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A Comparative Analysis of Rainfall in Manchester and Clarendon, Jamaica

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Abstract

Introduction: Jamaica is known as the land of wood and water, but some areas of Jamaica experience water issues such as extended dry spells and low-flowing rivers. It is common to see houses with rainwater gutters in Manchester and Clarendon that lead to ground tanks.

Objectives: 1) to assess rainfall in Manchester and Clarendon, 2) to compare the rainfall in the parishes of Manchester and Clarendon, and 3) to evaluate any correlation between rainfall in Manchester and Clarendon.

Methods: The current study employs time series data from 2001 to 2021 as it relates to the level of rainfall in the parishes of Manchester and Jamaica. The data were obtained from the Office of Jamaica Meteorological Service (JMS). The data were stored, retrieved and analyzed using the Statistical Packages for the Social Sciences (SPSS), for Windows, Version 27.0, and Microsoft Excel. Descriptive statistics, changes in percentages, and graphs to examine the univariate variable of the ever-changing levels of rainfall in both Manchester and Clarendon.

Findings: Manchester gets more rainfall (147.9±32.26mm) than Clarendon does for the studied period (101.1±42.26mm) - $t=11.583$, $P < 0.001$. Manchester had heavier levels of rainfall, ranging from 99mm to 219mm, throughout the years as compared to Clarendon, whose levels

ranged from 38mm to 168mm, in no particular order. There is a very strong statistical correlation between rainfall in Manchester and rainfall in Clarendon (r_{xy}=0.913, P< 0.001; Table 3).

Conclusion: Rainfall is affected by many factors; water's unique chemistry and properties allow it to act in the way it does. Water will always try to go to a region of low concentration. Access to this precious commodity is vital to human survival; we depend mainly on rainfall to supply our water needs.

Keywords: Clarendon, Manchester, Rainfall.

Introduction

Water is necessary for all life forms; it is an inorganic compound that is the main component of every fluid found on earth. While it doesn't provide food or energy, its unique chemical composition aids in those processes. Water helps maintain homeostasis in the human body and provides its hydrogen atoms to plants during photosynthesis.

However, that is just scratching the surface of how vital water is to almost every single process on earth. The earth's surface consists of about 71% of water, but in many cases, the type of water needed for survival is inaccessible. Most potable water is found underground or in large inland water bodies such as lakes and rivers. Not everyone has access to those sources and, as such, depends on rainfall. Water travels from regions of high concentration to areas of low concentration, known as osmosis. Saltwater and contaminated water are filtered through this natural process, making it safe for daily use. Water from the earth's surface is evaporated into the air and condensed over a region of low concentration; when this happens, the rainfalls, bring water to land-this is known as the water cycle.

Jamaica is known as the land of wood and water, but some areas of Jamaica experience water issues such as extended dry spells and low-flowing rivers. It is common to see houses with rainwater gutters in Manchester and Clarendon that lead to ground tanks. The objectives of this research are 1) to assess rainfall in Manchester and Clarendon, 2) to compare the rainfall in the parishes of Manchester and Clarendon, and 3) to evaluate any correlation between rainfall in Manchester and Clarendon.

Literature Review/ Conceptual Framework

Water has been essential throughout all life, but what is its source? Common knowledge would have one say, “rain”. What is rain? Rain is liquid water from droplets collected from the earth condensed from atmospheric water vapour. Raindrops fall to the ground when clouds become saturated or filled with water droplets. Millions of water droplets bump into each other as they gather in a cloud. When a tiny water droplet bumps into a bigger one, it condenses, or combines, with the larger one. As this continues to happen, the droplet gets heavier and heavier. When the water droplet becomes too heavy to continue floating around in the cloud, it falls to the ground. Could the world survive without rainfall? The answer is a simple no; the world would need to be placed on life support in the absence of rainfall, as all living things depend on water to survive. Rainfall is essential in meeting the demand for food supply. Patel 2019 cites that "rainfall is a

valuable way to manage crops, and it is a natural alternative to the strenuous man-made irrigation process employed by farmers in regions where less rain falls." Even so, the artificial irrigation process gets its water indirectly from rain. Therefore, even if it stops raining, it is only a matter of time before the cycle of life forces all things towards their end. According to the food chain, which states plants from herbivores to carnivores, this chain would be disturbed, as there would be no water for the plants, which means they would die, leaving herbivores to die of starvation would leave carnivores to die also. Following this line of reasoning, it would be wise to say that water, or rainfall, is essential for life.

