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RECENT CHANGES IN POPULATION AND ITS IMPACT ON USAGE OF DRINKING WATER SOURCES IN HOUSEHOLDS: A CASE STUDY OF KALUTARA DISTRICT, SRI LANKA

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ABSTRACT

The major problem that arises with the rapid growth of population is whether it is possible to fulfil basic requirements of human beings such as food, water, shelter and air (De Silva, 2007). Especially, drinking water is a basic need of human life and in fact an essential component in primary healthcare and poverty alleviation (Amponsah, Aidam and Senadza, 2009). However, the growing intensity of population and development activities create tremendous pressure on available water resources. Therefore, it is essential to understand the relationships among a full range of population characteristics such as the size, growth, distribution, and density of population, total households and the usage of water sources. With this brief background, the aim of this paper is to identify the recent changes in population and its impact on the usage of drinking water sources in households in Kalutara district during the period of 2001-2012. Towards achieving this aim, population and households data on sources of drinking water was obtained from the reports of Census of Population and Housing in 2001 and 2012. The data were analyzed using thematic maps and correlation analyses. Accordingly, the highest population and population density were recorded in the west coast while the lowest were in rural areas and there was an increase both spatially and temporally. The study also revealed that there was a similar distribution pattern in total households and the high total households was in Panadura and Kalutara DSDs in both the years. The high annual growth rates were recorded in Bandaragama and Horana DSDs. It was found that the majority of the households used improved sources of drinking water, especially from shallow ground water wells (including protected and unprotected dug wells). There was an increase in the use of improved sources of drinking water and a decrease in use of unimproved sources of drinking water. In the coastal side, there was a considerable increase in the use of pipe-borne water as the major source of water. It was evident that the highest proportion of unimproved sources of drinking water was used by the households in Palindanuwara DSD. The t-test results showed that there was a significant difference ($p<0.05$) between those who used all classified unimproved sources of drinking water in 2001 and 2012. Further, the study revealed that there was a strongly significant ($p<0.05$) relationship between the increase in population size, population density and total households while it led to a chain effect on the use of all the classified improved sources of drinking water in both the years. However, all the unimproved sources of drinking water, except two sources which use tanker-truck and bottled water, have shown negative correlation values. It was also evident that the increase in population density had a significant ($p<0.05$) influence on the use of surface water. The study, therefore recommends that the source of drinking water should be managed sustainably in order to ensure continuous availability in the long-term.

KEY WORDS: *population, drinking water sources, household, improved sources, unimproved sources, significant*

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1 INTRODUCTION

Of all natural resources, water is the most essential. It is fundamental to all vital processes of value to mankind (FAO, 1994). Further, water is the most important natural resource for sustainable development and quality of life, yet it is unevenly distributed; almost one-fifth of the world's population live in regions where water is scarce and one-quarter suffer from a severe water shortage (Fan et all., 2013). Especially, water used in households for drinking, bathing and cooking becomes contaminated by various chemicals and other constituents introduced during its use. However, drinking water is a basic need of human life and in fact an essential component of primary healthcare and in poverty alleviation (Amponsah, Aidam and Senadza, 2009).

The type of water source or the technology specified by the household is used as an indicator of whether the drinking water is of suitable quality. The Millennium Development Goals (MDGs) on drinking water were met globally in 2010; the water sources likely to be of suitable quality or *improved* are: piped water supply into the dwelling; piped water to a yard/plot; public tap/standpipe; tube well/borehole; protected dug well; protected spring; and rainwater. Water sources that are *unimproved* are: unprotected dug well; unprotected spring; cart with a small tank/drum; water tanker-truck; surface water and bottled water.

In general, population size, growth and distribution mainly influence on the natural resources (De Silva, 2007). Among those impacts, population growth and distribution have always been linked to the availability of freshwater and the sustainability of renewable water resources. Especially, population growth is a direct determinant of increases in water demand for domestic uses. According to the Population Reference Bureau (PRB), 2016, the demand for water has grown significantly over the last 50 years not only because of population growth, but also because of an increase in the use of water for households, agriculture and industrial production. Another key demographic factor is the change in the geographic distribution of population, which modifies the spatial pattern of demand for domestic water uses. Especially, over population density affects the use of drinking water sources. The reason is that an increase in population causes to increase water consumption. The problem regarding this condition is the limitation of water resources when compared with the increasing population. Furthermore, not only the population but also human settlements are heavily pressured on the availability of water sources, for example, increase in the number of households that use the sources of drinking water is indicated in the increase of the yearly drinking water requirement in the area.

Thus, the rapid growth of population constitutes the key factor when studying the relationship of natural resources in the geographical space because water is one of the most compelling needs for human life and socio-economic development. Many studies have been conducted to investigate the relationship between population growth and water availability in terms of both quantity and quality. These studies have underlined that the relationship between population growth and environmental problems are closely linked. It is important to establish in each household whether sufficient safe drinking water is available for drinking and cooking for all household members. In addition, identifying the factors that affect domestic water demand and consumption is very important in the management of available regional water resources. With this brief background, the purpose of the present study is to identify the recent changes in population and its impact on usage of drinking water sources in households with special reference to Kalutara district in Sri Lanka.

