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Research Article

Assessing the Effects of Anthropogenic Land Use on Soil Infiltration Rate in a Tropical West African Watershed (Ouriyori, Benin)

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Soil infiltration at a watershed scale is important for understanding and predicting the hydrological process in soil-water-plant systems. This study investigated the effects of land use (LU) conversion on the infiltration rate in the Ouriyori watershed. To that end, in situ infiltration was carried out over the watershed under thirty-six pairs of adjacent cropland-fallow plots using the hood infiltrometer. Saturated hydraulic conductivity (K_s), soil properties, and soil classes were further compared. Results showed a high variability of K_s following the LU classes with a coefficient of variation greater than 60%. After data log transformation, the mean values of K_s showed high infiltration and ranged between 2.59 and 2.42 cm d^{-1}, respectively, for fallow land and cropland. Thus, K_s was relatively lower in cropland compared to fallow land. Hence, the low infiltration recorded in croplands indicated the degradative impacts of unceasing tillage operations for crop production without crop residue incorporation into the soil during tillage. There was no significant difference in bulk density and soil texture in both types of land use. Considering soil classes, the highest infiltration rate was found in *Ferric Luvisol* and the lowest rate in *Dystric Gleysol*, meaning that the high infiltration observed in *Ferric Luvisol* was due to the abundance of soil macropores. Change in natural vegetation to croplands induced a low infiltration rate and macropore connectivity. Moreover, fallow lands tend to provide water storage capacity through the improvement of mesopores, while soil compaction through agricultural activities reduces soil porosity and therefore soil infiltration. In addition, the paired Student's *t*-test performed on the transformed data was statistically significant, indicating a difference between K_s under cropland and K_s under fallow land. To improve soil and water conservation for crop production as well as for sustainable rural populations' livelihoods in the watershed, occasional fallowing may be observed to dampen infiltration hindering soil surface conditions.

1. Introduction

In West Africa, since the 1990s, there have been extensive land use changes (LUC) and intensification of climate change [1]. Additionally, the rapid population growth has led to the expansion of croplands due to the need to grow more food to meet the rising food demand of the burgeoning population [2]. LUC is known to be the most important factor of human-induced alteration of the land and environment. This alteration includes agriculture and urbanization [3]. Dewan et al. [4] indicated that LUC is an important indicator of the interaction between anthropogenic activities and the environment. According to Schaldach [5], changes in LU will increase due to the increasing demand for land and energy to cover the needs of the growing population. Hence, LUC analysis calls the attention of scientists, environmentalists, agronomists, water resources managers, and policymakers [6].

In the last decades, Benin experienced an increase in human population of about 54% from 2000 (6.7 million) to 2015 (10.6 million) [7]. A recent study of land use/land cover change in Benin indicated a rapid increase in agricultural lands with a considerable decrease in savanna land from 2001 to 2013 [8].

Focusing on water-related ecosystem services provided to populations, LUC at watershed level may impact soil properties such as soil structures and soil water capacity due to changes in soil pores, including the crop water availability. Several studies on land use reported that soil infiltration rate can be considered as good indicator of soil quality [9, 10]. Additionally, hydraulic conductivity, an indicator of soil infiltration, has a key role in the repartitioning of precipitation into infiltration and surface runoff. LUC is considered one of the main factors influencing soil infiltration in soil and can lead to changes in soil hydraulic properties. Other factors that could modify the soil infiltration are soil structure, texture, and slope [11, 12]. Heterogeneity of these factors across the watershed will therefore lead to a variation in soil infiltration.

Previous studies have also addressed the variation of infiltration in soil types [13, 14], soil textures [15, 16], agricultural practices [17, 18], and land uses (e.g., [19, 20]). For example, Pirastru et al. [13] quantified the soil hydraulic conductivity due to the conversion of forest/natural conversion to grassland using an approach based on the comparison of adjacent forest-grass lands. Some studies considered the effect of dominant factors (e.g., soil type, topography, soil texture, and soil local heterogeneity) on soil hydraulic properties with regard to impact assessment of agricultural management options and soil hydraulic conductivity [17–24]. Among the different methods used to assess the saturated hydraulic conductivity, despite the error factors related to the soil sampling and its transportation, the laboratory method seems to be more reliable due to the controlled environment of the analyses. Differently, in situ measurement applies approximations and assumptions that can cause some bias in the measured values [17]. However, as mentioned by previous studies above, the variation in soil hydraulic conductivity depends not only on the conversion of LU but also on the associated land management practices (e.g., soil type, cropping calendar, soil texture, and soil water conditions).

In Northern Benin, LU conversion in the Ouriyori watershed (study area) showed an increase in cropland and fallow land about 42%, while grass savanna decreased up to 13% from 1988 to 2016 [25]. This indicated the expansion of agricultural areas due to the progressive replacement of natural vegetation by croplands. Moreover, very limited field investigations on hydrological processes have been done using comparative assessment of soil infiltration in an anthropized watershed of Ouriyori. To better address the water availability for both agricultural production and household water supply, the present study aims (i) to assess the saturated hydraulic conductivity, at plot scale, under two LU (cropland and fallow land/natural vegetation) considering soil properties and (ii) to evaluate the potential effects of LU change on soil water dynamics in the Ouriyori watershed.

