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Temporal trends and spatial heterogeneity of sanitation facilities in Ethiopia: evidence from the 2005–2019 Demographic and Health Surveys

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ABSTRACT

Background The main aim of sanitation is to prevent human contact with faecal pathogens to decrease occurrences of diseases. However, no region in the world is on the right track to accomplish Sustainable Development Goal (SDG) 6.2 for universal access to sanitation. Sub-Saharan Africa, including Ethiopia, is significantly behind in meeting the 2030 SDG 6.2 targets. Hence, this study focused on the spatial and temporal analysis of sanitation in Ethiopia based on four demographic health surveys.

Design This research was undertaken among households in Ethiopia based on a weighted sample size. Variables with a p<0.2 in bivariable analysis were incorporated into the multivariable analysis. Subsequently, a 95% CI and a p<0.05 were used to assess the statistical significance of the final model. Global and local indicators of spatial correlation were done. Statistical analyses were performed by using STATA V.17 and ArcGIS V.10.7 software.

Results This study includes data from 13 721 households in the 2005 Ethiopian Demographic and Health Survey (EDHS), 16 702 households in the 2011 EDHS, 16 650 households in the 2016 EDHS and 8663 households in the 2019 EDHS. The prevalence of improved sanitation facilities in Ethiopia was 20.46%, 25.61%, 25.86% and 27.45% based on EDHS 2005, 2011, 2016 and 2019, respectively. Global Moran's I spatial autocorrelations, hotspots and spatial interpolation analysis indicated the inequality of improved sanitation facilities. Educational status of primary (adjusted OR, AOR 2.43, 95% CI 2.00, 2.95), secondary (AOR 2.02, 95% CI 1.61, 2.54) and higher (AOR 4.12, 95% CI 3.35, 7.54), watching television (AOR 5.49, 95% CI 4.37, 6.89), urban areas (AOR 9.08, 95% CI 6.69, 12.33) and region were factors statistically associated with sanitation facilities.

Conclusion The overall finding of this study concludes a very slow increment in sanitation facilities over time and the presence of geographical heterogeneity in Ethiopia. Educational status, watching television, wealth index, community-level education, type of residence and region were factors statistically associated with sanitation facilities.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The first strength is using multi Ethiopian Demographic and Health Survey data, which enable to show trend analysis of sanitation status in Ethiopia.
⇒ The second strength is using data from multiple Demographic and Health Surveys ensures a large, nationally representative sample, which increases the generalisability of findings across Ethiopia.
⇒ The third strength, DHS surveys provide detailed information on the types of sanitation facilities, from basic to improved, which allows for a significance understanding of the sanitation countryside in Ethiopia.
⇒ The first limitation, there could be social desirable bias since the data were collected through face-to-face interview.
⇒ The second limitation, while the quantitative analysis identifies trends and spatial disparities, it may not provide insights into the behavioural and cultural-evel factors influencing sanitation adoption and usage.

BACKGROUND

Sanitation refers to the endowment of services and facilities for the safe and clean controlling of human excreta, from the toilet to handling and containment to the final end-use or removal.[1] Sanitation is an integral component of basic human rights comparable to food, shelter and water and is vital for healthy life.[2]

According to the United Nations (UN-2018) report, in the world, around 4.5 billion people had no safe sanitation and 892 million continue to practice Open Defecation (OD).[3 4] Inadequate access to sanitation is a principal reason for poverty in unindustrialised nations because it causes early mortality.[5 6] The WHO estimated in 2019 that over 800 000 people die each year from diarrhoea brought on by inadequate water, sanitation and hygiene (WASH), and that two billion people's drinking water sources were tainted with excrement. Climate change, shifting precipitation patterns, increasing urbanisation and a dearth of practical, context-specific guidance

Table 1 Sociodemographic characteristics of study participants in Ethiopia

Variables	EDHS 2005 (N=13 721) Frequency (%)	EDHS 2011 (N=16 702) Frequency (%)	EDHS 2016 (N=16 650) Frequency (%)	EDHS 2019 (N=8663) Frequency (%)
Sex of HHH				
Male	10 243 (74.65)	11 906 (71.28)	11 413 (68.55)	6291 (72.62)
Female	3478 (25.35)	4796 (28.72)	5237 (31.45)	2372 (27.38)
Age of HHH				
<30	3428 (24.98)	4823 (28.88)	4257 (25.57)	2520 (29.09)
30–40	3501 (25.52)	4116 (24.64)	4132 (24.82)	2287 (26.40)
41–54	3756 (27.37)	4047 (24.23)	4230 (25.41)	1717 (19.82)
>54	3036 (22.13)	3716 (22.25)	4031 (24.21)	2139 (24.69)
Educational status of HHH				
No education	8725 (63.59)	9309 (55.74)	8668 (52.06)	4128(47.65)
Primary	2705 (19.71)	5020 (30.06)	4658 (27.98)	2715 (31.34)
Second	1754 (12.78)	1189 (7.12)	1686 (10.12)	963 (11.12)
Higher	495 (3.61)	1140 (6.83)	1580 (9.49)	857 (9.89)
Wealth index				
Poor	5393 (39.30)	6506 (38.95)	7024 (42.19)	3498 (40.38)
Middle	2055 (14.98)	2364 (14.15)	2057 (12.35)	1285 (14.83)
Rich	6273 (45.72)	7832 (46.89)	7569 (45.46)	3880 (44.79)
Share toilet with other households				
Yes	2712 (45.72)	4467 (46.12)	4727 (43.83)	2222 (38.18)
No	3204 (54.01)	5204 (53.73)	6059 (56.17)	3598 (61.82)
Having radio				
No	8157 (59.45)	9658 (57.83)	11 680 (70.15)	6170 (71.22)
Yes	5560 (40.52)	7040 (42.15)	4970 (29.85)	2493 (28.78)
Having television				
No	12 116 (88.30)	13 643 (81.68)	12 818 (76.98)	6679 (77.10)
Yes	1601 (11.67)	3051 (18.27)	3832 (23.02)	1984 (22.90)
Community-level media exposure				
Unexposed	8105 (59.07)	8973 (53.72)	10 024 (60.20)	5195 (59.97)
Exposed	5616 (40.93)	7729 (46.28)	6626 (39.80)	3468 (40.03)
Community-level educational status				
Lower	8730 (63.63)	9309 (55.74)	8726 (52.41)	4308 (49.73)
Higher	4991 (36.37)	7393 (44.26)	7924 (47.59)	4355 (50.27)
Residence				
Urban	3666 (26.72)	5112 (30.61)	5232 (31.42)	2645 (30.53)
Rural	10 055 (73.28)	11 590 (69.39)	11 418 (68.58)	6018 (69.47)
Region				
Tigray	1282 (9.34)	1730 (10.36)	1734 (10.41)	714 (8.24
Afar	806 (5.87)	1267 (7.59)	1220 (7.33)	664 (7.66)
Amhara	2066 (15.06)	2071 (12.40)	1902 (11.42)	1007 (11.62)
Oromia	2155 (15.71)	2165 (12.96)	1988 (11.94)	1018 (11.75)
Somali	796 (5.80)	975 (5.84)	1564 (9.39)	657 (7.58)
Benishangul-Gumuz	869 (6.33)	1323 (7.92)	1280 (7.69)	734 (8.47)
SNNPR	1933 (14.09)	2045 (12.24)	1897 (11.39)	1017 (11.74)
Gambella	820 (5.98)	1215 (7.27)	1280 (7.69)	693 (8.00)
Harari	904 (6.59)	1201 (7.19)	1135 (6.82)	719 (8.30)
Addis Ababa	1333 (9.72)	1524 (9.12)	1489 (8.94)	702 (8.10)
Dire Dawa	757 (5.52)	1186 (7.10)	1161 (6.97)	738 (8.52)

EDHS, Ethiopian Demographic and Health Survey; HHH, household head; SNNPR, South Nation Nationalities Republic.

