Analysis of Differences in HDI from the Old Method and the New Method in Papua Province Using the t-test

Abstract- The Human Development Index (HDI) has become a key indicator in measuring human welfare throughout the world since it was introduced by the United Nations Development Program (UNDP) in 1990. The HDI provides a holistic picture of human progress by considering aspects such as longevity, health, knowledge and a decent standard of living. In the context of regional development, HDI is often used to rank regional development levels. This research uses the literature review method and secondary data from the Indonesian Central Statistics Agency (BPS) to compare HDI with the old method and the new method in Papua Province, both in 2014 and 2022. The analysis was carried out using the average method, hypothesis testing, and t-test. The aim of this research is to understand how changes in the HDI calculation method affect the assessment of human welfare in Papua Province. The results of this research provide valuable insight into the impact of changes in HDI calculation methods on the evaluation of human welfare in Papua Province. These findings can be used as a basis for more accurate and effective development planning and for understanding the effects of development policies at the regional level. This research opens up the potential to explore the challenges and opportunities facing Papua Province in achieving sustainable human development goals.

I. INTRODUCTION

The Human Development Index (HDI) has long been used as an important indicator to measure human welfare in various countries and regions throughout the world, where success is also used as a ranking or level of development of a region covered. HDI was introduced by the United Nations Development Program (UNDP) in 1990 and is published periodically in the annual Human Development Report (HDR) [1]. According to the Official Statistics News, the achievement of human development is measured by taking into account three essential aspects, namely long and healthy life, knowledge, and a decent standard of living (Official Statistics News, 2021). HDI provides a more holistic picture of human development than just economic parameters. HDI explains how residents can access development results in obtaining income, health, education, and so on.

In 1990, the first Human Development Report introduced a new approach to advancing human well-being. Human development or the human development approach is about expanding the richness of human life, and not just the richness of the economy in which humans live. It is an approach that focuses on people and their opportunities and choices [3]. HDI simplifies and only covers part of what is meant by human development. This index does not reflect inequality, poverty, human security, empowerment, etc. [4].

However, as time goes by, the concepts and methods for calculating HDI continue to develop to more accurately reflect social, economic and health developments. In recent years, there have been significant changes in HDI calculation methods, which have had an impact on the assessment of human development in various countries and regions. UNDP calls the revision a new era of human development. UNDP introduced two new indicators which simultaneously replaced two old method indicators. The expected years of schooling indicator replaces the literacy indicator, while Gross National Income (PNB) per capita replaces Gross Domestic Product (GDP) per capita (BPS, 2016).

Papua Province in Indonesia, as one of the provinces that has special challenges in social and economic development, is also affected by changes in the HDI calculation method. These changes could have a significant impact on the assessment of human well-being in Papua Province, which is known for its unique geographic and social characteristics. Therefore, this research aims to investigate and understand the differences between the old and new HDI methods in Papua Province. In this context, analysis using the t test is considered an appropriate tool to measure significant differences between the two HDI calculation methods.

This analysis compares the differences between Old Method HDI data and New Method HDI data using average, hypothesis and t-test methods with population case studies in the Papua Province area in

2014 and 2022. The results of this research are expected to provide valuable insight into how changes in HDI calculation methods affect human well-being assessments in Papua Province.

This information can be used as a basis for more accurate and effective development planning and for understanding the impact of development policies at the regional level. This research has the potential to provide a more in-depth view of the challenges and opportunities facing Papua Province in achieving its sustainable human development goals.

II. APPLICATION REVIEW LITERATURE

RStudio is an integrated development environment (IDE) that is popular in the world of statistics and data analysis. As the frontend of the R programming language, RStudio provides a variety of powerful tools and resources for users to perform statistical analysis, visualize data, and perform hypothesis verification. In this literature, we will explore a number of studies and articles that discuss the use of RStudio as an effective tool in learning and applying statistics.