2. Materials and Methods

2.1. Description of the Study Area. The Ouriyori watershed, with an area about 15 km^2, is located in the North-West of Benin, between latitudes 10°44′12″N and 10°55′48″N and longitudes 1°01′30″W and 1°14′30″W (Figure 1). The watershed is characterized by a hillslope drained by a tributary of the *Pendjari* River. The average slope of the watershed is about 4%, and the mean annual minimum and maximum temperatures are 18°C and 40°C, respectively. The mean annual precipitation is 980 mm (last 15 years) with one rainy season from May to October and a dry season from November to April. The study area is mainly covered by cropland and fallow land. The major crops are maize (*Zea mays*), sorghum (*Sorghum vulgare*), millet (*Panicum miliaceum*), groundnut (*Arachis hypogea*), bambara groundnut (*Vigna subterranea*), cowpea (*Vigna unguiculata*), groundnut (*Arachis hypogaea*), rice (*Oryza sativa*), and cotton (*Gossypium hirsutum*). More than two-thirds of the study area is under rainfed agriculture. Hydromorphic soil and tropical ferruginous soils with the dominant presence of *Dystric Plinthosol* (70% of the area) are the major soil classes of the watershed [26].

2.2. Experimental Procedure for Soil Infiltration Measurement and Data Analysis

2.2.1. Sampling Method. Infiltration tests over the Ouriyori watershed were performed on two types of land use, crop and fallow lands (Figure 2). The land qualities were selected in such a way that adjacent crop and fallow lands were 0–3 m apart with three replications. Care was taken as much as possible so as not to disturb the soil heterogeneity. In addition, selected lands matched identical slope, soil type, and climatic conditions. A total of 36 plots of crop and fallow lands, respectively, were used in this paper.

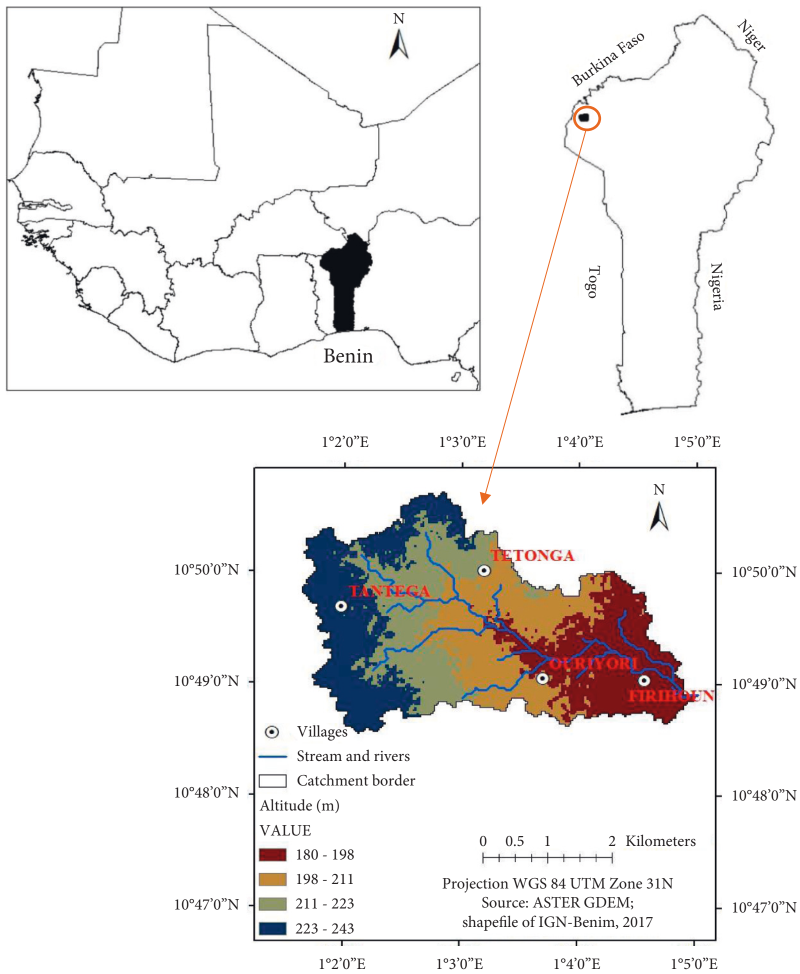


Figure 1: Location of the Ouriyori watershed.