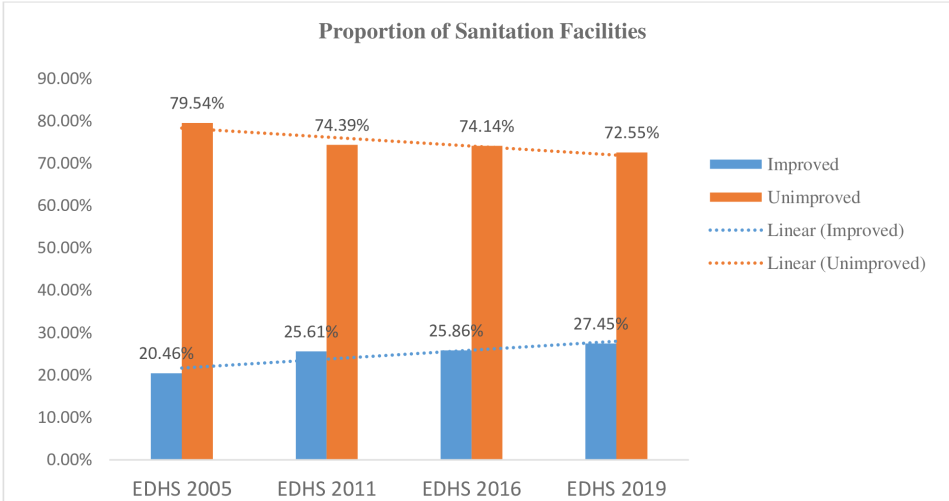

Figure 1 The proportion of sanitation facilities accessibility in Ethiopia using the four EDHS. EDHS, Ethiopian Demographic and Health Survey.

on adaption strategies for sanitation service providers are all predicted to have an influence on the sanitation sector globally.[7–9] Over 70% of the population in Eastern and Southern Africa—340 million people—do not have access to basic sanitation services, while 19% defecate in the open, 179 million use unimproved facilities and 63 million use shared sanitation facilities.[10]

The Sustainable Development Goals (SDGs 6.2) aim to guarantee universal access to fair sanitation by 2030 as a result of these issues.[11] SDG 6.2 of the United Nations, which emanated in 2015 from the Millennium Development Goals, aims at equitable access to safe and affordable sanitation for all by 2030.[10] The main aim of this SDG is to prevent human contact with faecal pathogens to decrease occurrences of diseases.[12 13] However, urban sewer connections are growing at an embarrassingly slow rate of 0.14% per year, and no place in the world is on track to achieve SDG 6.2 for universal access to sanitation.[14] Sub-Saharan African (SSA) nations, in particular, are well behind schedule in achieving SDG 6.2 of the 2030 agenda because of their fast population expansion and inadequate investment in sanitary infrastructure.[15 16] At the same time, disparities in SSA nations' access to sanitary facilities were more noticeable.[17] There are differences between nations, primarily in terms of urban and rural housing, which showed that people in rural areas had far worse access to sanitation than people in urban areas.[18] Low-income and middle-income nations exhibit this subnational variance in access to improved sanitation facilities, which is defined as the range of values from the unit with the highest level of access to the unit with the lowest level of access or no access at all.[19] Like other developing countries[20] access to sanitation is a challenge across Ethiopia,[21] as well as there are disparities among the regions of the country. However, countries have the power to either advance or impede the development of fair access to better sanitary facilities.

Previous studies in Ethiopia were based on a single Ethiopian Demographic and Health Survey (EDHS) or only multilevel analysis or spatial analysis in order to investigate improved sanitation facilities.[22] These researches are unable to demonstrate the trend of better sanitary facilities over time. As in earlier research, the enhanced sanitation source is linked to residence, educational achievement, television viewing, household size, region and wealth index.[23–25] In order to better understand the progress and geographical variance within Ethiopia, this study concentrated on the spatial and temporal analysis of sanitation facilities based on a combination of different demographic health surveys conducted in 2005, 2010, 2016 and 2019.

METHODS

Study area and data source

The study was carried out in Ethiopia, which consists of two administrative cities (Addis Ababa and Dire-Dawa) and nine geographical regions (Tigray, Afar, Amhara, Oromia, Somali, Benishangul-Gumuz, Southern Nations Nationalities and Peoples Region (SNNPR), Gambella and Harari). The nation is situated in the Horn of Africa, with coordinates of 40.4897° East longitude and 9.145° North latitude.[26] The four consecutive EDHS (EDHS 2005, 2011, 2016 and 2019) database surveys were used in this investigation. These are, therefore, population-based surveys that are nationally representative and have sizeable sample sizes at various points in time.

The DHS website, https://www.dhsprogram.com/data/dataset_admin/login_main.cfm, provides access to open-source EDHS data.

All EDHS samples were a two-stage stratified cluster sample,[27] sampling weights were calculated based on sampling probabilities separately for each sampling stage and each cluster. In 2005 surveys, 540 enumeration areas (EAs) (139 urban and 401 rural areas),[28] 2011 EDHS, 624

Table 2 Multilevel binary logistic regression analysis of predictors towards accessibility of sanitation facilities in Ethiopia, EDHS 2011

Variables	Model 0 (null model)	Model 1 AOR (95% CI)	Model 2 AOR (95% CI)	Model 3 AOR (95% CI)
Individual-level factors				
Sex of HHH				
Male		0.97 (0.82, 1.04)		1.01 (0.84,1.11)
Female		1	1	1
Age of HHH				
<30		0.97 (0.94,1.01)		0.96 (0.20, 2.34)
30–40		0.57 (0.35, 2.02)		1.49 (0.13, 2.41)
41–54		0.43 (0.22, 0.61)		1.17 (0.86, 1.59)
>54		1	1	1
Educational status				
No education		1		1
Primary		3.23 (2.63, 3.96)**		2.43 (2.00, 2.95)**
Secondary		6.36 (5.26, 7.67)**		2.02 (1.61, 2.54)**
Higher		8.11 (7.16, 9.19)*		4.12 (3.35, 7.54)**
Wealth index				
Poor		1		1
Middle		2.96 (2.34, 4.24)**		1.49 (1.21, 1.83)**
Rich		5.48 (3.45, 5.89)**		3.15 (2.55, 3.89)**
Having television				
No		1		1
Yes		4.81 (4.16, 5.56)**		5.49 (4.37, 6.89)**
Community-level factors				
Community-level education				
Higher			6.50 (5.82, 7.27)**	3.90 (3.15, 4.82)**
Lower			1	1
Community-level media exposure				
Exposed			6.07 (5.42, 6.81)**	5.61 (3.84, 10.09)**
Unexposed			1	1
Type of residence				
Urban			16.74 (11.85, 23.65)**	9.08 (6.69, 12.33)**
Rural			1	1
Region				
Tigray			0.50 (0.41, 0.62)**	0.46 (0.37, 0.57)**
Afar			0.86 (0.67,1.09)	0.67 (0.51, 0.86)*
Amhara			0.43 (0.35, 0.53)**	0.40 (0.32,0.49)**
Oromia			0.89 (0.72, 1.09)	0.90 (0.73, 1.12)
SNNRP			0.25 (0.20, 0.31)*	0.28 (0.22, 0.34)**
Somali			0.33 (0.26, 0.41)**	0.23 (0.18, 0.29)**
Benishangul Gumuz			0.74 (0.59, 0.94)*	0.63 (0.49, 0.80)**
Gambella			0.51 (0.41, 0.64)**	0.45 (0.35, 0.57)**
Harari				0.64 (0.52, 0.80)**
Addis Ababa			1	1
Dire Dawa			0.25 (0.21, 0.31)**	0.28 (0.22, 0.35)**
VIF		2.35	2.27	2.05

1= reference.
**P value < 0.001(Adjusted OR), *P value < 0.05(Adjusted OR).
Model 1 is adjusted for individuallevel variables. Model 2 is adjusted for community-level variables; Model 3 is the final model adjusted for both individual- and community-level predictors.
AOR, adjusted OR; EDHS, Ethiopian Demographic and Health Survey; HHH, household head; VIF, variance inflation factor.

