of water that becomes a stream causes the water to overflow, so the water stagnates in the area. Areas that are inundated or flooded will disrupt human activities. Human negligence in preserving nature and inaccurate land use has resulted in floods occurring in various locations, including the Loa Bakung area.

Loa Bakung Village is located in Sungai Kunjang District, Samarinda, whose area is dominated by the Kambisol-associated soil type. Rather steep topography and open land conditions. Land use in the Loa Bakung area consists of shrubs, settlements, mining, mixed dryland agriculture, and available land with a dominant Cambisol-associated soil type and rather steep topography.

This study aimed to analyze the runoff rate in the land use of the Loa Bakung Village. The results of this study are expected to provide information regarding the runoff rate in the land use of the Loa Bakung Village so that it can become the basis for handling the flood.

II. RESEARCH METHODS

2.1 Time and Place

The research was carried out from February - April 2021 at the Water and Soil Conservation Laboratory, Faculty of Agriculture, Mulawarman University. The object of this research is the land use of the Loa Bakung sub-district.

2.2 Materials and Tools

The materials used are administrative boundary maps of the Loa Bakung sub-district, land use maps of the Loa Bakung Sub-district, topographical maps of the Loa Bakung Sub-district, soil type maps of Loa Bakung Sub-district, sub-watershed maps in Loa Bakung Sub-district and maximum daily rainfall data for the last ten years (2011- 2020) Loa Bakung. The tools used in this study were laptops and ArcGIS 10.4.

2.3 Research Design

This research is a quantitative analysis research that aims to analyze the runoff rate on different land uses in the Loa Bakung area.

2.4 Research Procedures

The stages of conducting research are as follows: (1) preparation, (2) field observations, (3) data collection, (4) data processing, (5) interpretation, and (6) reporting.

2.5 Data Collection

Data collection was obtained from several related agencies, consisting of:

1) Administrative boundary map of the Loa Bakung sub-district obtained from the Cartography and Geographic Information System Laboratory, Faculty of Agriculture, Mulawarman University.
2) Topographic map of the Loa Bakung sub-district obtained from the Cartography and Geographic Information System Laboratory, Faculty of Agriculture, Mulawarman University.
3) Map of Soil Types for the Loa Bakung sub-district obtained from the Cartography and Geographic Information System Laboratory, Faculty of Agriculture, Mulawarman University.
4) The map of the Loa Bakung sub-watershed was obtained from the Cartography and Geographic Information System Laboratory, Faculty of Agriculture, Mulawarman University.
5) Maximum rainfall data for the last ten years (2011-2020) for the Loa Bakung subdistrict obtained from BMKG Samarinda.

2.6 Data Processing

Data processing is done by calculating the surface flow rate using the rational method. The results obtained are presented in the form of a histogram graph anabld tabular form. The value of C is obtained through the surface runoff coefficient price table while considering land use, soil type, and topography of the study area. The average rain intensity value (I) is obtained by processing maximum rainfall data for Loa Bakung Village for the last ten years (2011-2020). In contrast, the value of A is obtained by processing administrative boundary data for the Loa Bakung Village to get the area of the catchment area through the ArcGIS application.

III. RESULTS AND DISCUSSION

3.1 Overview of the Region

Loa Bakung Sub-district is one of the sub-districts in Sungai Kunjang District, Samarinda City, with an area of 11.83 km2. Soil is dominantly associated with Iutrudepts and Hapludalfs, with predominantly sloping topography in residential areas (8% - 15%) and rather steep in other regions (15% - 25%).

Types of land use in Loa Bakung Village are presented in Table 1 and Figure 1 below:

TABLE 1
TYPES OF LAND USE IN LOA BAKUNG VILLAGE 2021

No	Type of Land Use	Area (Ha)	Percentage (%)
1	Thicket	**481,34**	**43,60**
2	Settlement	**430,81**	**39,06**
3	**Land Without Vegetation**	**27,20**	**2,46**
4	**Mining**	**115,34**	**10,45**
5	Mixed Dryland Agriculture	**48,03**	**4,35**

Source; Calculation Results (2021)