Research by Peng et al. (2016) showed that students' introduction to RStudio helped them understand statistical concepts better. The integration of RStudio in the statistics curriculum can help students understand statistical theory and apply it in better data analysis. An article by Wickham (2016) in the "ggplot2" package shows how RStudio can be used to create informative and aesthetic statistical graphs. This is useful in understanding data distribution, trends, and patterns in statistics.

The use of RStudio in the learning and application of statistics has proven itself to be an effective and powerful tool. It helps students understand statistical concepts, perform in-depth data analysis, and prove hypotheses. With a variety of statistical packages, rich visualizations, and strong community support, RStudio remains a strong choice in the field of statistics and data analysis education.

III. **METHODS**

The research was conducted using the literature review method. At this stage, a literature study is carried out by looking for reference materials in the form of books, journals and the Internet according to the problem being discussed. Then, data collection uses secondary data from the Indonesian Central Statistics Agency (BPS) website. Data was searched using the keyword Human Development Index. The next step is to determine the first and second populations (p1, p2), where the Old Method HDI data for Papua Province in 2014 is (p1) and the New Method HDI for Papua Province in 2022 is (p2).

After the data population is determined, the first step taken is simple random sampling: In this method, each individual has the same chance of being selected in the sample from the population. Data is selected using random number tables or computer generated lists of random numbers. This can also be done using the lottery method, using paper money, etc. (Acharya, Anita S., et al, 2013).

This random sampling was carried out to ensure the representativeness of the sample to the larger population. Random sampling was carried out using the RStudio application with the sample( ) function. Random sampling was carried out on 30 population subjects who had been represented by numbers representing each population subject. The number of sample data taken was 15 out of 30 subjects available in the population.

The random sampling that can be obtained is then executed in calculating the data centering measure which consists of median, mode and mean. The first calculation is the median, which is the middle value of a distribution in ranking data (Ali, Bhaskar, and Sudhees., 2019). Median rule If n is an odd number, then the n+1 / 2th order statistic is the score that lies in the middle after the data is sorted. That score is called the median. So, if n is an odd number, then the median formula is as follows (Pratikno, Ahmad Sudi, et al, 2020).

$$\text{Median} = X_{\left[\frac{n+1}{2}\right]}$$

Description : n = large amount of data

The mode of a data set is the data that has the highest frequency of occurrence (A'yuni Sofro, Oktaviarina, & Maulana, 2019). In other words, it is the data that appears the most.

Furthermore, the mean or average (mean) of the sample, which is usually symbolized by ($\bar{X}$) read as exbar, is a group explanation technique that is based on the average value of the group. To find the average (mean) result from a single data set, it can be searched by adding up all the existing data and then dividing it by the number of existing data (Sutisna, Icam., 2020).

$$\bar{X} = \frac{\sum X_i}{n}$$

Description : $\bar{X}$ (bar) = mean, Xi = $data$ value , n = lots of data.

Observed data may be spread far from central values compared to values that are centrally distributed. This is expressed in the form of measures of data distribution (range, percentile, variance, standard deviation [SD], etc.) of data (Ali, Bhaskar, and Sudhees., 2019). So the next calculation is Range. The definition of range in a data set is the difference between the largest observer value and the smallest observer value (A'yuni Sofro, Oktaviarina, & Maulana, 2019).

Range = Max – Min

Next is to find the quartile value. Quartiles are the most commonly used percentiles. Roughly speaking, the first quartile (Q1) is the number that divides the bottom 25% of data from the top 75% of data. The second quartile (Q2) is the median, which as you know is the number that divides the bottom 50% of data from the top 50% of data and the third quartile (Q3) is the number that divides the bottom 75% of data from the top 25% of data. Note that the first and third quartiles are the 25th and 75th percentiles, respectively. Quartile values are needed for Interquartile calculations, where interquartile or IQR is the difference between Q1 and Q3 (Weiss, N., 2012).

After that, proceed to calculating the standard deviation, which consists of 3 steps. The first step, calculate the sample mean ($\bar{X}$), the second step is to create a table to get the sum of squared deviations (Xi - $\bar{X}$)^2, the final step is to apply the sample standard deviation formula which is denoted by (s) (Weiss, N., 2012).

$$s = \sqrt{\frac{\Sigma(x_i - \bar{x})^2}{n-1}}$$

Description : $\bar{X}$ (bar) = mean, Xi = $data$ value , n = lots of data.