The specific objectives of the study are mainly three folds: Firstly, it was aimed to identify the spatial and temporal changes of population in Kalutara district during the period of 2001-2012. Secondly, to identify the spatial and temporal changes of usage of drinking water sources in households in Kalutara district during the same period. Finally, to analyze the population changes and their impact on the usage of drinking water sources in households.

2 METHODOLOGY

Description of study area

The study area of this study is Kalutara district, located in the western province of Sri Lanka and on the southern coastal belt. Kalutara district is located at the coordinates between northern latitudes $6^{0}\ 25^{/}$ & $6^{0}\ 45^{/}$ and eastern longitudes $79^{0}\ 50^{/}$ & $80^{0}\ 20^{/}$. The elevation of the district is between the lowest of 61 m and the highest of 660.5 m above Mean Sea Level (MSL). Kalutara district is located in the low country wet zone of Sri Lanka, which receives an average annual rainfall of 3233.6 mm. It receives heavy rainfall during the Southwestern monsoonal period of May to September and second inter-monsoonal period of October to November.

The average annual temperature of the district is around 30.6 ^{0}C and there are high humidity levels. According to the Köppen Climate classification, Kalutara District features a tropical rainforest climate abbreviated “Af”. Kalutara district has a total area of 1606.4 Sq. km. It has 14 Divisional Secretariat (DS) divisions and 762 Grama Niladhari (GN) divisions for administrative purposes (Kalutara District Secretariat, 2017). Especially, the current study is based on fourteen Divisional Secretariat Divisions (DSDs), i.e. Panadura, Bandaragama, Horana, Ingiriya, Millaniya, Kaluthara, Dodangoda, Madurawala, Bulathsinghala, Beruwala, Mathugama, Agalawatta, Palindanuwara and Walallawita. Kalutara district is a multi-ethnic, multi-cultural district, and it is one of the most populated districts in the country. According to the Population and Housing Census of 2012, the total population of Kalutara district was 1,221,948 persons and the population density was 765 persons per square km. The total number of households was 305,737 in 2012.

Data collection

The study was based on divisional secretariats of the district. Data used for the study was based on secondary sources, population data and number of households by sources of drinking water for each divisional secretariats of the district obtained from the reports of Census of Population and Housing during the years 2001 and 2012 (DCS, 2001 & 2012).

Figure 1: Divisional Secretariat Divisions of Kalutara district

Data analysis

This study was a comparison of data of two census years. The variables of size, growth and distribution of population were used to study the changes in population in the study area. Population density and average annual population growth rates were calculated to identify the changes in population distribution and growth for the period of study respectively. The average annual population growth rate was calculated based on the following formula:

$$r = \frac{1}{n}\left(\frac{pt}{po} - 1\right) \times 100$$

(De Silva, 2007)

Where *r* is the average annual population growth rate, *n* is the number of years between two census years, *pt* is the population in last censes year and *po* is the population in the previous censes year.

Further, analysis based on spatial and temporal changes of usage of drinking water sources in households are displayed using thematic maps. Spatial patterns of population are also displayed using thematic maps; especially those maps are used to compare the patterns between two years of 2001 and 2012. Thematic maps are portrayed using Arc GIS 10.0 version and equal interval classification method was used for presenting the population data in thematic maps. Microsoft Excel was employed for the data analysis. Standard statistical techniques such as percentage analysis and correlation analyses were used wherever applicable. T-test was used to identify the statistically significant differences between two censes years.

3 RESULTS AND DISCUSSION

Identifying spatial and temporal changes of population

In order to identify the spatial and temporal changes of population in Kalutara district, the study was concentrated mainly on the characteristics of population, i.e. the distribution, growth and the density of the population and the total number of households.

Spatial and temporal changes of population distribution

Based on equal interval method the highest population is in Panadura, Kalutara and Beruwala Divisional Secretariat Divisions in both the years of 2001 and 2012. Figure 2 presents the spatial distribution of population in DS divisions of Kalutara district in 2001. These three DS divisions account for 42% and 41% of the total population in 2001 and 2012 respectively. Especially, it is clear that all the highest populated DS divisions in Kalutara district are located in the west coast. The lowest population is recorded from rural areas in the study, i.e. Ingiriya, Madurawala, Agalawatta, Palindanuwara, Walallawita, Dodangoda and Millaniya DSDs. These seven DSDs account for more than one quarter (29%) of the total population, while Bandaragama and Horana DSDs record a moderate population in both years. Therefore, based on the thematic maps it can be concluded that the spatial distribution pattern of population is similar in both the years. However, the t- test results showed that there is no significant temporal changes (p>0.05) of the spatial distribution in the population of the study area.