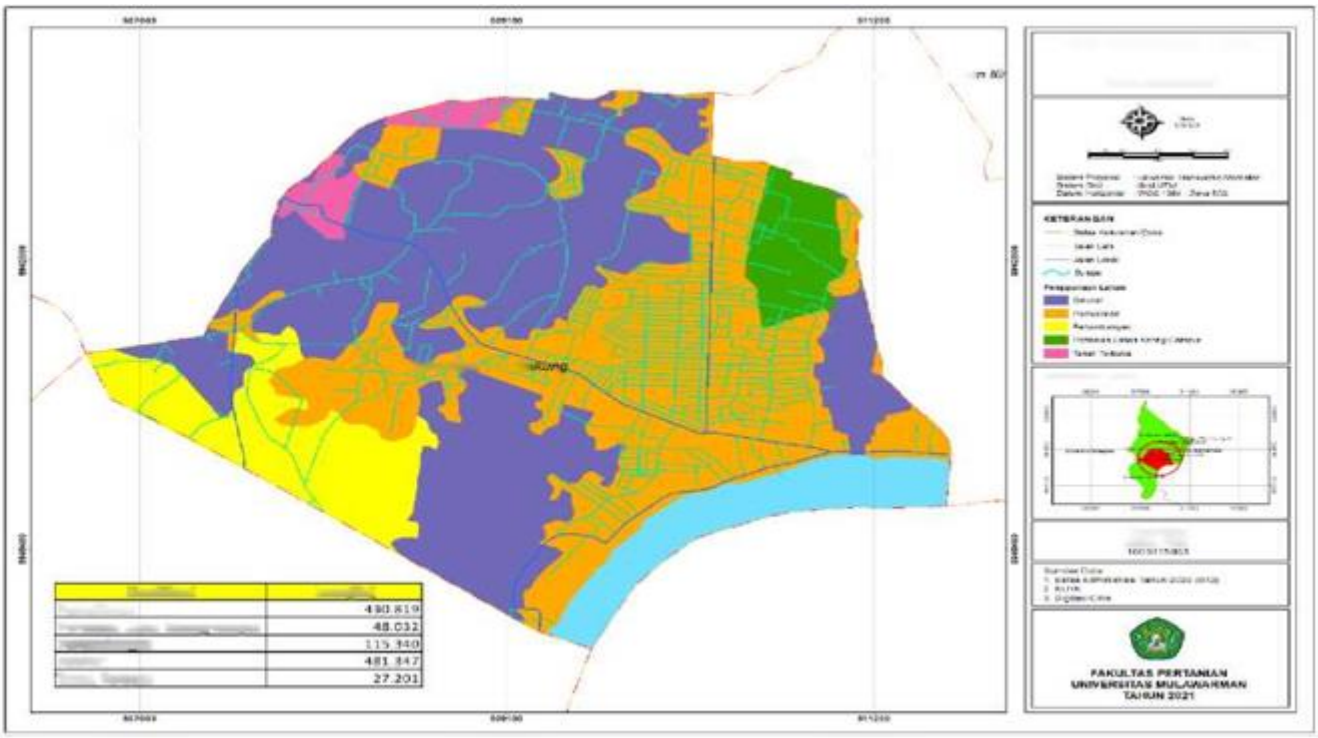

FIGURE 1: Land Use Map of Loa Bakung Village

3.2 Condition of Soil Type

Loa Bakung Village has four types of land, namely: (1) gleysol covering an area of 281.54 hectares, (2) endowments covering an area of 281.54 hectares, (3) cambisol covering an area of 527.85 hectares, (3) podzolic covering an area of 237.68 hectares. The soil type map is presented in Figure 2 below:

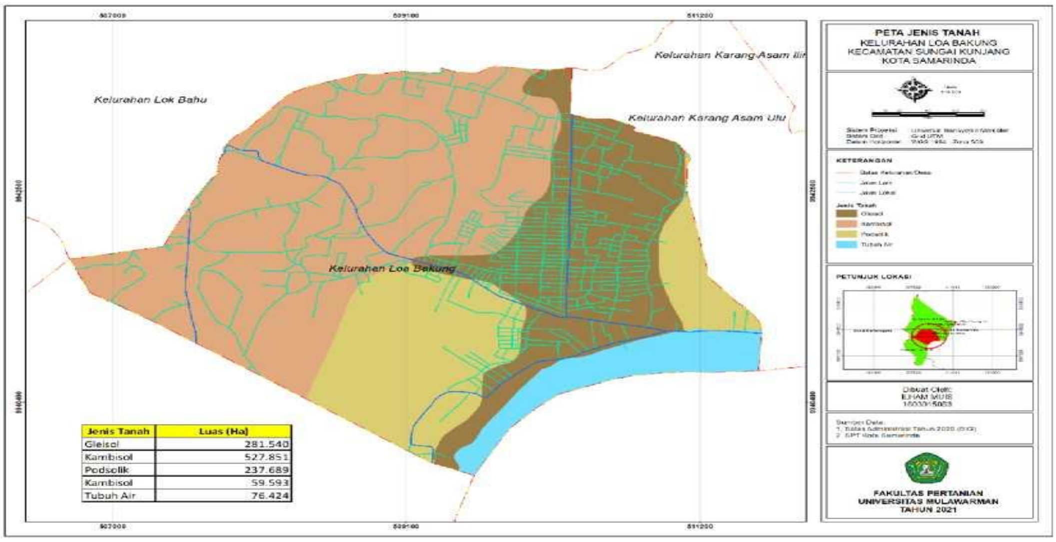

FIGURE 2. Map of Soil Types in Loa Bakung Village

3.3 Topography

Loa Bakung Village has topography with slope class in the study area generally dominated by type III or rather steep slopes (15% -25%) with an area of 553.72 hectares. Data on the distribution of the gradient of the slopes of the Loa Bakung Village are presented in Table 2 and Figure 3 below:

TABLE 2
LAND SLOPE CONDITIONS

No	Slope Class	Area (hectares)
1	Flat (0-8%)	548,72
2	Ramp (8%-15%)	237,40
3	Slightly Steep (15%-25%)	267,24
4	Steep (25%-45%)	127,62
5	Very Steep (>45%)	2,09

Source: Calculation Results (2021)

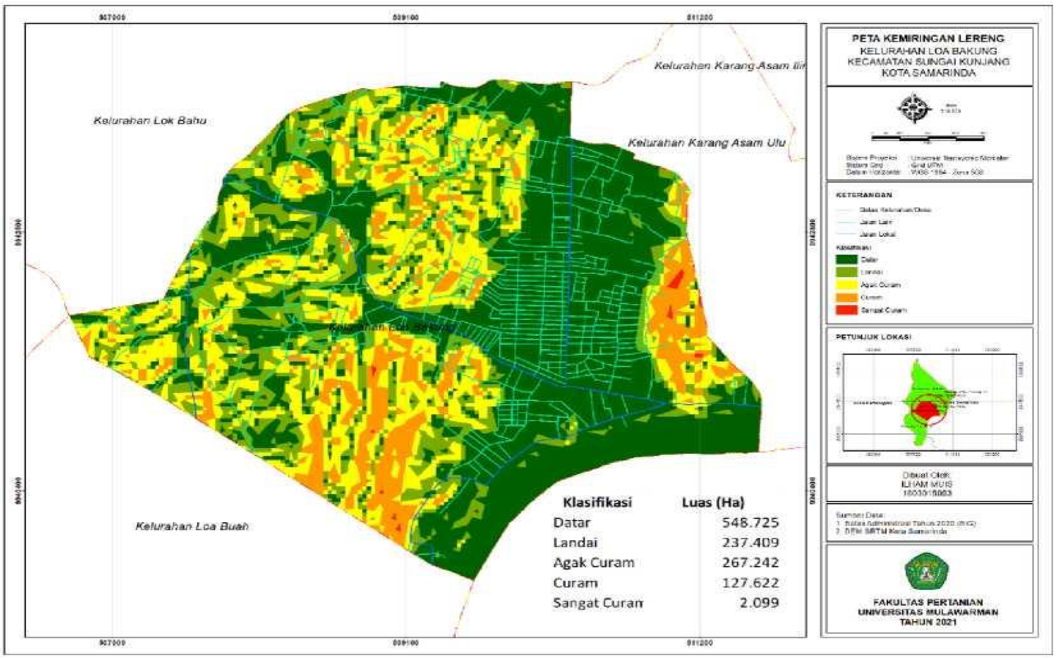

FIGURE 3: Slope Map of Loa Bakung Village

3.4 Rainfall

The maximum daily rainfall data for the Loa Bakung sub-district for 2011-2020 obtained from the BMKG Samarinda were processed to get the amount of rain intensity. The method used in calculating the average rainfall in the study area is the average algebraic method:

$$P = (Pl+P2+P3+..+Pn)/n \quad (1)$$

Where P1, P2, P3...., Pn is the rainfall recorded at the rain measuring post, and n is the number of rainfall measuring posts. The results of calculating the maximum daily rainfall data are presented in Table 3 below:

TABLE 3
MAXIMUM DAILY RAINFALL DATA PROCESSING

Year	Rainfall (mm)	$(Xi-X)^2$
2011	105,5	15,7609
2012	98,9	6,9169
2013	84,3	296,8729
2014	102,5	0,9409
2015	67,1	1185,425
2016	80	463,5409
2017	87	211,1209
2018	187	7305,121
2019	72	872,0209
2020	131	868,4809
Jumlah	1015,3	11226,2
Average (x)	101,53	1122,62
Standard Deviation	35,31792274	

Source: Calculation Results (2021)

After obtaining the maximum daily rainfall for 2011-2020 using the average algebraic method, it is necessary to carry out a frequency analysis. Frequency analysis aims to predict a certain amount of rainfall or discharge within a certain anniversary period. The frequency distribution in this study uses the Gumbel distribution.

$$R24 = X + [Sx/Sn]x[Yt - Yn] \quad (2)$$

Note: R24 = maximum daily rainfall for 24 hours (mm/24 hours); X = average rainfall (mm); Sx = standard deviation; Yn = reduced mean; Sn = reduced standard deviation; Yt = reduced variation as return period.

The results of calculating the Gumbel distribution are presented in Table 4

TABLE 4
CALCULATION RESULTS OF R24 GUMBEL

No	Repeat Period (Year)	R24 (mm)
1	5	138,897
2	10	166,803
3	25	202,072
4	50	228,234
5	100	254,202

Source: Calculation Results (2021)

Based on the data above, the planned rainfall intensity with an annual return period is calculated using the Mononobe formula. The statement of Loebis (1992) and Suroso (2006) that rain intensity (mm/hour) can be derived from empirical daily rainfall data using Mononobe.

$$I = [R24 : 24] \times [24 : t]^{2/3} \quad (3)$$

Description: I = rain intensity (mm/hour); R24 = maximum daily rainfall (for 24 hours) (mm); and t = duration of rain (hours)

The results of the analysis of rain intensity based on a specific return period can be seen in Table 5 below.

TABLE 5
MONONOBE RAINFALL INTENSITY VALUES

Duration (minute)	Mononobe Rainfall Intensity (mm)				
	5 years	10 years	25 years	50 years	100 years
5	243,0416	291,8715	353,5851	399,3633	444,802
10	153,8158	184,7191	223,7763	252,7484	281,5056
15	117,7011	141,3486	171,2355	193,4052	215,4104
30	74,49049	89,45649	108,3713	122,4019	136,3286
45	57,00076	68,45286	82,9266	93,663	104,3198
60	47,14342	56,61507	68,58582	77,46553	86,2794
120	29,83604	35,83045	43,40648	49,02626	86,2794
180	22,83604	27,41776	33,215	37,5131	41,78372
360	9,144531	17,35211	21,02105	23,74262	26,44401
720	5,787375	10,98177	13,30377	15,02619	16,73584

Source: Calculation Results (2021)

Based on the calculation results, the planned rain intensity shows an increased value compared to previous years. The highest rainfall intensity value occurs in the 100-year return period with rainfall of 86.2794 (mm/hour), and the minor rainfall intensity occurs in the five-year return period with the rain of 47.1434 (mm/hour).