Firstly, temperature, latitude and wind. Temperature and rainfall work hand in hand. Evaporation increases as the temperature at the earth's surface rise, increasing overall precipitation. Therefore, there is a greater possibility of heavier rainfall in areas with a warming climate. Secondly, higher wind speeds promote more evaporation, destabilising the boundary layer and triggering deep convection, increasing rainfall. In addition, the wind's direction determines which areas experience rainfall at a given time. Thirdly, the position of the region as it relates to the earth's latitude can influence the levels of rainfall. Rainfall decreases as one moves further away from the equator. As previously stated, temperature affects the amount of moisture in the air; moreover, the rate at which rainfalls usually decrease with the increase in latitude. As a result, areas closer to the equator experience more rainfall.

There are several scenarios in which water is beneficial. Some of these are human life, plant life, water storage, and agriculture. Humans need a constant supply of fresh water to sustain their bodies and life as it helps break down solids by flushing the human system of toxic substances, such as sweat, urine and faecal matter. Adequate rainfall results in plants growing and becoming sturdy, enabling them to produce the needed food many need to survive (in addition to water). Water serves multiple purposes; however, the end goal is to use this water. Rainfall helps to ensure that this stored supply of water is constantly available for use. Rainfall also helps with agriculture as it sustains the plants for future use by the human population(Stevenson, 2017).

According to a 2015 study called “The State of the Jamaican Climate 2015”, the annual cycle of rainfall for Jamaica (averaged over the entire island) reflects a bimodal pattern. The bimodal pattern is typical for most of the countries in the northwest Caribbean. It results from an interplay between the large-scale climatic modulators of the Intra-Americas region, including the North Atlantic subtropical High (Azores high), the trade winds, vertical shear in the Caribbean basin, and the Atlantic warm pool. In tandem, the large-scale influences condition the region to be conducive to rain during boreal summer and dry during the cooler winter months. For Jamaica, this translates into a dry season spanning December-March and a rainy season spanning April-November, divided into an early rainfall season (April-June) and a late rainfall season (September-November). A mid-summer minimum in July (termed the midsummer drought or MSD) separates the early and late wet seasons. Jamaica receives most of its rainfall during the late rainfall season, with May and October being the rainiest months, while February and March are the driest months of the year.

Researchers did this study based on data retrieved from the Jamaica Meteorological Services to compare the levels of rainfall between the parishes of Manchester and Clarendon. Manchester is

known to many as one of Jamaica's breadbasket parishes, meaning that the sources parish has many crops. During 2015, a severe all-island drought resulted in less crop production, implying that many faced both a water shortage and additional financial challenges. The lowest levels of rainfall collected during this research date back to 2015, with Manchester having an annual rainfall of 99mm and Clarendon having yearly precipitation of 38mm. This drought caused a decrease in crop production due to the lack of rain, the outbreak of crop disease, and multiple wildfires. With an already high standard of living, those who depended on crop production faced more financial burdens. (Droughts-Jamaica Information Service, n.d.). Due to the lack of rainfall, many had to turn to rivers or streams as their primary water source, causing people to gravitate toward the small body of water to meet their needs. Manchester, unlike Clarendon, does not have any significant bodies of water. Thus, even the tiny streams began to dry up, leaving the civilians in an even more drastic situation.

Materials and Methods

The current study employs time series data from 2001 to 2021 as it relates to the level of rainfall in the parishes of Manchester and Jamaica. The data were obtained from the Office of Jamaica Meteorological Service (JMS). The JMS collects information on Jamaica's weather climate and contains the annual rainfall level of Jamaica's parishes. The first recorded data dates back to 1993, with its latest entry being April 2022.

The data were stored, retrieved and analyzed using the Statistical Packages for the Social Sciences (SPSS), for Windows, Version 27.0, and Microsoft Excel. Descriptive statistics, changes in percentages, and graphs to examine the univariate variable of the ever-changing levels of rainfall in both Manchester and Clarendon.

Findings

Table 1 presents the annual rainfall in Manchester and Clarendon, Jamaica from 2002 to 2021. The findings revealed that Manchester gets more rainfall (147.9±32.26mm) than Clarendon does for the studied period (101.1±42.26mm) - $t=11.583$, $P < 0.001$. Furthermore, the levels of rainfall in both Manchester and Clarendon for the years 2001 to 2021. The data showed indicated that the levels of rainfall fluctuated throughout the years. Manchester had heavier levels of rainfall, ranging from 99mm to 219mm, throughout the years as compared to Clarendon, whose levels ranged from 38mm to 168mm, in no particular order. There is also evidence of the lightest rainfall for both Manchester and Clarendon being 99mm and 38thatmm, respectively, in 2015, leading to the assumption that both parishes experienced high levels of drought for that year. Additionally, both parishes experienced their highest levels of rainfall during the same years (2002 and 2005), where Manchester had levels of 219mm and 202mm, respectively, and Clarendon had levels of 156mm and 168mm, respectively.