Calculation of variance for the sample, where the value is used as an indication of how close the cluster's individual observations are to the average value. A large variance indicates that the data in the collection are far from the mean and each other, and vice versa.

$$s^2 = \frac{\Sigma(x_i - x)^2}{(n-1)}$$

Description : $\bar{X}$ (bar) = mean, Xi = $data$ value , n = lots of data.

All results of descriptive statistical calculations that have been obtained will be visualized in a histogram and boxplot.

The next stage is the calculation of inferential statistics. The t test consists of hypothesis testing with a significant level (alpha) or using p-value. The first stage is preparing a hypothesis. This analysis consists of two hypotheses which will later be compared and become the answer to the analysis carried out. The null hypothesis (H0) is the first hypothesis which has the same value (no difference) and the second is the alternative hypothesis (H1) which is a statement which states that the population parameter has a different value from the statement stated in the null hypothesis (Lolang E, 2015).

The next stage is to determine the significant level and degrees of freedom **(df = n-1 / 2)**, divided by 2 because it is two tail. The significant level and degrees of freedom values are then used to find the critical values obtained from the t table, by drawing from the degrees of freedom line (outer left side of the table) and the significant level value column (top of the table). The next main stage is the t test with the formula.

$$t = \frac{\bar{d}}{s_d / \sqrt{n}}.$$

Description: d = difference between the first and second data, sample standard deviation, n = lots of data.

The next stage is to make a comparison if the calculated value of t < the critical value, then reject H0 and apply the alternative H, and vice versa. The final step is to draw conclusions from the applicable hypothesis.

T test with p-value. The first step is to create a hypothesis, then calculate the p-value by means of **T(alpha, df) = T count**. The p-value calculation is looked for in the t-distribution table by pulling the df row (beside) and looking for the t-value that is the same or close to it. The results are in the alpha value section (above). Later the p-value will be compared with the alpha value. If the p-value is smaller than alpha then the decision to reject H0 and apply H1, and vice versa is high (A'yuni Sofro, Oktaviarina, & Maulana, 2019)

IV. RESULTS AND DISCUSSIONS

Two data are used in this analysis, consisting of the Papua Province Human Development Index (HDI) data calculated by the Old Method in 2014 and the Papua Province HDI calculated by the New Method in 2022. This is shown in table 1 (in the attachment).

The first stage of analysis with the dependent t test is sampling. This is done using the RStudio application. So the HDI data for Papua Province using the old calculation method for 2014 and the HDI for Papua Province with the New Method for 2022 produce a new form of data that covers a smaller interval than the original population as shown in table 2 (in the attachment).

The second stage is the calculation of descriptive statistics, both central tendency and dispersion. Central tendency calculations consist of mean, median, and mode. The manual results for each data will be compared with the RStudio application as a proof tool.

- Mean result

$$\text{Mean } (\bar{x}) = \frac{792.72}{15}$$

$$\text{Mean } (\bar{x}) = 52.85$$

p1 HDI Old Method

$$\bar{X} = \frac{870.7}{15}$$

$$\bar{X} = 58.046666$$

p2, HDI New method

- Median results are the 8th order data after the data is sorted

>P1 HDI Old Method 2014

25.38, 38.05, 39.68, 43.51, 45.91, 46.16, 47.88, **53.37**, 55.74, 56.75, 61.97, 62.73, 67.33, 70.4, 77.86

>P2 HDI New method 2022

34.1, 43.87, 47.21, 49.25, 50.51, 52.22, 53.1, **59.6**, 59.61, 61.39, 65.67, 67.24, 71.24, 75.08, 80.61

- Mode results

All data is a mode because all data has the same amount.