3.5 Surface Flow Coefficient (C)

Loa Bakung Village has five types of land use from the results of ArcGIS data processing and Google map satellite imagery in the form of shrubs, settlements, mixed dry land agriculture, mining, and open land. Furthermore, with the help of the ArcGIS overlay from land use data, soil type, and topography, the runoff coefficient (C) can be input by adjusting it in Tables 1, 2, and 3.

Meanwhile, if the area consists of various land uses with different runoff coefficients, then C is modified. The modified value of C is presented in Table 6.

TABLE 6
RUNOFF COEFFICIENT VALUE (C)

No	Land Use	Area (A)	C-Value	C x A	Ci.Ai/Ai
1	Thicket	481,3419441	0,31	148,37	0,13463
2	Mixed Dryland Agriculture	48,0324791	0,65	31,29	0,02839
3	Settlement	430,8016428	0,75	323,10	0,29319
4	**Land Without Vegetation**	27,18482407	0,20	5,44	0,00493
5	Mining	114,6443601	0,90	103,18	0,09363
6	Total	1102,00525	2,80	611,38	0,55478

Source: Calculation Results (2021)

Based on the analysis results, the highest surface runoff coefficient (C) is found in shrub land use because shrubs have the largest area of other land uses. The surface runoff coefficient (C) for scrub land use is 0.13463, which means that the soil absorbs rainwater that falls to the surface, and some of it becomes surface runoff. While the smallest surface runoff coefficient is found in open land use with a C value of 0.00493. The value of the runoff coefficient depends on land use and area; the larger the size, the greater the runoff coefficient (C) (Delmar, 2006).

3.6 The Rational Method

The Loa Bakung Subdistrict's catchment area was obtained by processing administrative boundary data for the Loa Bakung Subdistrict, which has a water catchment area of 11.83 Km2. After all the data needed to analyze runoff rates, such as land use data, rainfall data, and others. Then the next step is to calculate the runoff rate to obtain the runoff value for the return period using the modified rational method (Suripin, 2004), with the formula:

$$QT = 0.278 \text{ x } C \text{ x } IT \text{ x } A \quad (4)$$

Description: QT = maximum surface runoff with a return period of T years (m3/second); C = Surface runoff coefficient value (dimensionally); IT = Rainfall intensity with return period T (years) (mm/hour; and A = catchment area (Km2).

Based on the calculation results, the maximum runoff value is obtained in the return period as presented in Table 7 below:

TABLE 7.
CALCULATION RESULTS OF THE MAXIMUM RUNOFF VALUE IN THE RETURN PERIOD

Land Use Lahan	Wide Catchment Area (Km2)	Coefficient Flow (C) (C)	Qmaks (m^3/second)				
			T (5)	T (10)	T (25)	T (50)	T (100)
Thicket	11,8309	0,1346	20,8750	25,0691	30,36976	34,3016	38,20447
Mixed Dryland Agriculture	11,8309	0,2931	45,4606	54,5941	66,1376	74,7003	83,19964
Settlement	11,8309	0,2931	4,40201	5,28643	6,4042	7,2333	8,056338
Land Without Vegetation	11,8309	0,0049	14,5178	17,4346	21,1210	23,8555	26,569774
Mining	11,8309	0,0936	0,7644	0,91800	1,1121	1,25608	1,399005
Total	0,5547	86,1099	103,3023	125,1447	141,347	157,4292	

Source: Calculation Results (2021

The surface runoff discharge value calculated using the rational method to obtain the maximum surface flow rate (Qt) for the return period of 5, 10, 25, 50, and 100 years can be seen in Table 7. The Q value for the 5-year return period has a value of 86,1099 m3/sec, the Q value for the 10-year return period is 103.3023 m3/sec, and the Q value for the 100-year return period is 157.4292 m3/sec. This shows that the intensity of rainfall influences surface runoff discharge with a specific return period. The higher the rainfall intensity, the higher the Q value or surface runoff discharge. The calculation of the maximum surface runoff discharge results also shows that it is heavily influenced by rain intensity and vegetation or watertight areas along with the site.