During 2002-2021, Manchester and Clarendon had many arities and differences in precipitation. Both Manchester and Clarendon had their highest rainfall during the first five years. In 2002, Manchester had its maximum rainfall of 219mm, whereas Clarendon had its maximum rainfall of 168mm in 2005. When compared, there has been a trend where they had a gradual change in

rainfall around the same period; for instance, both gradually had a decline in rainfall from 2010 to 2015, where they arrived at their minimum rainfall of 99 mm and 38 mm, respectively.

Similarities exist in Manchester during the first and second decades. The first few years of both had a steady decrease in rainfall followed by a sudden escalation of up to 95 mm or 130% more rainfall. For two decades (2002-2011 & 2012-2021), Clarendon has a slightly less noticeable trend with each other as the average rainfall for each year fluctuates more arbitrarily with an average change of 17% precipitation.

While Manchester has relatively more rainfall than Clarendon, both parishes have had similar rainfall variability, having a standard deviation of 57 and 53, respectively, from 2002 to 2011. In other words, the rain in both parishes deviates or fluctuates in a very similar pattern. This fluctuation is also the case for the years 2012-2021. Both had their minimum rainfall in 2015 and peaked in 2017. Manchester, however, had a maximum of 37% change in rainfall, whereas Clarendon had a shift in rainfall as high as 110.5%.

Table 1: Annual Rainfall in Manchester & Clarendon, Jamaica, 2002-2021

Year	Manchester Average Rainfall (in mm)	Annual % change	Clarendon Average Rainfall (in mm)	Annual % change
2002	219	-	156	-
2003	165	-24.66	102	-34.62
2004	126	-23.64	73	-28.43
2005	202	60.32	168	130.14
2006	136	-32.67	71	-57.74
2007	170	25.00	165	132.39
2008	171	0.59	107	-35.15
2009	111	-35.09	54	-49.53
2010	195	75.68	165	205.56
2011	150	-23.08	118	-28.48
2012	154	2.67	87	-26.27
2013	129	-16.23	77	-11.49
2014	111	-13.95	46	-40.26
2015	99	-10.81	38	-17.39
2016	129	30.30	80	110.53
2017	177	37.21	167	108.75
2018	113	-36.16	73	-56.29
2019	121	7.08	82	12.33
2020	147	21.49	108	31.71
2021	133	-9.52	85	-21.30
Mean	147.9		101.1	
Standard Dev.	33.26		42.26	
Skewness	0.58		0.50	
Mode	111		73	
Median	141.5		86	
Minimum	99		38	
Maximum	219		168	
Variance	1106.2		1786.2	

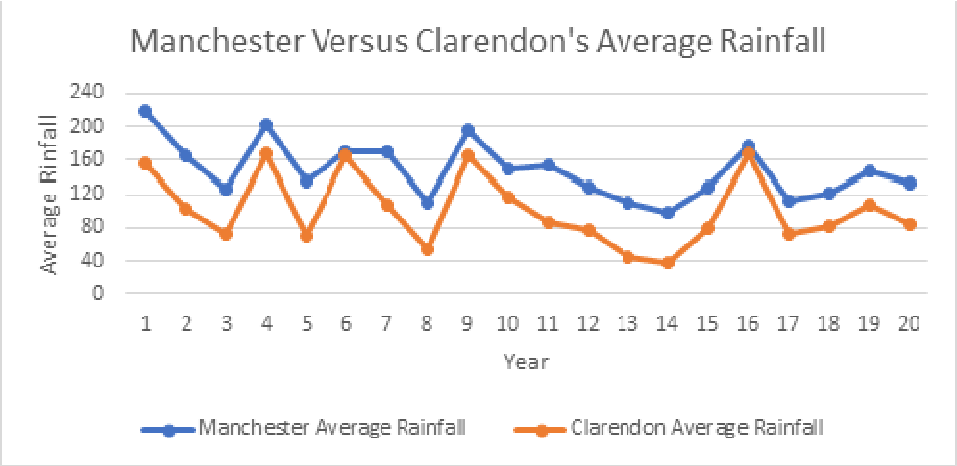

Figure 1: The Annual Rainfall of Manchester and Clarendon

Over the last two decades (2002-2021), annually, Manchester receives more rainfall than Clarendon does (Figure 1).