Table 3 Measures variation metrics and the model fitness test statistics used for included models

Metrics	Model 0 (null model)	Model 1	Variables	Model 0 (Null model)
Variance	6.88 (5.84, 8.10)	2.77 (2.30, 3.32)	2.04 (1.71, 2.44)	1.97 (1.65, 2.35)
MOR	7.07	4.35	3.82	3.78
PCV	Reference	59.74%	26.35%	3.43 %
ICC	0.6765	0.4571	0.3827	0.3745
Model fitness test statistics				
AIC	12204.07	11338.86	11610.79	11151.08
BIC	12 219.51	11 454.67	11 734.32	11 282.33
Deviance	12 200.0736	11 323.6174	11 611.497	11 117.0824

AIC, Akaike's information criteria; BIC, Bayesian information criteria; ICC, intraclass correlation coefficient; MOR, median OR; PCV, proportional change in variance.

EAs (187 urban and 437 rural areas),[29] 2016 EDHS 645 EAs (202 in urban areas and 443 in rural areas)[30] and 2019 EDHS 305 EAs (93 in urban areas and 212 in rural areas)[31] were selected using systematic sampling with likelihood proportional to size.

In the second stage of selection, a fixed number of 30 households per cluster were selected with an equal probability of systematic selection from the newly created household listing. The field practice was conducted in Adama in clusters that were not part of the survey sample. Ethiopian Public Health Institute investigators, an Information Consulting Firm technical specialist, an advisor and representatives from other organisations, including central statistics agency, the Federal Ministry of Health, the World Bank and USAID, supported the data collection in this EDHS data collection.[28]

Among included households, 13 721, 16 702, 16 650 and 8663 were successfully interviewed in EDHS 2005, 2011, 2016 and 2019, respectively.[28 30] Weighted by sampling weight was done to do a reliable statistical analysis. The geographical location data were taken from selected respective EAs.

STUDY VARIABLES

Outcome variables

The dependent variable was the sanitation facilities. The sanitation type designated as '1' represents 'improved sanitation', which can be accessed through flush/pour flush to piped sewer systems, septic tanks or pit latrines; ventilated improved pit latrines, composting toilets or pit latrines with slabs; and '0' represents 'unimproved sanitation' since it includes pit latrines without a platform or slab, hanging latrines or bucket latrines, and OD.[32–34]

PREDICTOR VARIABLES

Individual-level variables

Individual-level variables included sex of household head (male or female), wealth index (poor, middle and rich), educational status (no education, primary education, secondary education and higher education), having a television (yes or no) and radio (yes or no) were individual-level predictor variables.

Community-level variables

Community-level variables included community-level education (lower/higher), the place of residence (urban/rural), community-level media exposure (exposed/unexposed), region (Benishangul-Gumuz, Somali, Gambella, Afar, Oromia, SNNPR, Amhara, Tigray and Harari) and city administration (Addis Ababa and Dire Dawa).

Data management and analysis

The first step in data handling was downloading the raw datasets from the DHS website. These contained pertinent demographic and socioeconomic factors as well as household-level data on sanitation facilities. Pretests comprising in-class instruction, biomarker training and field exercises were conducted for ensuring the quality of the data. The field exercise was conducted in clusters, which were not included in the EDHS sample. A debriefing session was held with the pretest field staff, and adjustments to the questionnaires were made based on lessons drawn from the field practice.

Data cleaning techniques included recoding, removing duplicates and resolving missing values to get the data ready for analysis. The datasets underwent further processing after data cleaning in order to extract significant predictors and analytical findings. The management approach also ensured that sample weights from the DHS data were appropriately applied to all analyses, taking into account the complex survey design, to ensure nationally representative results. In order to prepare the spatial data, shapefiles of the Ethiopian regions were accessed, and sanitation data were superimposed on them.

Stata V.17 was used to do regression analysis and descriptive statistics. Logistic regression analysis was used to evaluate the relationships between outcome variables and predictor variables because the outcome variables were dichotomous. Multivariable binary logistic regression analysis was performed using bivariate analysis variables that had a $p<0.2$. In the final model, statistical significance was determined by a $p<0.05$ and a 95% CI.[35]

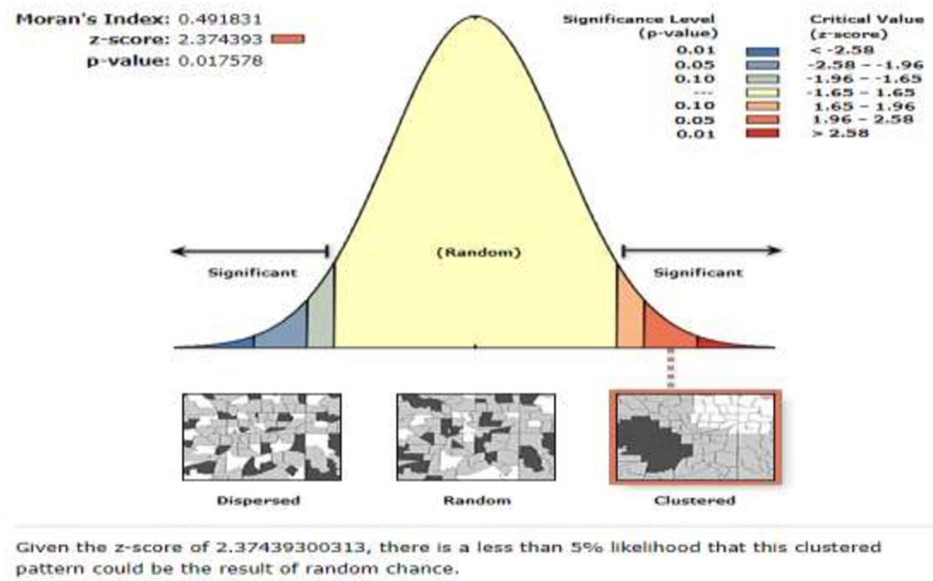

Figure 2 Global spatial autocorrelation analysis of accessibility of improved sanitation facilities in Ethiopia, EDHS 2005. EDHS, Ethiopian Demographic and Health Survey.

MULTILEVEL ANALYSIS

Model 1 included dependent and individual-level predictors, model 2 included dependent and community-level predictors, model 3 included all variables from models 1 and 2, and model 0 was a null model with no predictor variables. Random effects were measured using cluster variance (Vc), a proportional change in variance ((PCV $\left(\left(Vc-Vn\right)/Vc\right)$) the intraclass correlation coefficient (ICC$\left(Vc/\left(Vc+3.29\right)\right)$ and the median OR (MOR (exp $\left[\left(0.95\right)\sqrt{Vc}\right]$)).[36 37] The goodness-of-fit for all models was evaluated using AIC, BIC and deviance. Then the model with the lower value of deviance, AIC and BIC demonstrated the best-fit model.[38] As well as multicollinearity, the effect of independent variables was measured using the variance inflation factor.