2.2.2. Measurement Method. Saturated hydraulic conductivity was determined by the soil saturated hydraulic conductivity at saturation for the subsoil (0–30 cm) using the hood infiltrometer (Figure 3). Instead of the laboratory method, the in situ method was chosen to consider the heterogeneity of land use change across the watershed. The hood infiltrometer has been used worldwide to understand the variation of K_s under land use change (LUC) [18, 27–30]. The principle involved placing the circular hood connected to a Mariotte device within a retaining ring on the soil surface after cutting down to approximately 0.5 cm (5 mm) or removing the litter layer or vegetation cover for a direct contact with the infiltration surface. Infiltration data was then collected at sampling points and chosen tension following the technical procedure of Schwärzel et al. [29]. More details on the hood infiltrometer test procedure can be found in the UGT, IL-2700 hood infiltrometer manual [31].

To ensure the accuracy of the measurements, for each plot, infiltration measurements were repeated three times per year (from 2013 to 2017) for each LU following similar steps by Schwärzel et al. [29]. A total of 36 plots were explored for cropland and related 36 counterparts of the fallow areas with 3 replications. Thus, a total of 216 measurements were taken per year. The hydraulic conductivity, K_s, was then computed as the geometric average of the three experiments for each plot. The measurements were conducted during the rainy season corresponding to the crop development stage, that is, crops midseason stages (6 to 8 weeks after ploughing). The infiltration was then recorded, and analyses of the experiments were performed following the procedure of wooding [32]. Due to the unavailability of historical soil infiltration data, the measurements did not link directly the historical changes in land use with respect to soil infiltration, but they considered the antecedent dynamics of land use on current water infiltration rate.

For the determination of initial and final soil moisture content, soil core samples were collected before and after each infiltration. Moreover, to determine the gravimetric soil moisture, soil samples were weighed before and after the oven-drying process at a temperature of 105°C. The gravimetric soil moisture obtained was then multiplied by the bulk density of the soil to convert it to volumetric soil moisture. Among the soil moisture measuring devices, the hood infiltrometer provides more accurate results by limiting the disturbance in soil structure. Additionally, field capacity (at pF 2.5) and permanent wilting point (at 4.2) for soil classes were determined. Available water content and conductivity properties were derived from the pedotransfer

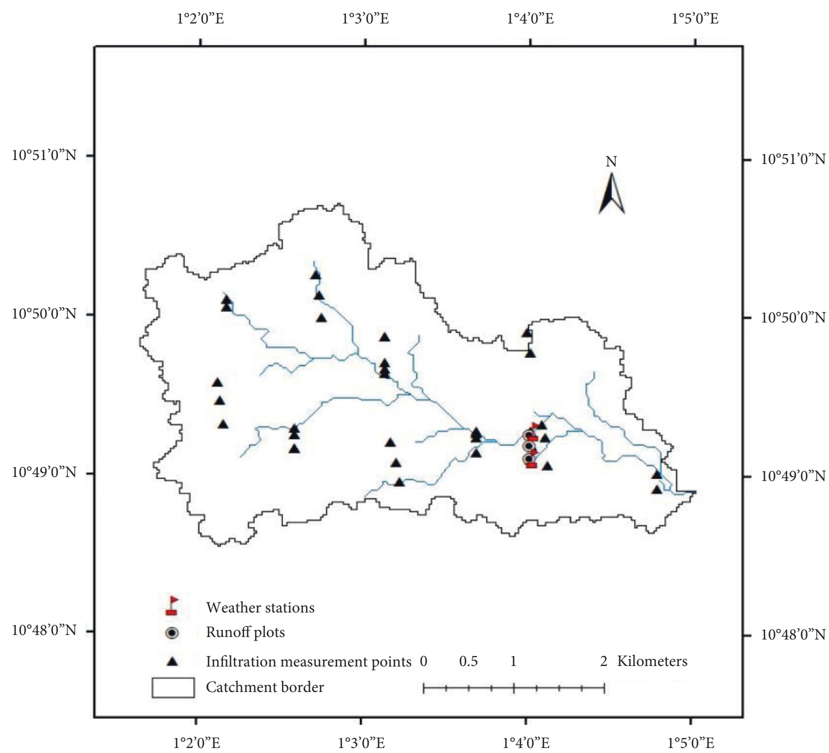


Figure 2: Infiltration measurement points in the watershed (each point represents both cropland and fallow land).

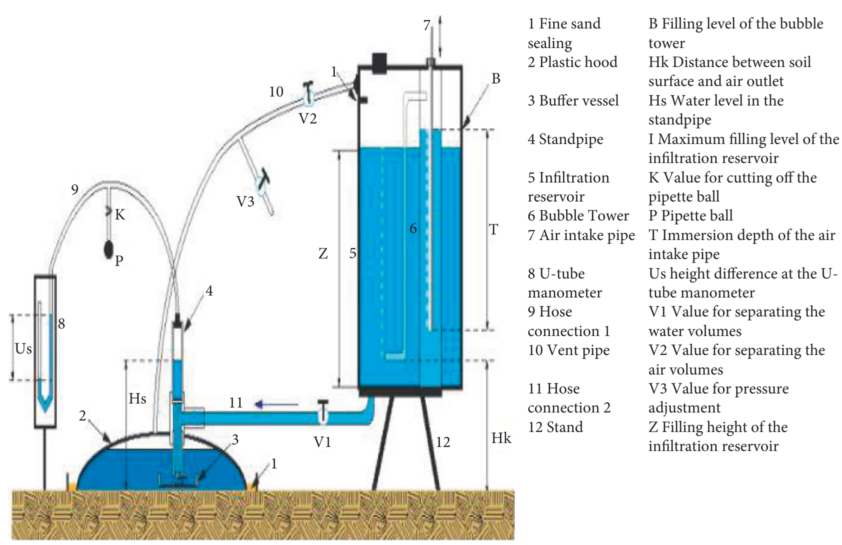


Figure 3: Hood infiltrometer [31].