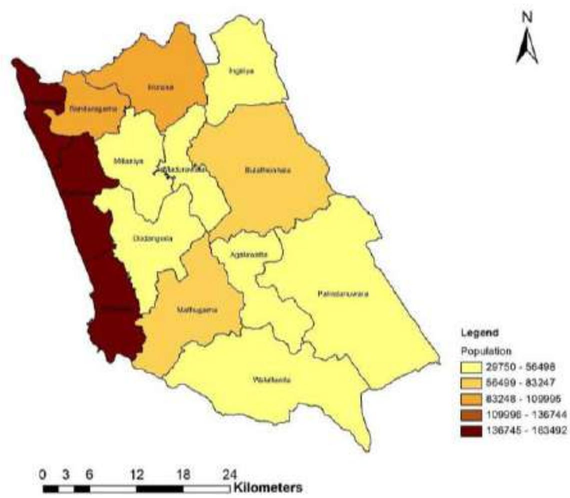

Figure 2: Distribution of population by DS divisions in 2001

Similarly, when considering the records of total population in DSDs level wise, it can be identified that the highest population is recorded in Panadura DS division while the lowest population is recorded in Madurawala DS division in both the years of 2001 and 2012 with a significant increase (Table 1). In addition, the records in the Table 1 revealed that the all DSDs have shown a continuous increase in the population distribution both spatially and temporally.

Spatial and temporal changes of population density

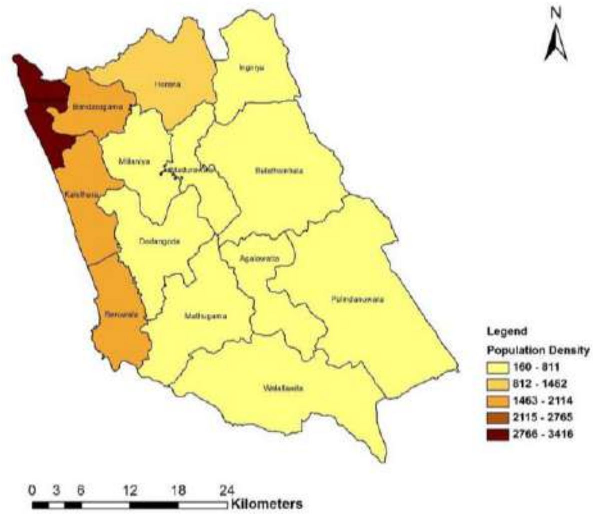

Figure 3: Population Densities of DS divisions in 2001

In general, the population density or number of persons per square km in a country increases corresponding to the increase in the total population (Table 1). The population density in Kalutara district was 677 persons per square km in 2001 census, and it has increased to 775 by the 2012 census. In comparison to the census of 2001, the population density has increased by 98 persons.

Similarly, when focussing on the population density on DS division basis, it could be seen that the DS division of Panadura (according to the census data, the highest population is recorded in Panadura) has the highest densities of population in both years. Numerically it is 3416 and 3809 in 2001 and 2012 respectively.

Figure 3 illustrates the Population Densities of DS divisions in 2001. This result is line with Nandaseela (2015) that recorded the highest density in Panadura DSD. Moreover, the population density of Panadura DSD has increased by 393 persons between 2001 and 2012.

Table 1: Summary of the population distribution in the study area

DS Division	2001	2012	Population Increases
Madurawala	29750	34381	4631
Agalawatta	33962	36669	2707
Millaniya	44476	52176	7700
Ingiriya	45726	53896	8170
Palindanuwara	45911	50801	4890
Walallawita	50676	54628	3952
Dodangoda	55052	63960	8908
Bulathsinhala	59787	64600	4813
Mathugama	73269	81286	8017
Bandaragama	86886	109236	22350
Horana	90690	113364	22674
Kaluthara	141829	159697	17868
Beruwala	144733	164969	20236
Panadura	163492	182285	18793

Note: Data have been arranged in ascending order based on the population

Source: Census of population and housing – 2001, 2012

Numerically it is 3416 and 3809 in 2001 and 2012 respectively. Figure 3 illustrates the Population Densities of DS divisions in 2001. This result is in line with Nandaseela (2015) that recorded the highest density in Panadura DSD. Moreover, the population density of Panadura DSD has increased by 393 persons between 2001 and 2012. According to Nandaseela (2015), the reason for the highest density in Panadura DSD is the location of the city and its infrastructure.

The road network with Panadura as a centre connecting Rathnapura, Colombo and Galle makes the city more connected with people who travel from different areas. Specially, the DSDs along the A2 road (Galle Road), i. e. Beruwala and Kalutara also indicate high population densities in both years. In addition to Beruwala and Kalutara, adjoining Bandaragama DS division also indicates a comparatively high population density.

Numerically, it is 1526 and 1919 in 2001 and 2012 respectively. The population density has increased by 393 persons. Population density in Ingiriya,, Bulathsinhala, Palindanuwara, Madurawala, Agalawatta, Walallawita, Mathugama, Dodangoda and Millaniya DSDs in both the years of 2001 and 2012 were low.

Specially, population density maps clearly show that population is congested along the low land areas within the district and a high density can be observed beyond the coastal sides.

Therefore, based on the thematic maps it can be concluded that the spatial distribution pattern of population density is similar in both years. The t-test results showed that there is no significant temporal changes ($p>0.05$) of the spatial distribution in the population density.

However, according to the table 2, it can be identified that all the DSDs have shown a continuous increase in the population density both spatially and temporally.