Spatial and temporal analysis

Spatial autocorrelation

In order to examine geographical variability, a geospatial study of the distribution of sanitary facilities was carried out using ArcGIS V.17. The best essential instruments for access to improved sanitation facilities within the designated term are both global and local indicators of

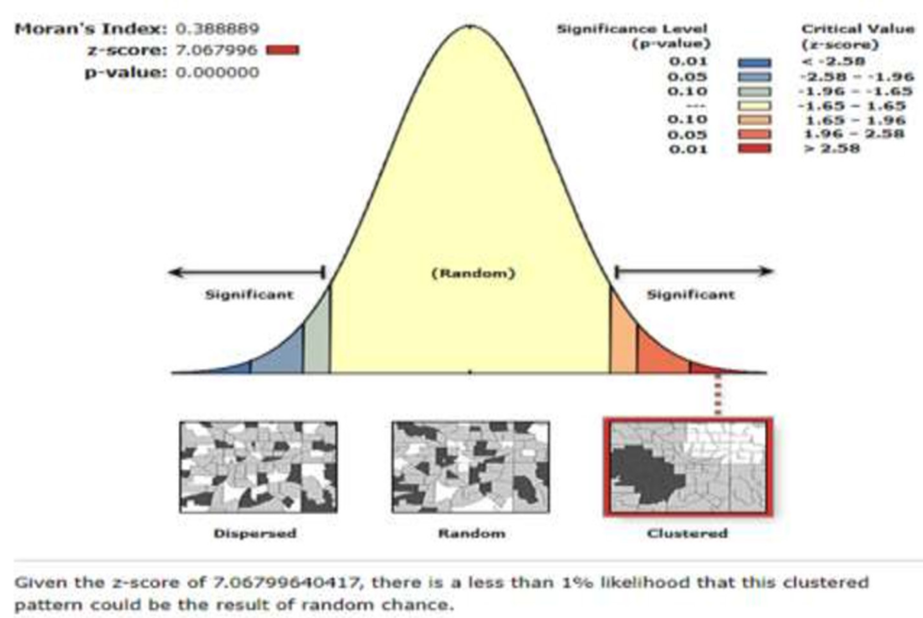

Figure 3 Global Spatial autocorrelation analysis of accessibility of improved sanitation facilities in Ethiopia, EDHS 2011. EDHS, Ethiopian Demographic and Health Survey.

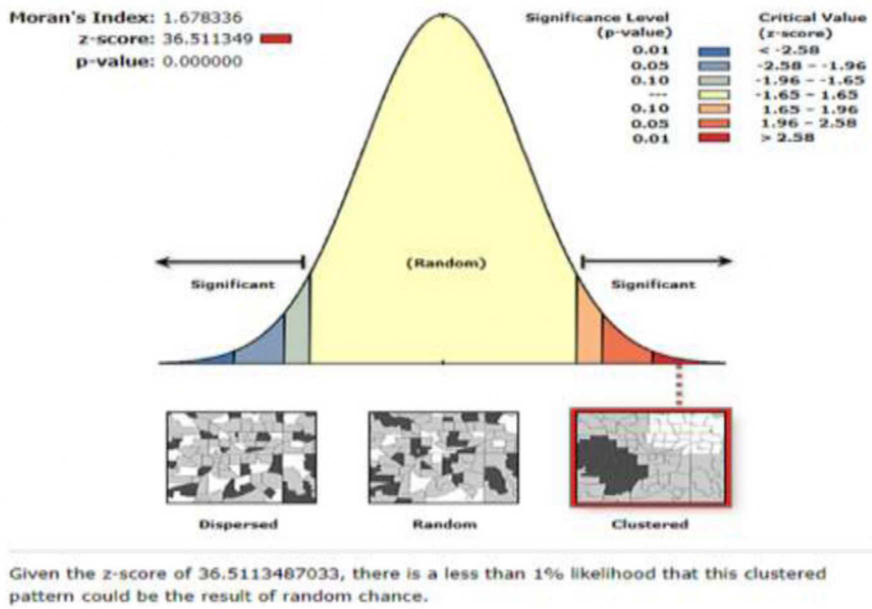

Figure 4 Global spatial autocorrelation analysis of accessibility of improved sanitation facilities in Ethiopia, EDHS 2016. EDHS, Ethiopian Demographic and Health Survey.

spatial correlation, which may be used to investigate the geographical distribution.

GLOBAL AUTOCORRELATIONS

Global autocorrelations analysis was performed in order to identify geographical variations in access to improved sanitation facilities. To determine whether the discrepancy is the result of non-random/dispersion or the clustering effect, global spatial autocorrelation (Moran's I index) was employed.[39 40] Additionally, a basic exploratory spatial analysis was conducted to determine the country's geographical reliance distribution and the existence of better sanitary facilities. Places with similar access to sanitation tended to cluster together when Moran's I value was positive, while places with varying levels of sanitation were near one another when it was negative.

Local statistical analysis

Since global autocorrelations show a clustering effect (positive spatial autocorrelation) on the availability of sanitary facilities nationwide, more research using figures and maps is required. In order to highlight the previously mentioned use of global autocorrelations (cluster effect) on access to sanitary facilities and to find patterns of geographical variation, hotspot analysis (Gettis-Ord

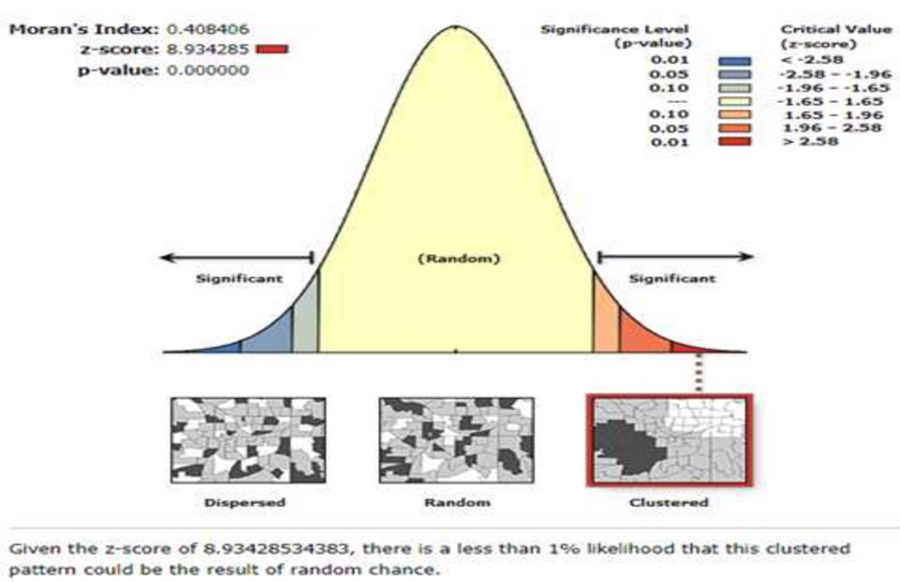

Figure 5 Global spatial autocorrelation analysis of accessibility of improved sanitation facilities in Ethiopia, EDHS 2019. EDHS, Ethiopian Demographic and Health Survey.