- Range results

>P1 HDI Old Method 2014

Range = 77.86 - 25.38

= 52.48

>P2 HDI New method 2022

Range = 80.61 - 34.1

= 46.51

- Interquartile

(Q1: green and Q2: purple, 2 data blocks added then divided by 2)

>P1 HDI Old Method 2014

25.38, 38.05, 39.68, 43.51, 45.91, 46.16, 47.88, **53.37**, 55.74, 56.75, 61.97, 62.73, 67.33, 70.4, 77.86

IQR = 62.35 – 44.71

= 17.64

>P2 HDI New method 2022

34.1, 43.87, 47.21, 49.25, 50.51, 52.22, 53.1, **59.6**, 59.61, 61.39, 65.67, 67.24, 71.24, 75.08, 80.61

IQR = 66.455 – 49.88

= 16.575

- Standard Deviation Results

> P1 HDI Old Method 2014

$$s^2 = \frac{\Sigma(x_i - \bar{x})^2}{N - 1}$$

$$= \frac{(25.38 - 52.848)^2 + \ldots + (77.86 - 52.848)^2}{15 - 1}$$

$$= \frac{2699.74024}{14}$$

$$= 192.83858857143$$

$$s = \sqrt{192.83858857143}$$

$$= 13.886633449884$$

> P2 HDI New method 2022

$$s^2 = \frac{\Sigma(x_i - \bar{x})^2}{N - 1}$$

$$= \frac{(34.1 - 58.046666666667)^2 + \ldots + (80.61 - 58.046666666667)^2}{15 - 1}$$

$$= \frac{2216.4261333333}{14}$$

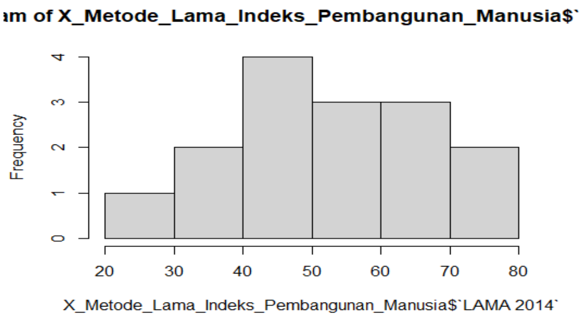
$$= 158.31615238095$$

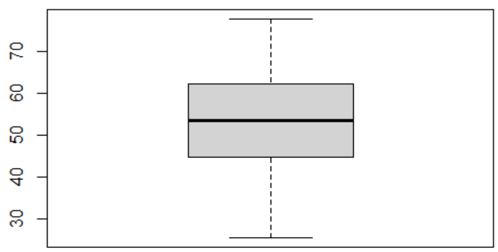
$$s = \sqrt{158.31615238095}$$

$$= 12.582374671776$$

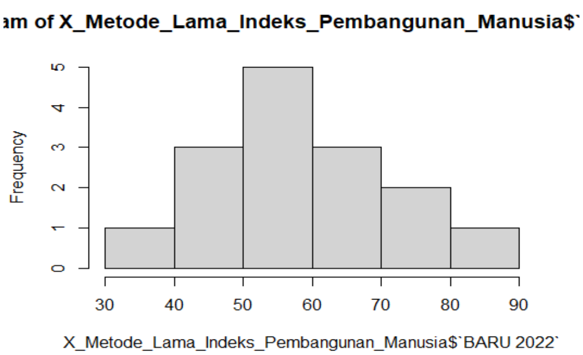
- Histogram and boxplot data visualization

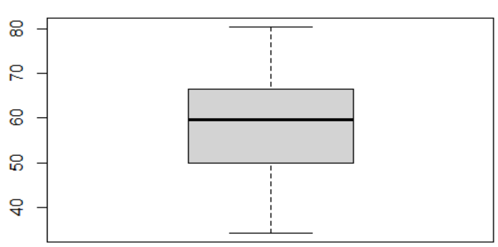
>P1 Histogram and Boxplot





>P2 Histogram and Boxplot





In the histogram visualization results, the graph is higher in the middle, which indicates that the data has a normal distribution or normality. And the boxplot results show the homogeneity of the data. Normality and homogeneity are assumptions that strengthen the validity of data. Next is the t test process, where H0: d = 0 (there is no difference, the data between the 2 populations have the same value as each other) and H1: d is not equal to 0 (there is a difference, the data between the 2 populations are different from each other) .