Table 2: Population Density in the study area, 2001 and 2012

DS Division	2001	2012	Population Density change (2001-2012)
Palindanuwara	160	177	17
Walallawita	241	260	19
Bulathsinhala	288	311	23
Agalawatta	453	489	36
Madurawala	474	548	74
Ingiriya	497	586	89
Dodangoda	515	598	83
Mathugama	546	606	60
Millaniya	585	686	101
Horana	847	1058	211
Bandaragama	1526	1919	393
Kaluthara	1978	2227	249
Beruwala	1983	2260	277
Panadura	3416	3809	393

Note: Data have been arranged in ascending order based on the population density

Source: Census of population and housing – 2001, 2012.

Spatial and temporal changes of population growth

When considering the annual growth of population, Bandaragama and Horana DS divisions have the highest average annual growth rates in 2001 - 2012 with 2.34% and 2.27% respectively. In fact, according to the results of the study area, Bandaragama and Horana DSDs recorded a moderate population in both the years of 2001 and 2012. In addition, Ingiriya (1.62%), Madurawala (1.42%), Millaniya (1.57%) and Dodangoda (1.47%) DS divisions also indicate comparatively high average annual growth rates. However, the low average annual growth rates are reported in Bulathsinhala (0.73%), Palindanuwara (0.97%), Agalawatta (0.72%), Mathugama (0.99%) and Walallawita (0.71%) DSDs. This could be explained as being due to the migrating of estate population for employment prospects. Moreover, the high-populated DSDs namely Panadura, Kalutara and Beruwala are recorded as second low average annual growth rates with 1.04%, 1.15% and 1.27% respectively.

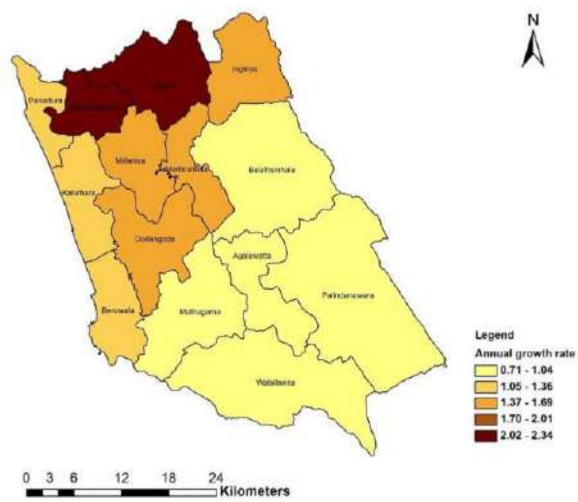

Figure 4: Average annual growth rates by DS divisions between 2001 and 2012

However, according to the average annual growth rates, it can be identified that Bandaragama DSD has recorded the highest population growth rate while Walallawita DSD has recorded the lowest population growth rate.

Spatial and temporal changes of total households

Figure 5 presents the spatial distribution of total households by DS divisions in Kalutara district in 2001. According to the figure, high values of the total households are in Panadura and Kalutara Divisional Secretariat Divisions in 2001. The same pattern could also be identified in 2012.

The low numbers are recorded from rural areas in the study area, i.e. Ingiriya, Madurawala, Agalawatta, Palindanuwara, Walallawita and Millaniya DSDs, while Bandaragama and Horana DSDs recorded moderate total households in both the years.

Therefore, based on the thematic maps it can be concluded that the spatial distribution pattern of total households is similar in both the years. However, the t- test results showed that there is no significant temporal changes ($p>0.05$) of the spatial distribution in the total households of the study area.

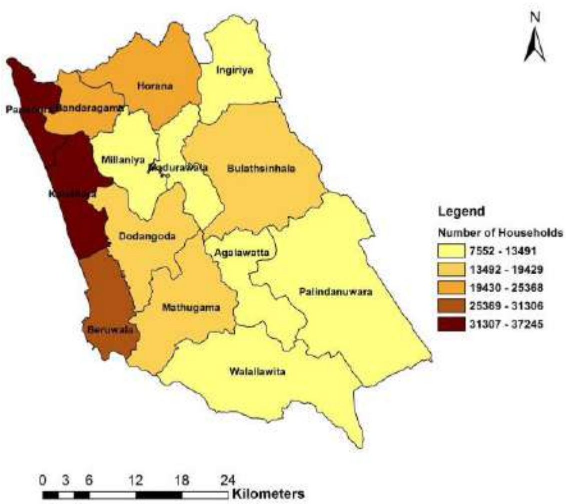

Figure 5: Total households by DS divisions in 2001

Identifying the spatial and temporal changes in the usage of drinking water sources in households

In particular, the Millennium Development Goals (MDGs) on drinking water were met globally in 2010; water target is measured by the proxy indicator of use of 'improved' or 'unimproved' drinking-water sources. As already mentioned, the "improved" water sources are piped water supply into the dwelling; piped water to yard or plot; public tap or standpipe; tube well or borehole; protected dug well; protected spring; and rainwater. Water sources that are "unimproved" are unprotected dug well; unprotected spring; cart with small tank or drum; water tanker-truck; surface water; and bottled water. However, according to the census data in Sri Lanka, the data can be categorized in nine sources according to the MDGs standard. The nine classified sources of drinking water which are included in "improved" water sources are piped water supply into the dwelling; piped water to yard or plot; tube well or borehole; protected dug well; and rainwater while "unimproved" are unprotected dug well; water tanker-truck; surface water; and bottled water. Therefore, in this study, the data of the main sources of drinking water by households were analysed by using the nine classified sources of drinking water categories. Particularly spatial analysis tools in Arc GIS were used as the main analytical tool for identifying the spatial changes of the usage of drinking water sources. Especially, equal interval classification method was used for presenting household data in thematic maps.