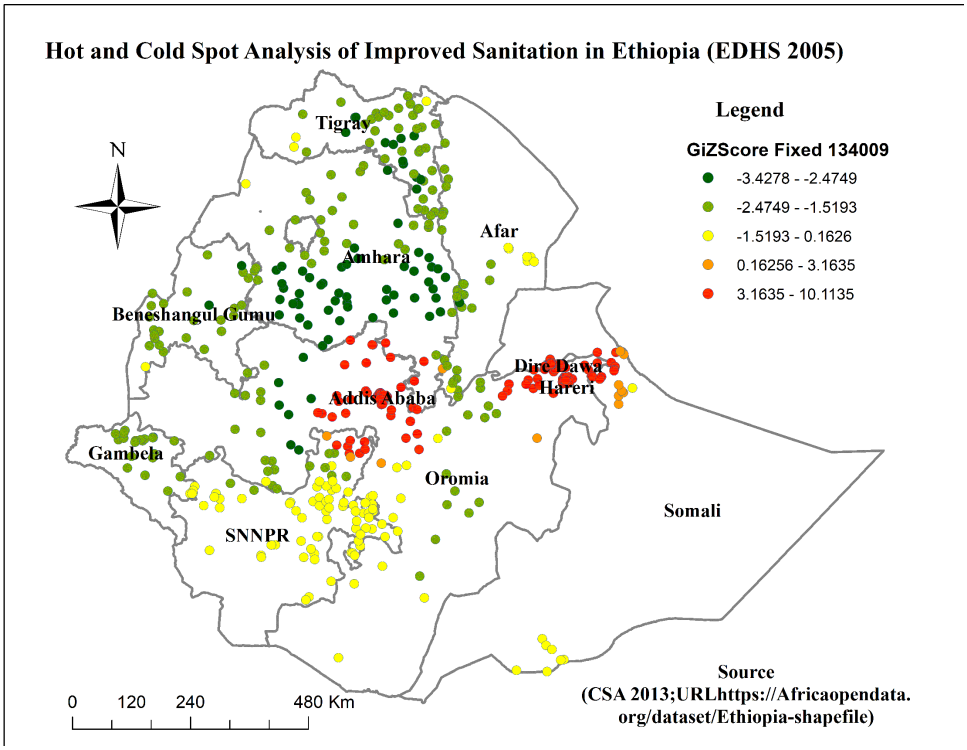

Figure 6 Hot and cold spot analysis of accessibility of improved sanitation facilities in Ethiopia based on the dataset of EDHS 2005. EDHS, Ethiopian Demographic and Health Survey.

Gi*) was carried out. The spatial patterns of the dependent variables (access to sanitary facilities) were described using cluster and outlier analysis (Anselin local Moran is I). Since this cluster and outlier analysis allows for the identification of groups and regions where the discrepancies occur, it was used to confirm and accompany the display of extremes (the hotspot and cold spot).[41]

Additionally, Kriging interpolation techniques were employed to visualise and forecast sanitary availability in locations that were not specifically studied. Kriging provided a continuous surface of sanitation access across Ethiopia and generated more precise spatial projections by taking into account both the distance between survey points and the degree of spatial autocorrelation. This allowed us to pinpoint the regions that have experienced the greatest improvements in cleanliness over time as well as those with the lowest coverage.

The authors used a graphical presentation to do temporal trend analysis in order to examine the evolution of sanitation access through time. The combination of trend and spatial studies allowed for a thorough understanding of the regional heterogeneity and temporal evolution of sanitation access in Ethiopia between 2005 and 2019.

RESULTS

Sociodemographic characteristics of the study population

This study includes 13 721 in 2005 EDHS, 16 702 in 2011 EDHS, 16 650 in 2016 EDHS and 8663 participants in 2019 EDHS. The higher percentage of study participants in all EDHS data sets had no education (63.59%, 55.74%, 52.06% and 47.65%, respectively). According to table 1, the majority of participants in the 2005 EDHS, the 2011 EDHS, the 2016 EDHS and the 2019 EDHS—88.30%, 81.68%, 76.98% and 77.10%, respectively, did not own a television (table 1).

Trends of sanitation facilities in Ethiopia

Figure 1 presents that the trend of improved sanitation facilities in Ethiopia was 20.46%, 25.61%, 25.86% and 27.45% based on EDHS 2005, 2011, 2016 and 2019, respectively).

Factors associated with sanitation facilities accessibility

The odds of accessibility to improved sanitation facilities among participants with educational status of primary, secondary and higher were 2.43 (adjusted OR, AOR 2.43, 95% CI 2.00, 2.95), 2.02 (AOR 2.02, 95% CI 1.61, 2.54) and 4.12 (AOR 4.12, 95% CI 3.35, 7.54) times more likely, respectively, compared with those with no education.

Study participants with wealth status of the middle and rich were 1.49 (AOR 1.49, 95% CI 1.21, 1.83), and 3.15 (AOR 3.15, 95% CI 2.55, 3.89) times more likely in the odds of accessing improved sanitation facilities, respectively, compared with those counterparts poor.

The odds of accessing improved sanitation facilities among study participants who watched television were 5.49 (AOR 5.49, 95% CI 4.37, 6.89) more likely compared with counterparts who did not watch television.

Community-level education was a statistically significant predictor variable. The odds of accessing improved

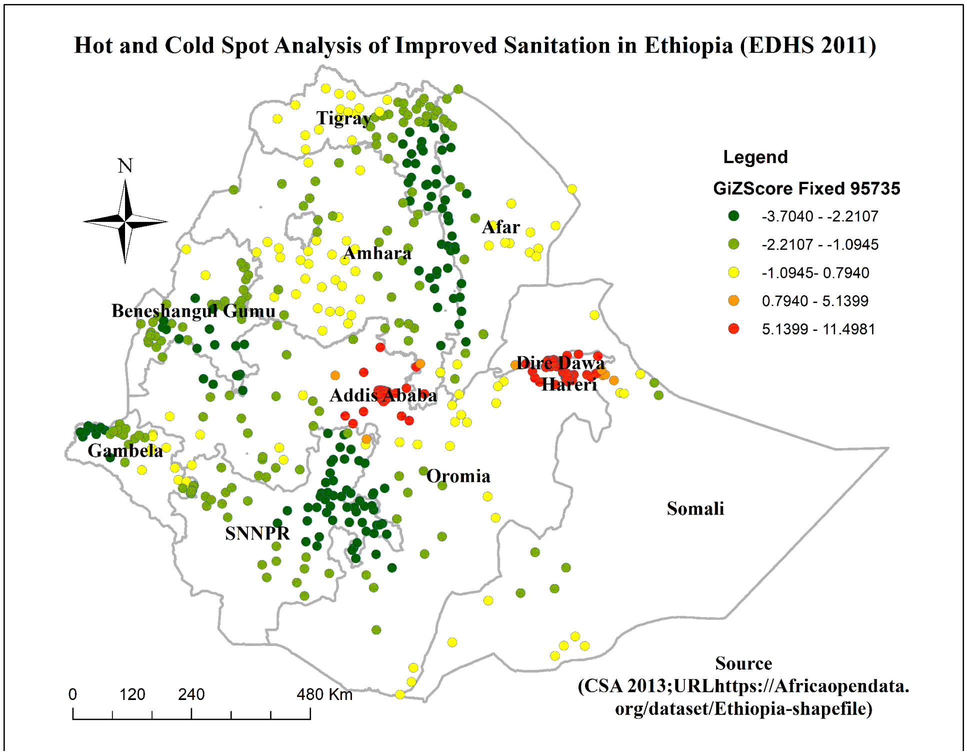

Figure 7 Hot and cold spot analysis of accessibility of improved sanitation facilities in Ethiopia based on the dataset of EDHS 2011. EDHS, Ethiopian Demographic and Health Survey.

sanitation facilities among communities with higher educational levels were 3.90 (AOR 3.90, 95% CI 3.15, 4.82) times more likely compared with the community with lower education.

The chance of accessing improved sanitation facilities among communities exposed to media was 5.61 (AOR 5.61, 95% CI 3.84, 10.09) times more likely than in the community unexposed to the media.