functions such as van Genuchten model [33] and SPAW hydrology model [34]. Fine root density of both types of land use was collected randomly in measurement plots using soil core samplers. Moreover, after oven-dried for 24 h at 70°C, the fine roots were weighted, and the density was computed by dividing its mass by core volume.

2.2.3. Theoretical Principles of Hydraulic Conductivity. The hydraulic conductivities K_h and K_s can be described as a function of water tension using the following equation of Gardner [35]:

$$K_h = K_s \exp^{(\alpha . h)}, \quad (1)$$

where K_s (L T^{-1}, e.g., cm min^{-1}) is the saturated hydraulic conductivity, α (L^{-1}) is the inverse capillary length scale, an empirical fitting parameter, and h (L^{-1}) is the water tension in the soil or the hydraulic pressure head.

According to Wooding [32], under the steady-state flow, Q from a circular infiltration area with radius r into the infinite soil is given by the following equation:

$$Qho = \pi r^2 Ks \ \exp(\alpha ho)\left(1 + \frac{4}{(\pi r \alpha)}\right), \quad (2)$$

where Qho ($L^3\ T^{-1}$, e.g., $cm^3\ min^{-1}$) is the steady-state infiltration rate under a given supply potential h_o (L) and r (L) is the radius of the circular infiltration surface.

For the experimental determination of K_s and α above, the infiltration test can be run at fixed water tensions (hydraulic pressure heads) with different disc radii or at a fixed disc radius for different water tensions [36]. The latter option was chosen for this study. For the infiltration test at different water tensions and fixed disc radius up to the bubble point, the chosen water tensions (h_1; h_2) were applied (equations (3)–(6)):

$$\frac{Q_1}{\pi r^2} = Ks \exp(\alpha h_1)\left(1 + \frac{4}{(\pi r \alpha)}\right), \quad (3)$$

$$\frac{Q_2}{\pi r^2} = K_s \exp(\alpha h_2)\left(1 + \frac{4}{(\pi r \alpha)}\right). \quad (4)$$

Then, by the way of division, α can be derived as follows:

$$\alpha = \frac{\ln(Q_1/Q_2)}{(h_1 - h_2)}. \quad (5)$$

And finally, the hydraulic conductivity for h_1 is given by the following equation:

$$K(h_1) = \frac{(Q_1/\pi r^2)}{1 + (4/\pi \alpha r)}. \quad (6)$$

During the soil infiltration measurement, soil samples were taken for laboratory analyses. Undisturbed soil (1–10 cm depth) and disturbed topsoil were collected following the UGT procedure. The bulk density was determined using the ordinary oven-drying method, soil texture by a combination of wet sieving for sand and sedimentation for silt and clay. The infiltration measurement was also performed in the different soil classes of the watershed.

2.2.4. Data Analysis. Soil hydraulic conductivity was transformed into normal distribution before conducting statistical analysis. The infiltration test compares a paired sample of two land uses. To conduct variance analysis, the Shapiro–Wilk test for normality was performed to determine whether or not the infiltration data were normally distributed. A paired two-tailed Student's t-test was performed on the normally distributed data set to test the statistical difference of K_s and other variables between cropland and fallow land. Descriptive statistics tests were performed to determine the means, median, coefficient of variation, and standard deviation of K_s. All data were analysed using XLSTAT software.

3. Results

3.1. Soil Infiltration Rate in Land Uses. Due to the non-normality of the saturated hydraulic conductivity data based on the Shapiro–Wilk statistical test, the K_s variables were transformed following log transformation. Results showed a normal distribution for Log K_s data (Figures 4 and 5). The same results were reported in previous studies where data transformation was needed for further statistical analysis [27, 28, 31, 32, 37–39]. The descriptive statistical analysis performed for this study showed that the infiltration rate (raw data) ranged from 50.47 $cm\ d^{-1}$ to 989.76 $cm\ d^{-1}$ under cropland and 94.86 $cm\ d^{-1}$ to 1527.47 $cm\ d^{-1}$ under fallow land. The non-normal distribution of the raw data is confirmed by the skewness, kurtosis, Z values, and p value of the Shapiro–Wilk test. This explains the relatively high values of the coefficient of variation (CV) of K_s under both types of LU (64.66% for cropland and 68.69% for fallow land) following SCS [40]. However, the CV of the transformed data showed a relatively low value under both types of LU (11.40% for cropland and 10.69% for fallow land) compared to the raw data and the p value of the Shapiro–Wilk test, which indicated the normal distribution of the Log K_s data. Furthermore, the paired Student's t-test performed on the transformed data was statistically significant indicating a difference between K_s under cropland and K_s under fallow land (p value = 0.113) at 95% confidence interval (Table 1).