Spatial and temporal changes in the usage of the improved sources of drinking water

According to the data as well as the percentage share of major drinking water sources in both censuses, the results indicated that in Kalutara district, majority (86% and 94%) of the households used "improved" sources of drinking water while 14% and 6% used "unimproved" sources of drinking water in 2001 and 2012 respectively. Therefore, it can be identified that there is an increase in the use of improved sources of drinking water by 8%. In addition, it is important to note that the majority of the current population in the study area has access to safe drinking water. Specially, availability and access to improved source of drinking water is a basic indicator for human development. It bears direct relevance to health and well-being and is thus symbolically linked to the achievement of Millennium Development Goals.

Among the nine classified sources of drinking water, the study also showed that the majority (63% and 59%) of the households used protected dug well as the main source of drinking water in 2001 and 2012 respectively. Therefore, it can be identified that most of the households (about 74% and 63% in 2001 and 2012 respectively) in the study area obtained their drinking water from shallow ground water using wells (including protected and unprotected dug wells).

However, the absolute figures reveal a decrease in the use of protected dug well (4%) as a major drinking water source, indicating a fall in ground water tables. Moreover, the results of the study showed that there was a significant increase (18%) in the use of piped water into the dwellings (12% and 30%) in 2001 and 2012 respectively

When considering the spatial distribution of usage of improved sources of drinking water, it is revealed that the highest proportion of usage of improved sources of drinking water was reported in Panadura DSD (figure 6) in 2001. Kalutara and Beruwala DSDs rank in second position in 2001.

Moreover, Horana and Bandaragama DSDs depend moderately on improved sources of drinking water, whereas Ingiriya, Bulathsinhala, Palindanuwara, Walallawita, Agalawatta, Madurawala, Millaniya and Dodangoda DSDs depend the least on improved sources of drinking water. However, when comparing the figures 6 & 7, it is revealed that the high proportion of improved sources of drinking water is used by the households in Panadura and Kalutara DSDs, while Beruwala DSD ranks in the second position in 2012, although, the same position of use of improved source is recorded in other DSDs in both the years in 2001 and 2012. However, the t- test results showed that there is no significant difference ($p>0.05$) between those who used improved sources of drinking water in 2001 and 2012.

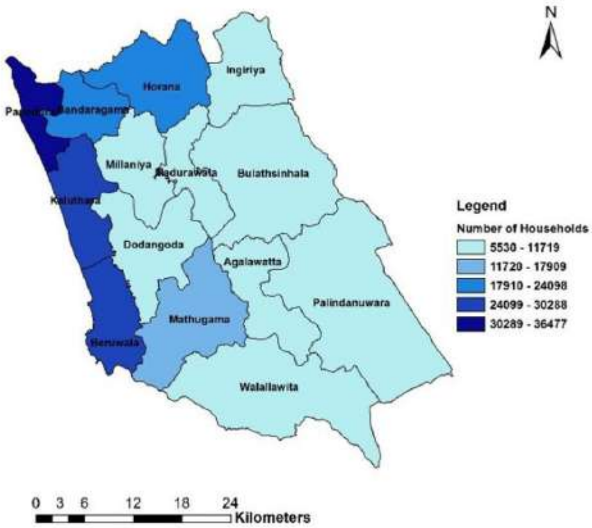

Figure 6: Distribution of usage of improved sources of drinking water, 2001

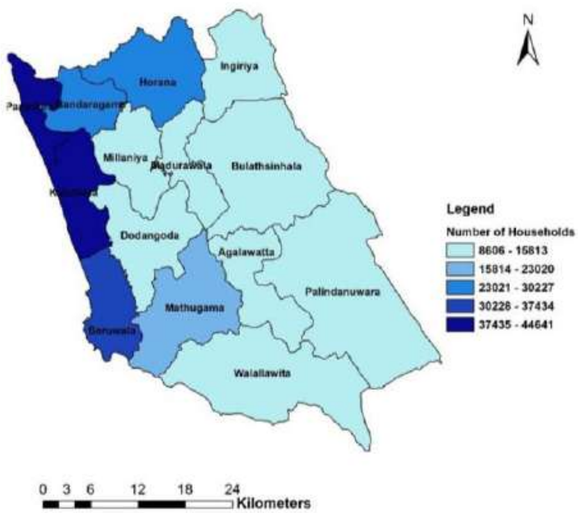

Figure 7: Distribution of usage of improved sources of drinking water, 2012

According to the classified sources of "improved" water sources, at the DSDs level, Panadura and

Beruwala DSDs depend the most on piped water supply into the dwelling while Kalutara DSD ranks in the second position in 2001.