The significant level applied in this case is 5% or 0.05 (alpha) then divided by 2 (two tail) so alpha = 0.025 with degrees of freedom df = 15-1 = 14. So the critical values found in the distribution t table are (+ and **- 2,145**). Next, look for the average value of d (the difference between 2 populations) and the standard deviation.

d =-8.72,-7.53,-4.68,-3.7,-3.91,-6.31,-5.22,-5.82, -4.64,-3.87,-6.23,-5.74,-2.75,-4.51,-4.35

- Mean of d (the difference between two populations)

$$\bar{X}\, d = \frac{-77.98}{15}$$

$$\bar{X}\, d = -5.1986666666667$$

- Standard deviation of d

$$s^2 = \frac{\Sigma(x_i - \bar{x})^2}{N - 1}$$

$$= \frac{(-8.72 - -5.1986666666667)^2 + \ldots + (-4.35 - -5.1986666666667)^2}{15 - 1}$$

$$= \frac{34.256773333333}{14}$$

$$= 2.4469123809524$$

$$s = \sqrt{2.4469123809524}$$

$$= 1.5642609695803$$

- t-count

$$t = \frac{-5.198667}{1.56426097 / \sqrt{14}}$$

t = -12.871

- **P- value** is found with T(alpha,14) =- 12.871

Obtained smaller than 0.0005

- Comparison

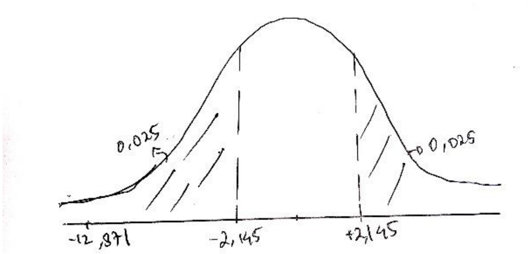
  Alpha value = alpha /2 (two tail) = 0.025

  - Comparison of critical values and t-count

  -2,145 > (-12,871)

  t-count is in the shaded area so H0 is rejected and H1 applies, namely p1 is not the same as p2.

- Comparison of P-value with alpha
(< 0.005) < 0.025
With the conclusion that H0 is rejected and H1 is valid.



V. CONCLUSION

In this article, a comparative analysis has been carried out between the old and new Human Development Index (HDI) measurement methods in Papua Province. The analysis results show that there are differences between the two methods.

The analysis results also show that the new method has a real impact on the HDI ranking in Papua Province. The 95% confidence interval for the mean difference indicates that with that level of confidence, the difference between the two methods is likely in the range-6.064926 to-4.332408.

With these findings, it can be concluded that the new method of measuring HDI in Papua Province has changed the HDI ranking and value significantly compared to the old method. The implications of these changes need to be understood further in the context of development and planning in Papua Province.

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APPENDIX

Table 1.
Papua Province Human Development Index Population Old Method 2014 and New Method 2022.

NO	Kabupaten	LAMA 2014	BARU 2022
1	PAPUA	56.75	61.39
2	Merauke	67.33	71.24
3	Jayawijaya	53.37	59.6
4	Jayapura	69.55	72.67
5	Nabire	66.25	69.91
6	Kepulauan Yapen	64.89	68.41
7	Biak Numfor	70.32	72.85
8	Paniai	53.93	57.14
9	Puncak Jaya	44.32	49.84
10	Mimika	70.4	75.08
11	Boven Digoel	58.21	62.52
12	Mappi	55.74	59.61
13	Asmat	45.91	52.22
14	Yahukimo	46.36	50.25
15	Pegunungan Bintang	39.68	47.21
16	Tolikara	46.16	50.51
17	Sarmi	60.48	64.86
18	Keerom	62.73	67.24
19	Waropen	61.97	65.67
20	Supiori	59.7	63.65
21	Mamberamo Raya	47.88	53.1
22	Nduga	25.38	34.1
23	Lanny Jaya	43.28	49.62
24	Mamberamo Tengah	43.19	49.25
25	Yalimo	44.21	49.9
26	Puncak	38.05	43.87
27	Dogiyai	52.25	55.72
28	Intan Jaya	43.51	49.25
29	Deiyai	48.12	50.42
30	Kota Jayapura	77.86	80.61

Tabel 2.
Results of Human Development Index Sampling for Papua Province, Old Method 2014 and New Method 2022.