Table 2 presents the annual Rainfall in Manchester and Clarendon and annual rainfall in Clarendon as a per cent of annual Rainfall in Manchester. Rainfall in Clarendon as a per cent of annual rainfall in Manchester has been a cyclical phenomenon. In fact, over the last two decades (i.e., 2002-2021), average rainfall in Clarendon was 66%±15.8% of annual rainfall in Manchester. Furthermore, in 2007, annual rainfall in Clarendon was 97.06% of the annual rainfall in Manchester and a decade later, it was 94.35%. This means that there are only two occasions in which annual rainfall in Clarendon was also the same as annual rainfall in Manchester. In addition, in 2021, the average rainfall in Clarendon was 63.91% of the annual rainfall in Manchester

Table 2: Annual Rainfall in Manchester and Clarendon and Annual Rainfall in Clarendon as a per cent of annual Rainfall in Manchester

Year	Annual Rainfall in Manchester (in mm)	Annual Rainfall in Clarendon (in mm)	Annual Rainfall in Clarendon as a per cent of fall in Manchester
2002	219	156	71.23
2003	165	102	61.82
2004	126	73	57.94
2005	202	168	83.17
2006	136	71	52.21
2007	170	165	97.06
2008	171	107	62.57
2009	111	54	48.65
2010	195	165	84.62
2011	150	118	78.67
2012	154	87	56.49
2013	129	77	59.69
2014	111	46	41.44
2015	99	38	38.38

2016	129	80	62.02
2017	177	167	94.35
2018	113	73	64.60
2019	121	82	67.77
2020	147	108	73.47
2021	133	85	63.91

There is a very strong statistical correlation between rainfall in Manchester and rainfall in Clarendon (r_{xy}=0.913, *P*< 0.001; Table 3).

Table 3: Pearson's Product Moment Correlations between annual rainfall in Manchester and the annual rainfall in Clarendon

		Annual Rainfall in Manchester	Annual Rainfall in Clarendon
Annual Rainfall in Manchester	Pearson Correlation	1	0.913**
	Sig. (2-tailed)		<.001
	N	20	20
Annual Rainfall in Clarendon	Pearson Correlation	0.913**	1
	Sig. (2-tailed)	<0.001	
	N	20	20
**. Correlation is significant at the 0.01 level (2-tailed).			

Table 4 presents an ordinary least square (OLS) regression of annual rainfall in Manchester and annual rainfall in Clarendon, Jamaica. Table 4 reveals that the rainfall in Manchester is linearly related to rainfall in Clarendon (F [1, 18] = 89.804, P <0.001; adjusted R^2 = 0.824). Annual rainfall in Manchester is linearly determined by annual rainfall in Clarendon (see, Equation [1]):

M = f(C) ……..…[1.1]

M = 75.28mm + 0.718mm(C)……..……[1.2]

where M denotes the annual rainfall in Manchester and C is the annual rainfall in Clarendon in millimeters (mm).

Table 4: Ordinary Least Square (OLS) regression of annual rainfall in Manchester and rainfall in Clarendon, Jamaica

Model	Unstandardized Coefficients		Beta	t	P value	95% Confidence Interval	
	B	Std. Error				Lower	Upper
Constant	75.284	8.274		9.098	<0.001	57.900	92.668
Annual Rainfall in Clarendon	0.718	0.076	0.913	9.477	<0.001	0.559	0.877

Table 5 presents the average 5-year and 10-year periods of rainfall in Manchester and Clarendon, Jamaica. The average annual rainfall in Manchester declined by 20.2% in the second decade

(2012-2021) compared to the first decade (2002-2011). However, the decline in rainfall in Clarendon over the same aforementioned period was 28.5%. Nevertheless, in the last 5-year period (2017-2021), there has been an increase in rainfall in both parishes in Jamaica compared to the previous 5-year period (2012-2016).