However, there is a decrease in the use of piped water supply into the dwelling as the main source of drinking water in Beruwala DSD in 2012. The thematic maps also indicate that Ingiriya, Bulathsinhala, Palindanuwara, Walallawita, Agalawatta, Madurawala, Horana, Bandaragama, Millaniya, Dodangoda and Mathugama DSDs depend the least on piped water supply into the dwelling in both the years of 2001 and 2012.

However, the t- test results showed that there is no significant difference (p>0.05) between those who used piped water supply into the dwelling in 2001 and those who did so in 2012.

When thematic maps on the sources of drinking water is compared between census 2001 and 2012, the use of piped water to a yard or plot has recorded an appreciable decrease in Kalutara DSD. Of the users of piped water to a yard or plot, 20% of the users have recorded in 2001 while in 2012 only 14.7% of the households have used that facility in Kalutara DSD. Further, the high numbers of households which use piped water to a yard or plot is reported from the DSDs of Panadura and Beruwala, and the low numbers of households which use piped water to a yard or plot is reported from the DSDs of Ingiriya, Bulathsinhala, Palindanuwara, Walallawita, Agalawatta, Madurawala, Horana, Bandaragama, Millaniya, Dodangoda and Mathugama in both the years. Moreover, it is revealed that most of the users of piped borne water (including the piped water supply into the dwelling) were in the coastal side of the study area. However, the t- test results showed that there is no significant difference (p>0.05) between those who used piped water to a yard or plot in 2001 and those who did so in 2012.

When considering the use of protected dug well as the main sources of drinking water, it is revealed that the high numbers of households is reported in Bandaragama, Panadura and Kalutara DSDs in 2001, while only Bandaragama DSD ranks as the highest in 2012. Panadura and Kalutara DSDs rank third and second position in 2012 respectively. However, a significant increse in use of protected dug well as the main sources of drinking water can be identified in Horana DSD in 2012.

Therefore, it can be noticed that the decrease in the use of protected dug well in the coastal side DSDs is indicating fall in ground water tables. Moreover, the use of protected dug well has increased in Ingiriya and Walallawita DSDs in 2012 as the main source of drinking water. However, the t- test results showed that there is no significant difference (p>0.05) between those who used of protected dug well in 2001 and 2012.

At the DSDs level, Kalutara DSD have the maximum number of households with use of rainwater while other DSDs depend the least on rainwater in both the years of 2001 and 2012. However, the t- test results showed that there is no significant difference (p>0.05) between those who used rainwater in 2001 and 2012.

Spatial and temporal changes of the usage in the “unimproved” sources of drinking water

As already mentioned, there is a decrease in the use of “unimproved” sources of drinking water as their main source of drinking water in the study area between the year 2001 and 2012. When considering the spatial changes of the use of unimproved sources of drinking water, figure 8 reveals that the highest proportion of unimproved sources of drinking water was used by the households in Palindanuwara DSD, while Bulathsinhala and Walallawita DSDs ranks in the second position in both years. Moreover, Beruwala and Mathugama DSDs depend moderately on unimproved sources of drinking water in 2001. However, in 2012, only the Mathugama DSD depend moderately on unimproved sources of drinking water and Beruwala has decreased the use of unimproved sources. Furthermore, Ingiriya, Madurawala, Millaniya, Bandaragama, Panadura and Kalutara DSDs depend the least on unimproved sources of drinking water in 2001.

However, Horana and Agalawatta DSDs have decreased the use of unimproved sources of drinking water and those DSDs are considered as the DSDs which used the least unimproved water by 2012. Although, Dodangoda DSD in the same position in both years. Thus, the t-test results showed that there is significant difference ($p<0.05$) between those who used unimproved sources of drinking water in 2001 and those who did so in 2012.

When considering the spatial changes of the classified sources of "unimproved" water sources, at the DSDs level, Beruwala, Walallawita, Palindanuwara and Bulathsinhala DSDs depend the most on unprotected dug well while Mathugama DSD ranks in second position in 2001.

However, in Beruwala and Bulathsinhala DSDs a decrease in the use of unprotected dug wells can be identified by 2012. In addition, in Ingiriya, Kalutara, Dodangoda and Agalawatta DSDs a decrease in the use of unprotected dug wells can be identified by 2012. Therefore, by 2012 it can be identified that there are five DSDs as the lowest in use of unprotected dug well. Thus, the t-test results showed that there is significant difference ($p<0.05$) between those who used unprotected dug well in 2001 and those who did so in 2012 in the study area.

It is also indicated that Beruwala DSD depends the most on tanker-truck while Horana and Kalutara DSDs rank in the second position in 2001. The thematic maps also indicate that Panadura, Bandaragama, Ingiriya, Bulathsinhala, Madurawala, Millaniya, Dodangoda, Mathugama, Agalawatta, Palindanuwara and Walallawita DSDs depend the least on tanker-truck in 2001. Although, by 2012 Dodangoda DSD depends the most on tanker-truck and other DSDs depend the least.

However, the t-test results showed that there is significant difference ($p>0.05$) between those who used water from tanker-truck in 2001 and those who did in 2012.