SAMPLE	NAMA SAMPLE	LAMA 2014	BARU 2022
22	Nduga	25.38	34.1
15	Pegunungan Bintang	39.68	47.21
10	Mimika	70.4	75.08
19	Waropen	61.97	65.67
2	Merauke	67.33	71.24
13	Asmat	45.91	52.22
21	Mamberamo Raya	47.88	53.1
26	Puncak	38.05	43.87
1	PAPUA	56.75	61.39
12	Mappi	55.74	59.61
3	Jayawijaya	53.37	59.6
28	Intan Jaya	43.51	49.25
30	Kota Jayapura	77.86	80.61
18	Keerom	62.73	67.24
16	Tolikara	46.16	50.51

RStudio DESCRIPTIVE STATISTICS OUTPUT CODE

```
> mean(X_Metode_Lama_Indeks_Pembangunan_Manusia$`LAMA 2014`)
[1] 52.848
> median(X_Metode_Lama_Indeks_Pembangunan_Manusia$`LAMA 2014`)
[1] 53.37
> modus(X_Metode_Lama_Indeks_Pembangunan_Manusia$`LAMA 2014`)
[1] 25.38
> range(X_Metode_Lama_Indeks_Pembangunan_Manusia$`LAMA 2014`)
[1] 25.38 77.86
> IQR(X_Metode_Lama_Indeks_Pembangunan_Manusia$`LAMA 2014`)
[1] 17.64
> sd(X_Metode_Lama_Indeks_Pembangunan_Manusia$`LAMA 2014`)
[1] 13.88663
> var(X_Metode_Lama_Indeks_Pembangunan_Manusia$`LAMA 2014`)
[1] 192.8386
> mean(X_Metode_Lama_Indeks_Pembangunan_Manusia$`BARU 2022`)
[1] 58.04667
> median(X_Metode_Lama_Indeks_Pembangunan_Manusia$`BARU 2022`)
[1] 59.6
> modus(X_Metode_Lama_Indeks_Pembangunan_Manusia$`BARU 2022`)
[1] 34.1
> range(X_Metode_Lama_Indeks_Pembangunan_Manusia$`BARU 2022`)
[1] 34.10 80.61
> IQR(X_Metode_Lama_Indeks_Pembangunan_Manusia$`BARU 2022`)
[1] 16.575
> sd(X_Metode_Lama_Indeks_Pembangunan_Manusia$`BARU 2022`)
[1] 12.58237
> var(X_Metode_Lama_Indeks_Pembangunan_Manusia$`BARU 2022`)
[1] 158.3162
```

CODE OUTPUT UJI T RStudio

```
Paired t-test

data:  X_Metode_Lama_Indeks_Pembangunan_Manusia$`LAMA 2014` and X_Metode_Lama
_Indeks_Pembangunan_Manusia$`BARU 2022`
t = -12.871, df = 14, p-value = 3.784e-09
alternative hypothesis: true mean difference is not equal to 0
95 percent confidence interval:
 -6.064926 -4.332408
sample estimates:
mean difference
      -5.198667
```