Control of surface runoff as a result of development needs to be done with development planning that pays more attention to the aspects and conditions of an area's hydrology. Hydrological functions such as storage, infiltration, and groundwater filling or the volume and frequency of surface runoff discharge can be maintained by handling rainwater flows on a small scale that is thorough and integrated both in terms of retention and detention areas. A Map of the distribution of Runoff Coefficients for Loa Bakung Village is presented in Figure 4.

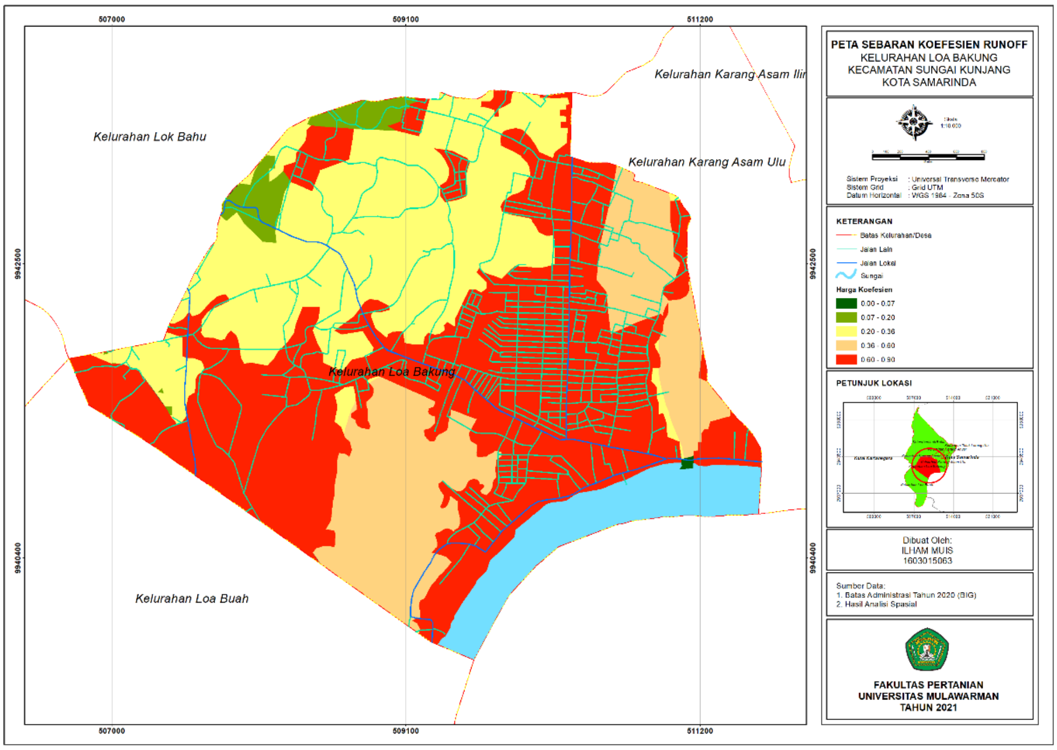

FIGURE 4: Runoff Coefficient Distribution Map of Loa Bakung Village

IV. CONCLUSIONS AND SUGGESTIONS

4.1 Conclusion

Based on the results of research and discussion, it can be concluded as follows.

1) The results of the GIS analysis show that there are five types of land use in Loa Bakung Village: shrubs, settlements, roads, mining, open land, and dry mixed agriculture. The land use of shrubs has the largest area of 481.34 hectares and the smallest on land without vegetation, with an area of 27.18 hectares.

2) The highest runoff coefficient (C) is in shrubland, 0.13463. At the same time, the value of C, or the smallest runoff coefficient, is on the use of open land with a C value of 0.00493.

3) The highest surface runoff rate (Q) in the land use of Loa Bakung Village occurs in the 100-year return period (Q100) with a value of 157.4292 m3/sec, and the lowest Q value appears in the 5-year return period (Q5) with a value of 86, 1099 m3/sec.

4.2 Suggestion

Based on this research, suggestions can be put forward, namely as follows:

1) Comparing land use in previous years to the surface runoff rate value is necessary.

2) It is necessary to carry out further research to reduce the value of C or runoff coefficient, and it is necessary to carry out approaches in controlling surface runoff rates such as bioretention, infiltration wells, and others.

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