Both values of K_s in LU indicated single K_s ranging from very low to very high values (Figure 6). Results of soil bulk density (BD) indicated that the mean values of bulk density were $0.67 \pm 0.009\ g\ cm^{-1}$ and $0.66 \pm 0.009\ g\ cm^{-1}$, respectively, for cropland and fallow land. Moreover, BD values in topsoils were found low in both types of land use. Similarly, the mean values of soil porosity for cropland and fallow land were $22.22\% \pm 1.27$ and $24.02\% \pm 1.91$, respectively. Moreover, the coefficient of variation of porosity in fallow land (7.94%) is higher than that in cropland (5.69%).

Water flow into soil is influenced by the structure and texture of a particular soil. The rate of water circulation into soil depends, among other factors, on the pore spaces in the soil. Hence, further comparison is performed between land uses and soil porosity. Results showed a correlation between land use and soil porosity with high porosity values of soil in fallow land compared to cropland (Figure 7). Soil porosity values ranged from 20 to 27%. This indicates that the wider the pores in the soil, the more the infiltration rate.

As soil infiltration is also related to soil moisture conditions, an analysis of soil moisture recorded (year 2016) under both types of land use indicated high values in fallow lands compared to cropland areas (Figure 8). However, soil moisture was found to be low with values ranging between 0.04 and 0.18 vol/vol. High values were obtained in the rainy season and low values in the dry season.

3.2. Soil Infiltration in Soil Classes. Many factors other than the soil class and topography of the terrain may explain the variation of K_s in fallow land. The structure of the soil (coarse state) in the watershed, the variation within the crop development stage, and ploughing in the cropland may also explain the high variation of K_s under cropland areas. Results of K_s in top layers of soil classes in the watershed indicated higher values with K_s in *Ferric Luvisol* than those in *Dystric Gleysol* and *Gleyic Alisol* (Figure 9). Furthermore, soil with high coarse particles (*Ferric Luvisol* and *Dystric Plinthosol*) was found to have the highest porosity values (Table 2). This study did not link directly the historical

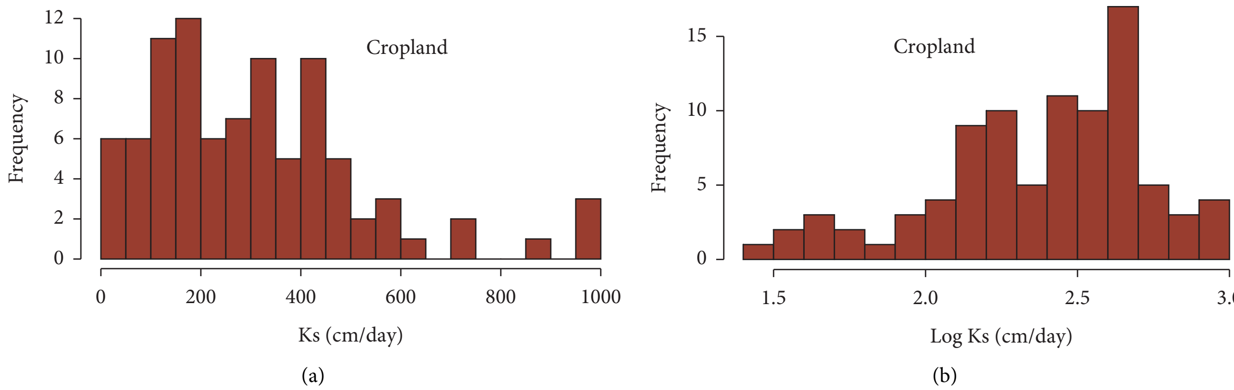


Figure 4: Histograms of K_s (a) and Log K_s (b) under cropland.