TABLE OF CALCULATION OF STANDARD DEVIATION SAMPLE HDI DATA OLD METHOD 2014

$$s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{X})^2}{n-1}}$$

x_i	$x_i - \bar{x}$	$(x_i - \bar{x})^2$
25.38	-27.468	754.491024
38.05	-14.798	218.980804
39.68	-13.168	173.396224
43.51	-9.338	87.198244
45.91	-6.938	48.135844
46.16	-6.688	44.729344
47.88	-4.968	24.681024
53.37	0.522	0.272484
55.74	2.892	8.363664
56.75	3.902	15.225604
61.97	9.122	83.210884
62.73	9.882	97.653924
67.33	14.482	209.728324
70.4	17.552	308.072704
77.86	25.012	625.600144
Σx_i = 792.72		**$\Sigma(x_i - \bar{x})^2$ = 2699.74024**

$$s = \sqrt{\frac{SS}{n-1}}$$

$$s = \sqrt{\frac{2699.74024}{14}}$$

$$s = \sqrt{192.83858857143}$$

$$s = 13.8866$$

CALCULATION TABLE OF VARIANCE OF OLD METHOD IPM DATA SAMPLE 2014

Temukan Varians (s^2)

$$s^2 = \frac{\sum_{i-1}^{n}(x_i - \bar{X})^2}{n-1}$$

Untuk menemukan Varians (s^2) temukan Sum ($\Sigma(x)$) dan Jumlah Kuadrat (SS)

x_i	$x_i - \bar{x}$	$(x_i - \bar{x})^2$
25.38	-27.468	754.491024
38.05	-14.798	218.980804
39.68	-13.168	173.396224
43.51	-9.338	87.198244
45.91	-6.938	48.135844
46.16	-6.688	44.729344
47.88	-4.968	24.681024
53.37	0.522	0.272484
55.74	2.892	8.363664
56.75	3.902	15.225604
61.97	9.122	83.210884
62.73	9.882	97.653924
67.33	14.482	209.728324
70.4	17.552	308.072704
77.86	25.012	625.600144
Σx_i = 792.72		**$\Sigma(x_i - \bar{x})^2$ = 2699.74024**

$$s^2 = \frac{SS}{n-1}$$

$$s^2 = \frac{2699.74024}{14}$$

$$s^2 = 192.83858857143$$

NEW 2022 2022 NEW METHOD HDI DATA SAMPLE VARIANCE CALCULATION TABLE

Temukan Varians (s^2)

$$s^2 = \frac{\sum_{i-1}^{n}(x_i - \bar{X})^2}{n-1}$$

Untuk menemukan Varians (s^2) temukan Sum (Σ(x)) dan Jumlah Kuadrat (SS)

x_i	$x_i - \bar{x}$	$(x_i - \bar{x})^2$
34.1	-23.947	573.458809
43.87	-14.177	200.987329
47.21	-10.837	117.440569
49.25	-8.797	77.387209
50.51	-7.537	56.806369
52.22	-5.827	33.953929
53.1	-4.947	24.472809
59.6	1.553	2.411809
59.61	1.563	2.442969
61.39	3.343	11.175649
65.67	7.623	58.110129
67.24	9.193	84.511249
71.24	13.193	174.055249
75.08	17.033	290.123089
80.61	22.563	509.088969
Σx_i = 870.7		**$\Sigma(x_i - \bar{x})^2$ = 2216.426135**

$$s^2 = \frac{SS}{n-1}$$

$$s^2 = \frac{2216.426135}{14}$$

$$s^2 = 158.3161525$$

TABLE OF CALCULATION OF STANDARD DEVIATION SAMPLE HDI DATA NEW METHOD 2022

$$s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{X})^2}{n-1}}$$

x_i	$x_i - \bar{x}$	$(x_i - \bar{x})^2$
34.1	-23.947	573.458809
43.87	-14.177	200.987329
47.21	-10.837	117.440569
49.25	-8.797	77.387209
50.51	-7.537	56.806369
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71.24	13.193	174.055249
75.08	17.033	290.123089
80.61	22.563	509.088969
Σx_i = 870.7		**$\Sigma(x_i - \bar{x})^2$ = 2216.426135**

$$s = \sqrt{\frac{SS}{n-1}}$$

$$s = \sqrt{\frac{2216.426135}{14}}$$

$$s = \sqrt{158.3161525}$$

$$s = 12.5824$$