The odds of accessibility-improved sanitation facilities among the study population living in urban areas were 9.08 (AOR 9.08, 95% CI 6.69, 12.33) times more likely compared with the study population living in rural areas.

Communities across various regions, including Tigray (54% less likely, AOR 0.46; 95% CI 0.37, 0.57), Afar (33% less likely, AOR 0.67; 95% CI 0.51, 0.86), Somali (77% less likely, AOR 0.23; 95% CI 0.18, 0.29), Amhara (60% less likely, AOR 0.40; 95% CI 0.32, 0.49), Benishangul Gumuz (37% less likely, AOR 0.63; 95% CI 0.49, 0.80), Gambella (55% less likely, AOR 0.45; 95% CI 0.35, 0.57), Harari (36% less likely, AOR 0.64; 95% CI 0.52, 0.80), SNNRP (72% less likely, AOR 0.28; 95% CI 0.22, 0.34) and Dire Dawa (72% less likely, AOR 0.28; 95% CI 0.22, 0.35), exhibit decreased access to improved sanitation facilities compared with communities in Addis Ababa.

The MOR, PCV and intracluster correlation coefficient were used to illustrate the random changes in cleanliness. According to the null model's ICC, variations through cluster regions accounted for 67.65% of the overall variability in access to improved sanitation services. According to models 1 and 2, individual and community-level characteristics accounted for 59.74% and 26.35% of the PCV of the variation in the communities' access to better sanitation, respectively. If two areas were chosen at random, the MOR between the area with the greatest access to improved sanitary facilities and the region with the least access was 7.07.

Using the lowest AIC, DIC and Deviance values, the model statistics showed a fair fit. Consequently, the best-fit model was validated by the final model's lowest AIC; DIC and Deviance, which were 11 151.08, 11 282.33 and 11 117.0824, respectively (tables 2 and 3).

Analysis of spatial heterogeneity

Spatial autocorrelation (Moran's I)

All EDHSs were clustered in obtaining better sanitation facilities through Ethiopia, according to global Moran's I spatial autocorrelations positive z-scores (with the z-scores of 2005 EDHS 2.374393, 2011 EDHS 7.067996, 2016 EDHS 8.9374285 and 2019 EDHS 36.511348) (figures 2–5).

Hot and cold spot analysis (Getis-Ord Gi*)

All EDHS in Ethiopia showed the same trend in the spatial distribution of improved sanitation facilities, according to hot and cold spot analysis. The percentage of EDHS that had access to improved sanitation was much lower in the majority of the country, according to the numbers below, and it was higher only in Addis Ababa and Dire Dawa (figures 6–9).

SPATIAL INTERPOLATION

The study used spatial Kriging interpolation analysis to determine which parts of the country had less improved

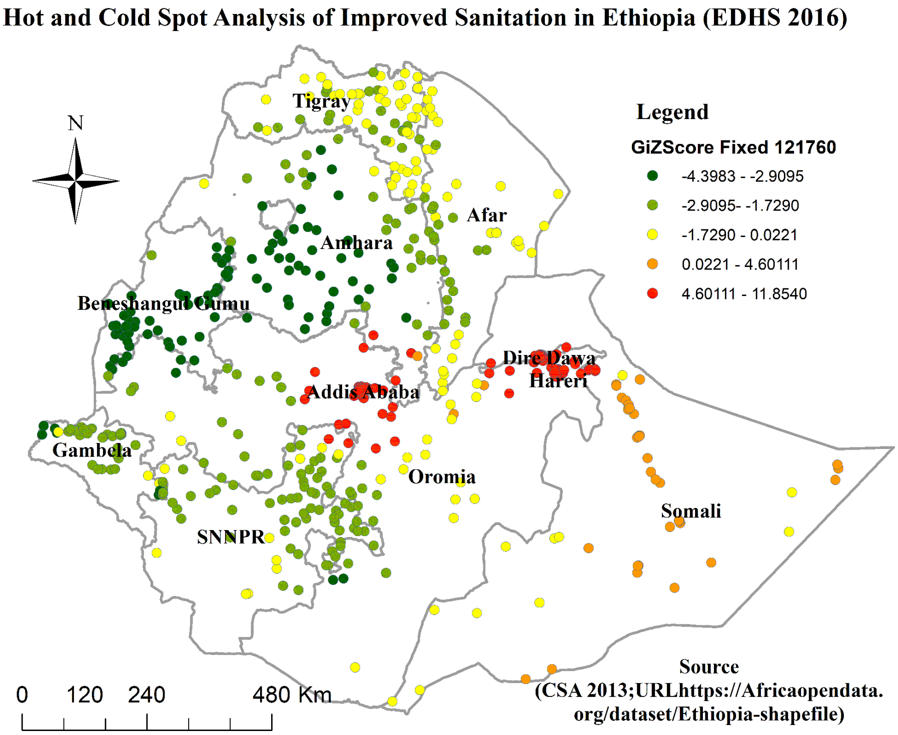

Figure 8 Hot and cold spot analysis of accessibility of improved sanitation facilities in Ethiopia based on the dataset of EDHS 2016. EDHS, Ethiopian Demographic and Health Survey.

sanitation accessibility. As illustrated in the figures below, the red colour denotes areas of the country (Addis Ababa and Dire Dawa) with greater access to improved sanitation facilities, while the green colour (the majority of the country) indicates areas with lower access (figures 10–13).

DISCUSSION

Using multilevel and geographical analysis techniques on Ethiopia's 2005–2019 EDHS datasets, the studies are unique in their thorough investigation of geographical variances and temporal changes in sanitation facilities.

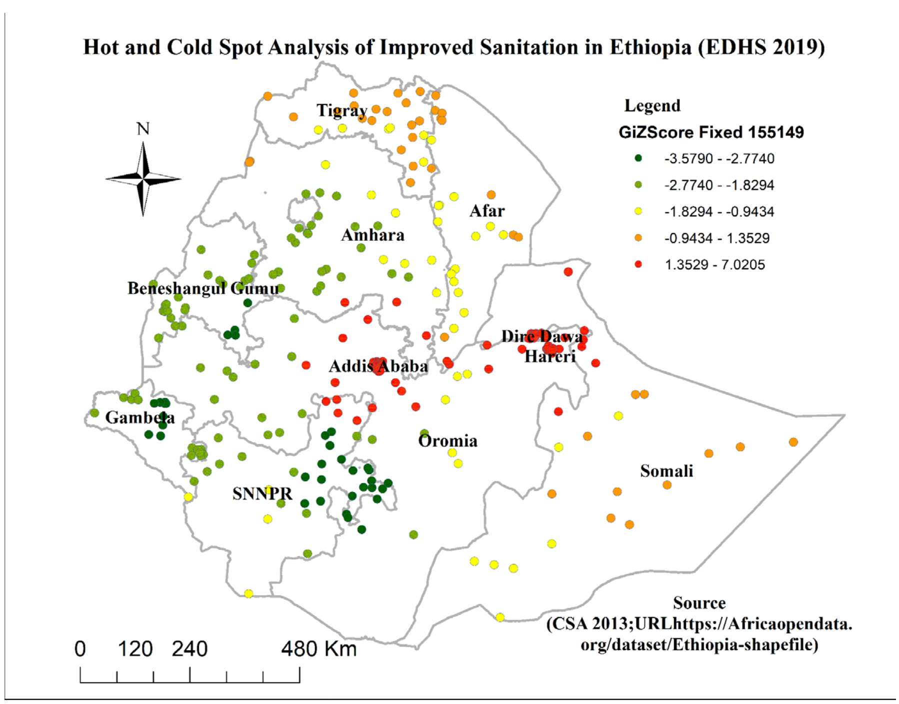

Figure 9 Hot and cold spot analysis of accessibility of improved sanitation facilities in Ethiopia based on the dataset of EDHS 2019. EDHS, Ethiopian Demographic and Health Survey.