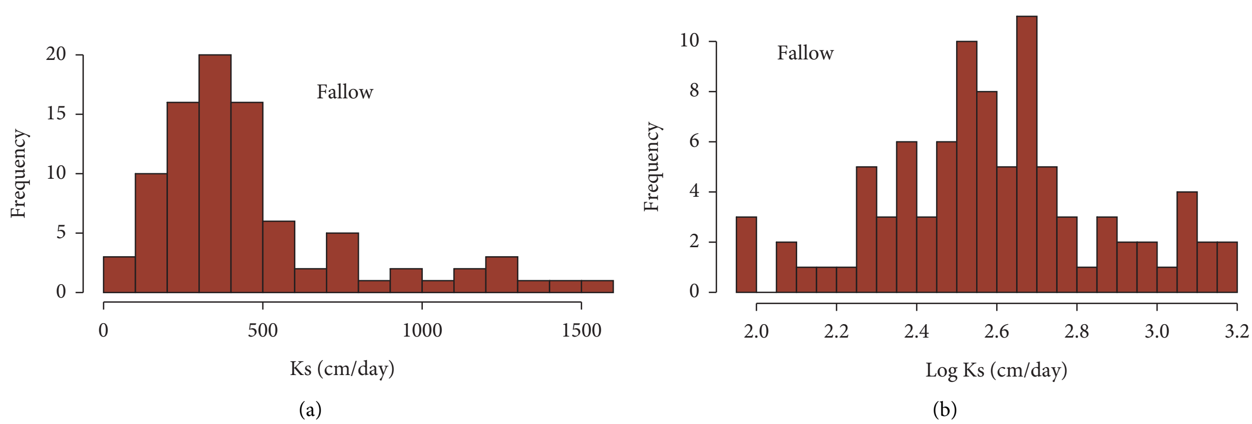


Figure 5: Histograms of K_s (a) and Log K_s (b) under fallow land.

Table 1: Paired t-test for K_s in cropland and K_s in fallows.

	n	Mean	STD	SE mean
Fallow_K_s	90	473.5	325.3	34.3
Cropland_K_s	90	365.9	559.6	59
Difference	90	107.6	638.5	67.3

STD and SE stand for standard deviation and standard error, respectively.

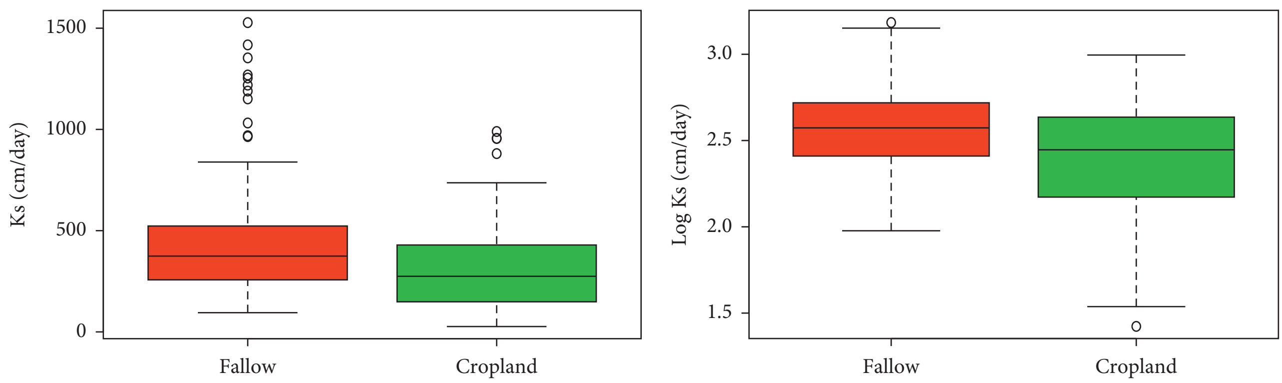
changes in land use on soil infiltration, but it considered the previous changes in LU on current water infiltration rate. The basic properties of investigated soils are presented in Table 2.

3.3. Soil Water Retention. Parameters of soil water retention were obtained from lab measurements and the pedotransfer functions of van Genuchten [33] and Saxton and Willey [34]. Considering the field capacity and the available water capacity for plants, a few differences were depicted in terms of soil water limits (Table 3). Moreover, soil water content in topsoils is not much different from those in subsoils. This trend is also observed in plant available water capacity. In addition, K_s in *Dystric Gleysol* depicted the lowest values as available water capacity for plants decreases. Hence, this decrease indicated that less pore spaces were filled with water (Table 3). In addition, available water capacity for plants in *Ferric Luvisol* showed high values indicating thereby high hydraulic conductivity (Table 3; Figure 9).

4. Discussion

4.1. Soil Infiltration and Land Use. Conversion of natural vegetation to agricultural land has increased in the watershed over time. The significant decrease in vegetation is due to the expansion of agricultural areas and demographic pressures. Projection of future LU over the region shows the increase in agricultural land, while savanna and forest areas will decrease strongly [41]. It has been observed that, in the northern part of Benin, LUC has mainly affected land in terms of degradation and thereby increased soil erosion and loss of soil fertility [42]. Stream sedimentation and water contamination observed in the watershed may also be due to intensive vegetation clearing over the watershed.

The dispersion of K_s under cropland can be related to the difference within crop types according to the findings of Yira [27] who investigated the infiltration under cropland and fallow/natural vegetation in semiarid watershed of Dano and revealed that the difference in crop species and cropping calendar had an effect on the soil infiltration. The major crops cultivated in the croplands investigated during the soil infiltration measurement were maize, sorghum, millet, beans, rice, groundnut, and cotton. All these were not at the



(a) (b)

Figure 6: Boxplots of K_s (a) and Log K_s (b) in cropland and fallow land.