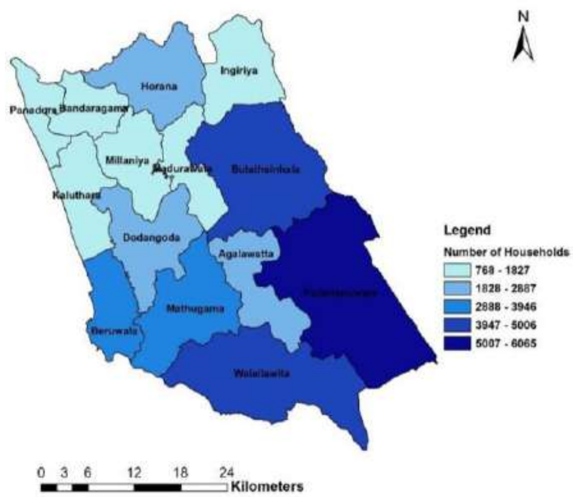

Figure 8: Distribution of usage of unimproved sources of drinking water, 2001

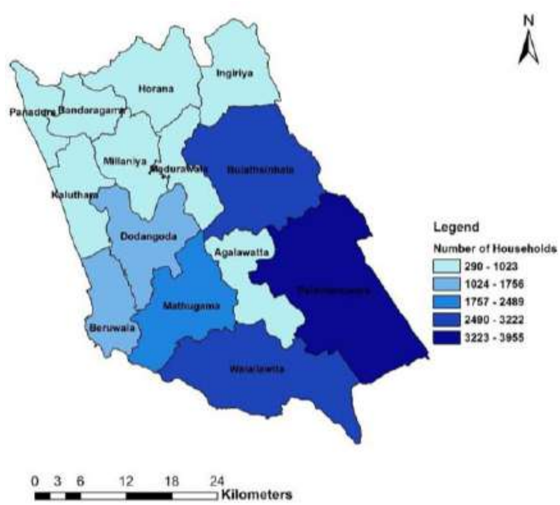

Figure 9: Distribution of usage of unimproved sources of drinking water, 2012

The thematic maps also indicate that the highest number of households used water from the surface water, which is considered an unsafe source of water for drinking purposes in Palindanuwara DSD in both the years. Further, it is revealed that there is an increase in the use of surface water in Bulathsinhala DSD and a decrease in Agalawatta DSD by the year 2012. However, the t-test results showed that there is a significant difference ($p>0.05$) between those who used surface water in 2001 and those who did so in 2012.

According to the mapping analysis, it is revealed that Panadura and Beruwala DSDs depend the most on bottled water while Kalutara DSD ranks in the second position in 2012. Further, Bandaragama, Horana, Ingiriya, Bulathsinhala, Madurawala, Millaniya, Dodangoda, Mathugama, Agalawatta, Palindanuwara and Walallawita DSDs depend the least on bottled water as the main source of drinking water.

Analyze the population changes and their impact on usage of drinking water sources in households

Correlation analysis was used to establish the type of relationship between population and usage of drinking water sources in households in the study area. T-test was also used to identify the statistically significant relationship between two censes years. Null hypothesis and Alternative Hypothesis are presented below.

Null Hypothesis (H_0): There is no significant relationship between the population increase and use of drinking water sources in households.

Alternative Hypothesis (H_1): There is a significant relationship between the population increase and use of drinking water sources in households.

Relationship between population size and usage of drinking water sources

According to the results of correlation analysis, the correlation values of 0.98 and 0.99 indicate a strong relationship between the increase in population size and the usage of improved sources of drinking water in 2001 and 2012 respectively. It is also significant ($p<0.05$) change in both the years. Furthermore, the positive correlation among the correlated factors has increased by 2012. On the other hand, it means that the relationship between population size and the use of improved sources of drinking water in the study area is really a strong one, in the sense that any significant increase in the population of the district leads to a chain effect on the use of improved sources of drinking water of the district. This also really means that safety water is affected at a rate of 98% and 99% by the continuous increase in the population size of the district in 2001 and 2012 respectively.When considering the classified sources of “improved” water sources, there is a strong positive relationship between the increase in population size and the uses of all the classified improved sources of drinking water in the Kalutara district. It is significant ($p<0.05$) in both the years. These values are also really high, and it shows that the population factor is highly dependent on water use.

However, according to the correlation analysis, the correlation values of -0.29 and -0.36 indicate a weak relationship among the correlated factors in 2001 and 2012 respectively. It has a negative correlation and is not significant ($p > 0.05$). Therefore, it can be concluded that the relationship between population size and use of unimproved sources of drinking water in the study area is really a weak one, in the sense that significant increases in the population has no significant influence on the use of unimproved sources of drinking water. There is a strong positive relationship between the increase in population size and the use of tanker-truck as the main source of drinking water in 2001 and is significant ($p<0.05$). It can also be identified in the use of bottled water in 2012.

Relationship between population density and usage of drinking water sources

There is a significant ($p<0.05$) strong positive relationship between the increase in population density and the usage of improved sources of drinking water in both the years of 2001 and 2012 with $r = 0.93$ and $r = 0.92$ respectively. Further, all the classified improved sources of drinking water show a significant ($p<0.05$) positive correlation values. Therefore, it can be concluded that improved sources of drinking water are affected at high rates by the continuous increase in the population density of the district in 2001 and 2012 respectively.