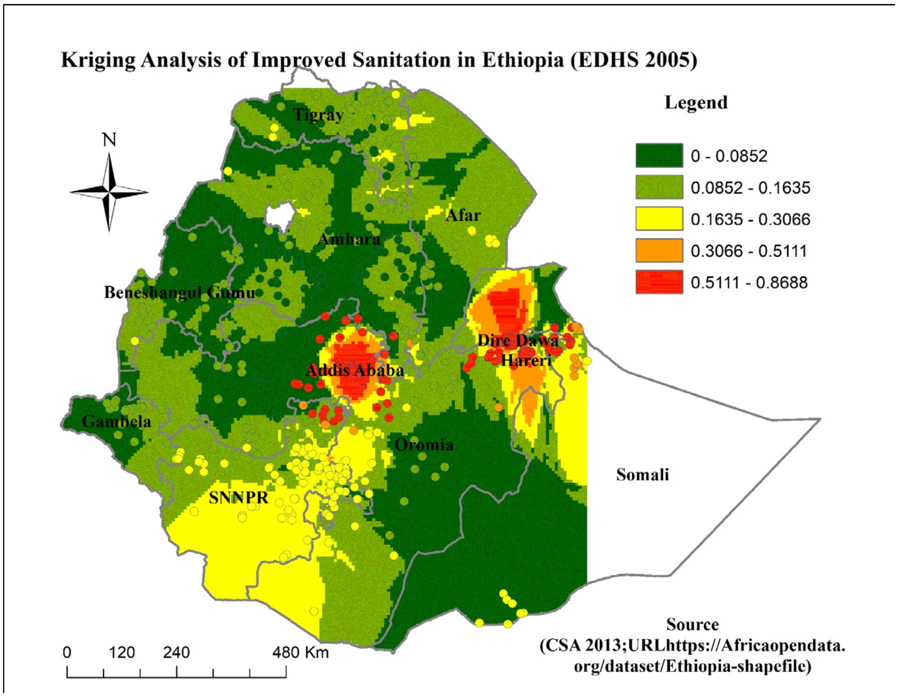

Figure 10 Kriging interpolation analysis result of improved sanitation facilities accessibility in Ethiopia based on EDHS 2005. EDHS, Ethiopian Demographic and Health Survey.

Their thorough investigation into the ways in which access to sanitation infrastructure has changed over time and differed among Ethiopia's many regions has produced a fresh contribution by illuminating hitherto unseen trends and inequalities. In order to reduce inequities and enhance overall sanitation access in Ethiopia, this research highlights locations for focused interventions and offers insightful information about the dynamic nature of sanitation service.

To hygienically isolate human excreta from human touch, which causes many infectious diseases, improved sanitation facilities must be accessible in a sustainable and

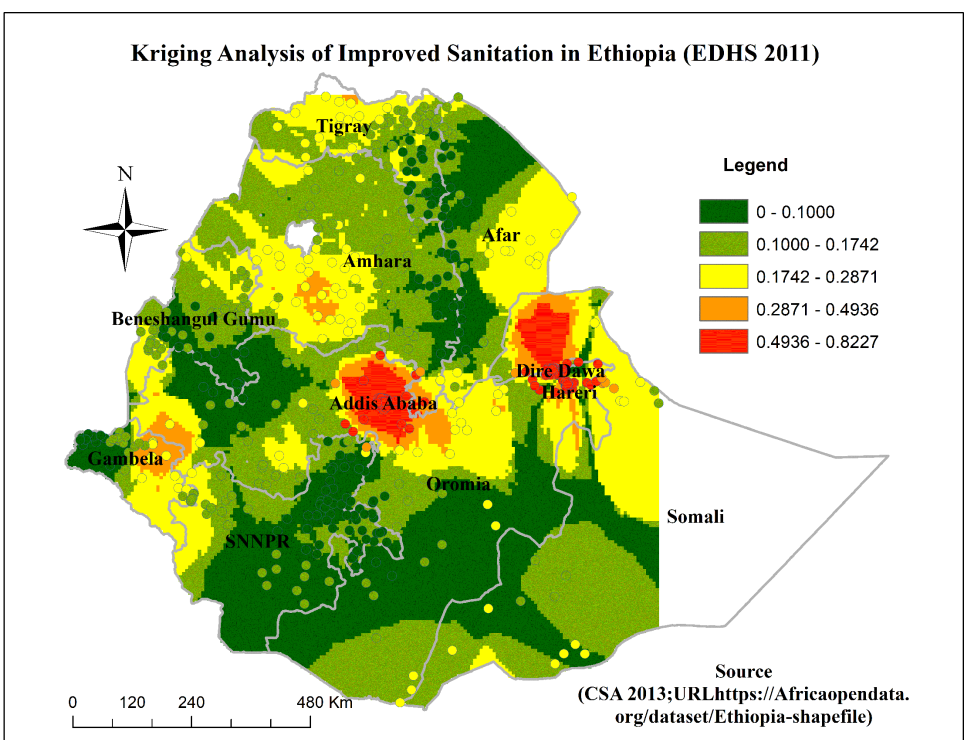

Figure 11 Kriging interpolation analysis result of improved sanitation facilities accessibility in Ethiopia based on EDHS 2011. EDHS, Ethiopian Demographic and Health Survey.

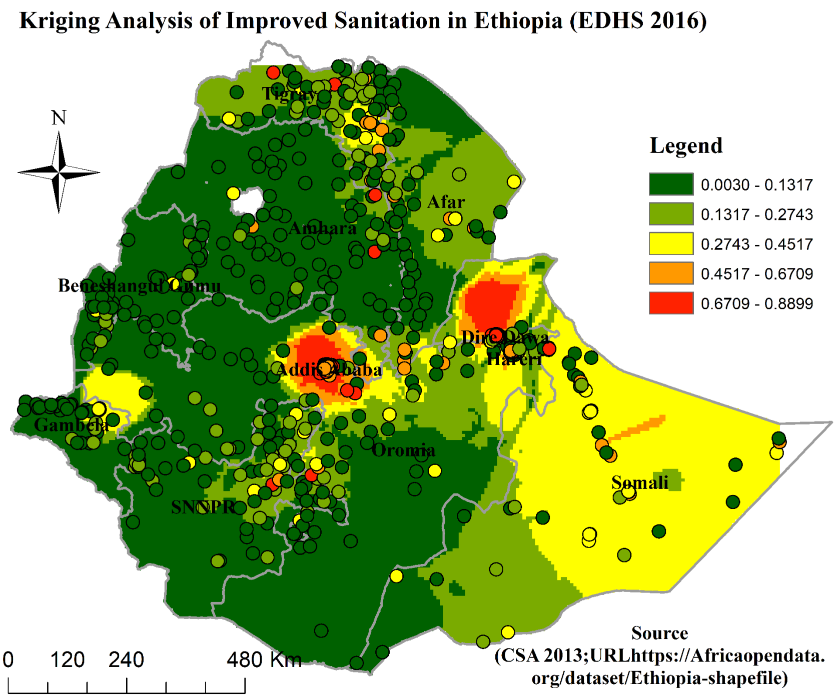

Figure 12 Kriging interpolation analysis result of improved sanitation facilities accessibility in Ethiopia based on EDHS 2016. EDHS, Ethiopian Demographic and Health Survey.