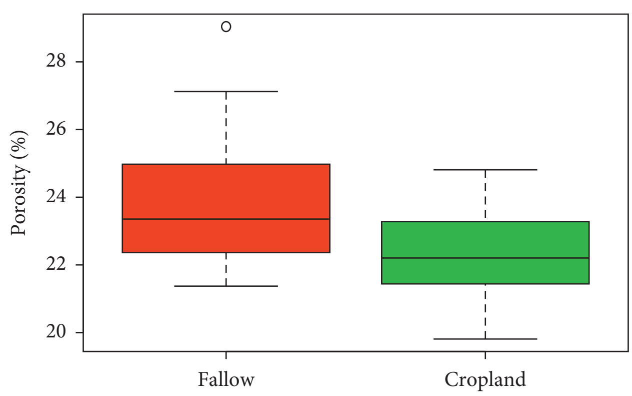


Figure 7: Soil porosity under cropland and fallow land.

same stage of development due to their different cropping calendar. Several authors highlighted the good relationship between crop development stage as a factor of soil hydraulic variation, and this may probably explain the variation of K_s across cropland. Dossou-yovo et al. [43] showed the effect of soil hydraulic conditions on the rate of development and the yield of crops in the same area. The findings of his study underlined the fact that the hydraulic conductivity of soil increases after tillage. Tillage is known to have a transient effect on K_s. Yira [27] found that the variation of K_s in cropland can be explained by agricultural practices and the ploughing system (e.g., hoeing, shovelling, and mechanization) in croplands and thereby the modification of the soil structure during the cropping period. Osunbitan et al. [44] showed that eight weeks after tillage in cropland, K_s could decrease more than K_s under LU without tillage system. Additionally, the coarse state of the soil in the watershed, the variation within the crop development stage, and the ploughing in the cropland may explain the high disparity in K_s under cropland areas. Many other factors apart from soil class and topography of the terrain may also explain the variation of K_s in fallow lands. Among those factors, the fallowing practice as stated by Yira [27] led to the development of the diversity of plant species in the fallow land. Moreover, the fallow lands in the Ouriyori watershed are mainly bush-fallow and bare land. The difference of K_s within the fallow land was related to the age of the fallow land investigated (from 1 year to 11 years). This difference in age can increase the porosity of the soil depending on the period of fallowing as highlighted by Miranda et al. [45]. All these observations may explain the wide variation of K_s within the fallow land.

Soil moisture recorded under cropland and fallow lands showed high values of K_s in fallow lands compared to cropland areas. These low values of K_s in cropland can be explained by the continuous tillage operation before planting. Thereby, the degree of loosening affects therefore the soil physical properties (e.g., bulk density, infiltration, and water retention in soil) and water redistribution within the soil profile [44].

4.2. Soil Infiltration and Soil Classes. These results give support to previous studies on LU impact on soil hydraulic properties [27, 46]. In addition, Shabtai et al. [20] compared the LU effect on the structure and hydraulic properties of *Vertisols* and concluded that the conversion of natural vegetation to cropland with tillage operations had destabilized the soil structure in cropland due to an increase of swelling force leading to a decrease in K_s values. Thus, K_s values under cultivated soils are significantly low. With reference to the soil properties in the watershed, K_s was high in *Ferric Luvisol* and low in *Dystric Gleysol* and *Gleyic Alisol* with the mean values ranging from 498 cm d^{-1} to 193 cm d^{-1}. This may be due to the soil macropores such as plant roots and soil biological activity. Macropores are formed by the rearrangement of the soil based on the biological activities of microfauna such as termites, earthworms, and ants under vegetation. Moreover, macroporosity was low under tillage compared to fallow/natural vegetation or no-tillage area due to the abundance of termites and earthworms under natural vegetation or fallow lands compared to cropland area in the watershed. This corroborates the findings of Cameira et al. [47] who reported larger macroporosity under fallow lands in agricultural areas. This provides evidence that tillage could have increased the macropores in topsoil along with long-term regular ploughing and soil compaction [48, 49]. This could be also one of the reasons of low saturated