When considering the unimproved sources, there is a moderate negative relationship (r = - 0.41 in 2001 and r = - 0.52 in 2012) between the increase in population density and the usage of unimproved sources of drinking water in the Kalutara district. There is no significant relationship ($p>0.05$) in 2001 whereas there is a significant relationship ($p<0.05$) in 2012. In addition, it is evident that all the unimproved sources of drinking water, except two sources, show a negative correlation values. Use of tanker-truck in 2001 and use of bottled water in 2012 are the only sources that have shown a significant positive correlation ($p<0.05$). Moreover, the use of surface water is indicated significant ($p<0.05$) and a moderate negative relationship. Therefore, it can be concluded that increases in the population density has significant influence on the use of surface water and when there is an increase in population density the use of surface water has decreased.

Relationship between total households and usage of drinking water sources

According to the results, the correlation values of 0.99 and 1.00 indicate a strong relationship among the correlated factors in 2001 and 2012 respectively. Accordingly, it can be said that there is a strong relationship between the increase in total households and the usage of improved sources of drinking water in the study area. Moreover, it is a significant relationship ($p<0.05$). Furthermore, the positive correlation among the correlated factors has increased by 2012. This also really means that improved sources of drinking water is affected at a rate of 99% and 100% by the continuous increase in the number of households in the district in 2001 and 2012 respectively. It is also identified that any significant increase in the number of households leads to a chain effect on the use of improved sources of drinking water of the district. Moreover, according to the results of correlation analysis it is evident that all the improved sources of drinking water show a strong positive relationship among the correlated factors and are significant ($p<0.05$) in both the years.

When considering the usage of unimproved sources of drinking water, the correlation values of -0.29 and -0.35 indicate a weak relationship among the correlated factors in 2001 and 2012 respectively. It has a negative correlation and is no significantly different ($p>0.05$).

Therefore, it can be concluded that the relationship between total households and use of unimproved sources of drinking water in the study area is really a weak one, in the sense that increases in the population has no significant influence on use of unimproved sources of drinking water in the study area is really a weak one, in the sense that increases in the population has no significant influence on the use of unimproved sources of drinking water. However, there is a strong positive relationship between the increase in total households and the use of tanker-truck as the main source of drinking water in 2001 and it is significant ($p<0.05$). It can also be identified in use of bottled water in 2012.

4 CONCLUSIONS

The study was carried out to identify the spatial and temporal changes of population and usage of drinking water sources in Kalutara district. Similarly, the study aimed at establishing a relationship that exists between the population increase and the use of drinking water sources in Kalutara district. The study has revealed that all the DS divisions with the highest population and population density are located in the west coast while the lowest are recorded from rural areas in the study area. It is also revealed that there was an increase in the population size and population density both spatially and temporally. The study has also shown that there was a similar distribution pattern in total households and the highest total households were in Panadura and Kalutara DSDs in both the years. Further, the study has revealed that the highest annual growth rate of population is recorded in Bandaragama and Horana DS divisions. However, the t- test results showed that there is no significant temporal changes ($p>0.05$) of the spatial distribution in the population size, population density and total households of the study area.

This study showed that the majority of the households used improved or safe sources of drinking water. It could be identified that there was an increase in the use of improved sources of drinking water while there was a decrease in the use of unimproved sources of drinking water. The results also showed that most of the households in the study area obtained their drinking water from shallow ground water using wells (including protected and unprotected dug wells). However, in terms of absolute figures it revealed a decrease in the use of protected dug wells as their major source of water in the coastal side indicating a fall in ground water tables in the area. Moreover, the results showed that there was a significant increase in the use of piped water into dwelling in both the years. According to the thematic maps, it was revealed that most of the households use pipe borne water as their major source of water in the coastal side of the study area. However, the t- test results showed that there was no significant difference ($p>0.05$) between those who used all classified improved sources of drinking water in 2001 and those who used them in 2012. It was evident that the highest proportion of unimproved sources of drinking water was used by the households in Palindanuwara DSD. The t-test results showed that there was a significant difference ($p<0.05$) between those who used all classified unimproved sources of drinking water in 2001 and those who used them in 2012.

Further the present study revealed that there was a strong relationship between the increase in population size, population density and total households, and it led to a chain effect on the use of all the classified improved sources of drinking water in Kalutara district and was significant ($p<0.05$) in both the years.

However, the study indicated that the relationship between population size and use of unimproved sources of drinking water as well as total households and use of unimproved sources of drinking water in the study area is really a weak one, in the sense that significant increases in the population size and total households had no significant influence on the use of unimproved sources of drinking water. Although, there was a strong positive relationship between the increase in population size and the use of tanker-truck as well as total households and the use of tanker-truck as their main source of drinking water in 2001 and was significant ($p<0.05$). It could also be identified in the use of bottled water in 2012.

There was a moderate negative relationship between the increase in population density and the uses of unimproved sources of drinking water in Kalutara district. In addition, it was evident that all the unimproved sources of drinking water, except two sources which use tanker-truck and bottled water, show negative correlation values. It was also evident that the increase in population density had significant influence on the use of surface water. The study therefore recommend that the source of drinking water should be managed sustainably in order to ensure continuous availability in the long-term.

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