fair manner.[42] This study's primary goal was to examine, using four consecutive EDHS datasets, the spatiotemporal variation and factors linked to improved sanitation facilities that are accessible in Ethiopia. According to these findings, the percentage of households with access to improved sanitation facilities was 20.46% in EDHS 2005, 25.61% in EDHS 2011, 25.86% in EDHS 2016 and 27.45% in EDHS 2019. The rise from 2011 to 2016 was only 0.25%, but the increase from 2005 to 2011 was 5.15%. These results indicate that, between 2005

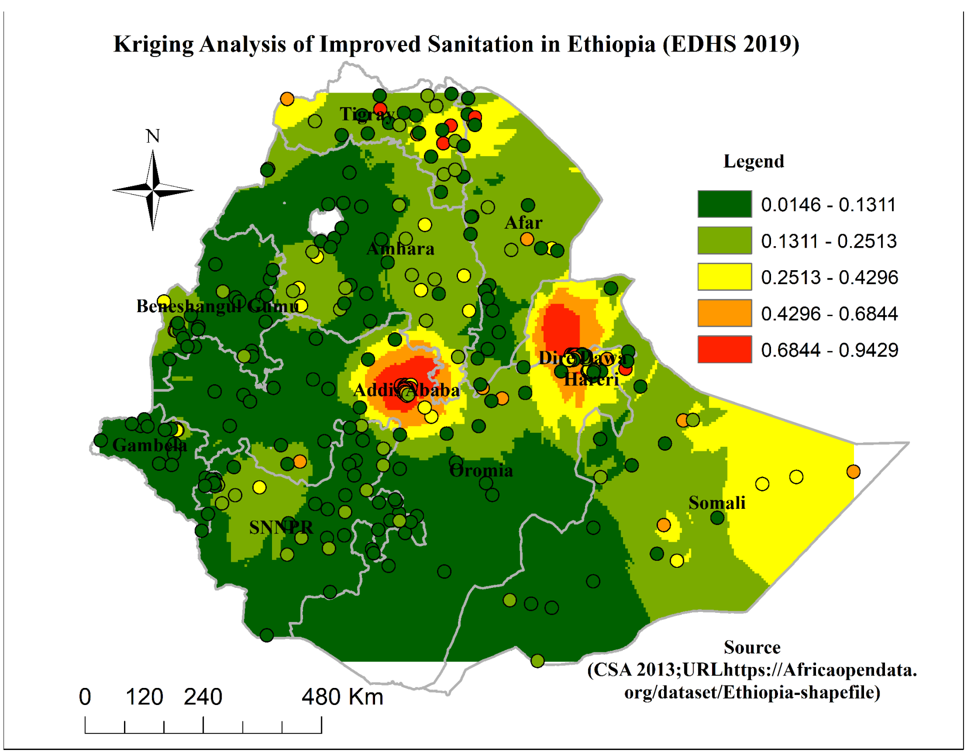

Figure 13 Kriging interpolation analysis result of improved sanitation facilities accessibility in Ethiopia based on EDHS 2019. EDHS, Ethiopian Demographic and Health Survey.

and 2019, Ethiopia's access to better sanitation facilities improved at relatively modest steady rates. This outcome is consistent with other research showing that certain nations have made significant strides toward SDG 6, while others look to be stuck at low levels of sanitation coverage with little or no development.[43] Such setback with little or no development levels of access to improved sanitation facilities is the experience of developing countries including Ethiopia.[44] The construction of sanitation facilities may receive less attention from the government and non-governmental organisations because of international environmental change, poverty and the nation's instability brought on by the trauma of the civil war. This result is in line with previously conducted research conducted globally.[32 45–48]

Based on four EDHS datasets, the geographical analysis's results for Global Moran's autocorrelation, hotspot, cluster and Kriging revealed significant differences in Ethiopia's access to better sanitation services. Among other regions of the nation, Addis Ababa and Dire Dawa were identified as high hot spots for improved sanitation facilities based on the findings of the Kriging analysis and hot spot analysis conducted in all EDHS. This result demonstrated that access to better sanitation facilities varies significantly by region across the nation. It ran counter to aim 6.2 of the 2030 SDGs, which is to 'end OD and provide access to adequate and equitable sanitation for all'.[49] This variation could be the difference in economic growth, overpopulation growth, unplanned urbanisation and inaccessibility of infrastructure, government overload towards other burning daily tasks, sociopolitical instability, awareness and adaptability towards sanitation facilities.

The household head's educational level, television ownership and wealth index were individual-level predictors linked to access to better sanitation facilities, while community-level predictor variables included education, media exposure, residence type and region.

Household heads with higher levels of education were more likely to have access to better sanitary facilities than heads with lower levels of education. Ethiopia, Kenya, West and Central Africa, Bangladesh, Benin and Vietnam have all conducted research that corroborates this conclusion.[50–53] The community with higher education accessed improved sanitation facilities than part of the community with lower education. This finding was in line with other previous studies conducted in different parts of the world.[23 54 55] Other possible explanation for this discrepancy is that more people who are educated may be aware of the link between better sanitary facilities and health. If so, compared with household heads with lower educational backgrounds, they are excited to have these sanitation services.

Access to better sanitary facilities was correlated with wealth status in a proportionate manner. Compared with the poorest homes, wealthy and middle-class households were more likely to have access to better sanitary facilities. The research conducted in Ghana, Benin, Vietnam and Eswatini supports this conclusion.[51 56–58] This discrepancy may result from the development of better sanitation facilities like septic tanks and pour-flush toilets; the impoverished may find it difficult to afford slab pit latrines and composting toilets.

When all other factors were held constant, families with television had a higher chance of having access to better sanitary facilities than those without. This may be because residents spend a lot of time watching television, which serves as a visual information source about topics like how better cleanliness can prevent the spread of disease. The other statistically significant predictor of access to better sanitation facilities at the community level was media exposure. In Ethiopia, householders who were exposed to community-level media—whether it was radio, television or both—were more likely to have access to better sanitation. This result was consistent with earlier research carried out in Ethiopia[22 23] and SSA.[59]

Compared with households in rural areas, urban households are more likely to have access to better sanitation services. A prior Ethiopian study that showed Ethiopia's rural communities are severely trailing behind in the battle to achieve SDGs supported this issue 6.2[43] and the other study done in Vietnam.[56] Different amounts of improved sanitation facilities were available to households located in different parts of Ethiopia. Addis Ababa, the capital, was better than the other parts of the country. This finding is aligns with the studies done in Kenya,[60] Nepal[61] and WHO, UNICEF, 2019 report[62] which indicated that persist disparities in access to WASH services in rural versus urban settings. This discrepancy could be explained by the fact that Addis Ababa serves as both the nation's capital and the headquarters of the African Union, providing access to better infrastructure, including sanitary facilities. Low socioeconomic position, regional sociopolitical instability, ignorance and a lack of ability to adjust to sanitary facilities could all be contributing factors.[63]

The self-report nature of data collection, which leads to interviewer bias, social acceptability bias, recall bias and incompleteness of the recent mini demographic health survey (EDHS 2019), could be potential sources of errors and the limitations of this study.

CONCLUSION

According to the study's general findings, Ethiopia's access to sanitary facilities has gradually increased over time. Additionally, there was geographical variation in the country's accessibility of improved sanitation facilities that was statistically significant. To achieve the suggested goal, the rate of advancement in universal access to sanitary facilities (SDG 6.2) in 2030 should be accelerated. The following parameters were statistically linked to the accessibility of sanitation facilities in Ethiopia: region, type of habitation, wealth index, community-level education, community-level media exposure, educational status and television viewing. This study recommended that local and international organisations focus on solutions that allow for the advancement of universal access to sanitary facilities, particularly in developing nations.

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