Table 5: The Yearly Average, 5-year Average, And Decade Average Rainfall Of

Year	Manchester Annual Rainfall (mm)	Clarendon Annual Rainfall (mm)	Manchester's Total Average Rainfall Per Decade (mm)	Clarendon's Total Average Rainfall Per Decade (mm)	Manchester's Rainfall Per Five Years (mm)	Clarendon's Rainfall Per Five Years (mm)
2002	219	156	164.5±34.6	117.9±43.5	169.6±40.4	114.0±45.7
2003	165	102				
2004	126	73				
2005	202	168				
2006	136	71				
2007	170	165			159.4±31.4	121.8±46.3
2008	171	107				
2009	111	54				
2010	195	165				
2011	150	118				
2012	154	87	131.3±23.0	84.3±35.3	124.4±20.9	65.6±22.0
2013	129	77				
2014	111	46				
2015	99	38				
2016	129	80				
2017	177	167			138.2±25.2	103.0±38.0
2018	113	73				
2019	121	82				
2020	147	108				
2021	133	85				

Discussion

Water is necessary for life, so much so that some speculate it could hold the secrets to creating life itself. Water's natural, artificial processes are essential to human life. Humans will rarely move to anywhere that has little to no water. Rainfall is how most of the world has gotten its water for most of history. Animals rely on rainfall's different cycles; many animals in Africa wait months for the rains to reach the dry savannahs.

It is well known scientifically that the higher and more rural a place is, the more likely to have increased rainfall, and the data reflects this information. Manchester consistently gets more rainfall than its neighbouring parish Clarendon due to the difference in elevation and level of

vegetation, among other factors. Rainfall is vital to both the environment and population of both parishes. Access to the water it provides directly impacts things like agriculture. Agriculture is a big part of Jamaica's economy but is very splintered and not nationalised. Something that affects agriculture is access to water. Several farmers in Jamaica are poor landowners with little or no access to water from the mains or rivers. For some, it's too expensive, and for others, they are too far away, so rainfall is their primary water source. Jamaica has many small streams, but they have been running dry recently due to a lack of rainfall. So, it all comes down to rainfall for most of these small farmers, and climate change has not made things any better for them. The rain is scarce, and when it does come, it comes hard, and without proper government backing, they can't manage these conditions.

Jamaica gets much of its water from rivers, dams and ground aquifers. However, these sources rely on annual rainfall, especially in the wet season. When the rain is scarce, it negatively affects water access to places like Manchester more than Clarendon because it has to get most of its water out of the parish. The gleaner ran a story exploring how lower rainfall has impacted Jamaica (8), and we can see that many of the things referred to are the same.

Researchers surveyed residents of both parishes. A few things were made clear. Neither parish had a majority of people who had water all year round; many people had alternate water storage solutions, and rainfall is a highly precious resource to them. Some other things have been witnessed first-hand in Manchester. Such as people having gutter systems set up to catch rainfall because water comes only once are twice a week in the mains. You see, both parishes' unique geography is at the core of their rainfall level. Manchester is higher above the sea floor and filled with much vegetation but being so high (and the soil type) means that there are few places to get ground and river water. On the other hand, Clarendon receives much less rainfall, but its low marshy areas are the perfect place for groundwater to be stored naturally and harnessed.

A drought depends on the average amount of precipitation an area receives. If significantly less rain falls, water shortages may result in drought. Manchester gets an average rainfall of 147mm per year, indicating significant water shortages during 2009, 2014, 2015 and 2018. There has been a significant drought in Clarendon in 2009, 2014 and 2015, as the average rainfall is 100mm.

Conclusion

Rainfall is affected by many factors; water's unique chemistry and properties allow it to act in the way it does. Water will always try to go to a region of low concentration. Access to this precious commodity is vital to human survival; we depend mainly on rainfall to supply our water needs. Changing climates and pollution threaten to distort the natural processes of water, such as rainfall. Sporadic rainfall is becoming more common right now, especially in Jamaica, with small streams commonly available yearly now dry during the summer months. We must learn to protect the planet, and we need it and its natural processes to survive. The population can take measures to increase the levels of rainfall; we still can catch the rain used for basic needs and other purposes. In Clarendon, where rainfall has been less throughout the years, there is an

opportunity to build a dam on a river to increase water availability for Clarendon and Manchester residents.

Recommendations

Based on the information gathered, changing climates caused by destructive and inefficient practices have damaged many natural cycles and processes needed to keep the planet functioning. Many factors that affect rainfall can be influenced directly by us humans; we could invest more in trying to control rain in an economical and environmentally friendly way. Cloud seeding is one such thing

The researchers recommend that each household have at least two water sources at any given time, as the amount of rainfall varies annually. A dam on one of Clarendon's rivers could increase water availability. More reservoirs could also result in more water on a large scale.

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