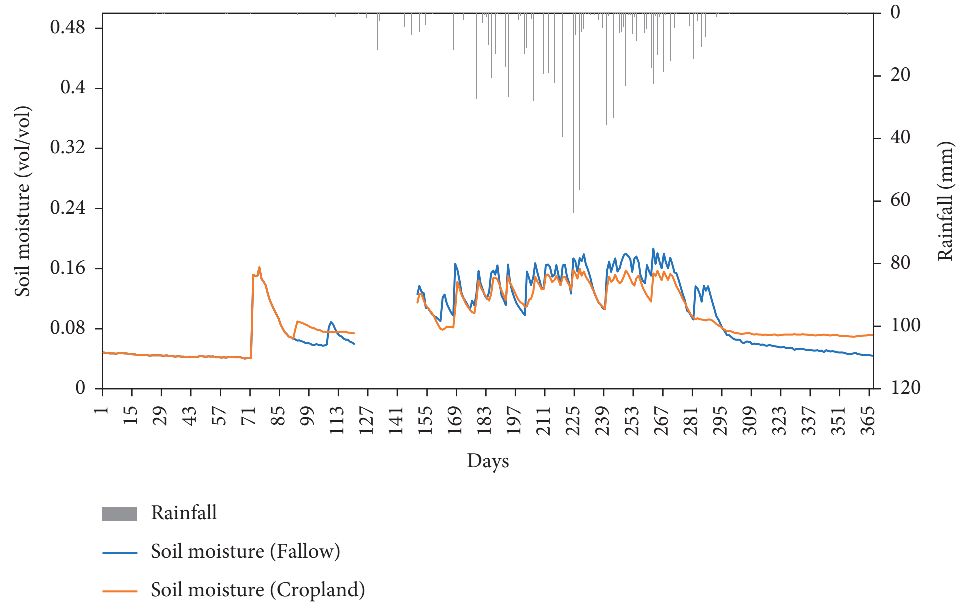


Figure 8: Soil moisture recorded under cropland and fallow land.

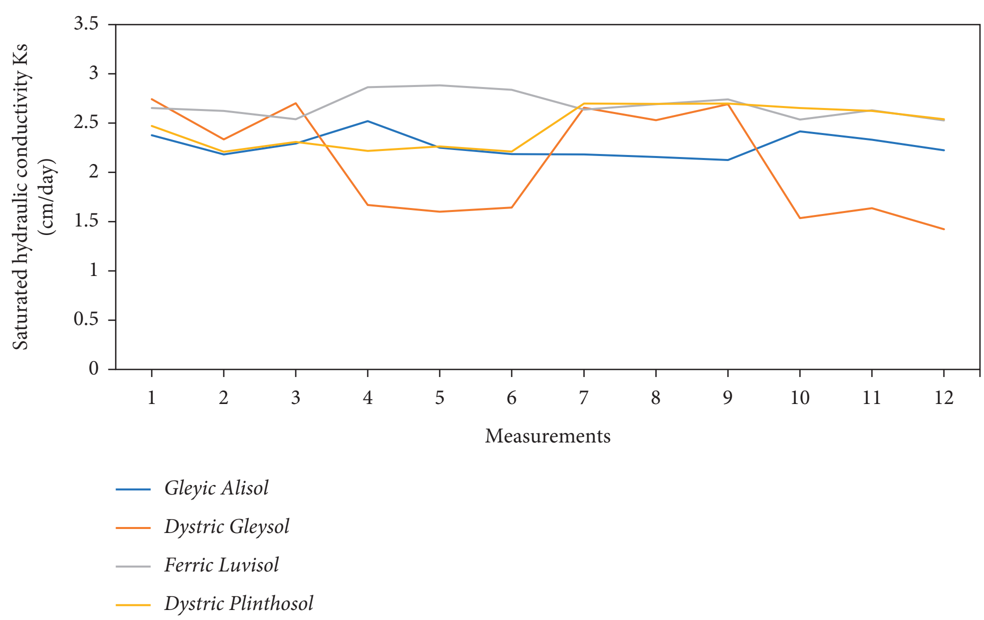


Figure 9: Saturated hydraulic conductivity under the soil classes of the watershed.

hydraulic conductivity found in fallow lands. Previous studies in semiarid watersheds reported a reduction in infiltration rate due to microfauna activities in the soil [27, 50]. In addition, there is no significant difference between bulk density under cropland and fallow land investigated. This supports the fact that the observed differences of K_s under the two land uses were caused by land use classes. During the infiltration measurement, the observation in the field attested to a higher density of plant roots in fallow lands than in croplands. The decomposition of the root may contribute to the increase of the macroporosity intensity in fallow lands. This study did not consider the difference in the slope of the watershed. Due to limited soil infiltration data, the measurements did not link directly the historical changes in land use regarding soil infiltration, but they considered the antecedent changes in land use on the current water infiltration rate. Furthermore, the comparison of microfauna (termites, ants, and earthworms) was not done. Further studies could focus on the effect of the slope on soil infiltration rate as well as the comparison of saturated and unsaturated hydraulic conductivity. Moreover, hydrological ecosystem services may be needed to further evaluate both the service capacity and flow of the watershed, especially for crop water and household water supplies.

Table 2: Basic properties of the soil investigated. SOC refers to soil organic carbon.

Soil	Depth (cm)	Clay (%)	Silt (%)	Sand (%)	Coarse particles (%)	SOC (%)	pH (H_2O)
Gleyic Alisol	0–20	2.51	15.19	82.30	0.34	0.28	5.94
	20–45	5.09	12.75	82.07	1.91	0.13	6.07
Dystric Gleysol	0–18	11.41	30.06	58.53	1.18	0.59	6.71
	18–32	12.44	35.50	52.06	0.64	0.4	7.51
Ferric Luvisol	0.2	4.79	21.49	73.72	20.82	0.47	6.64
	20–45	9.33	29.3	61.73	42.99	0.28	6.42
Dystric Plinthosol	0.15	12.6	30	57.4	41.73	0.54	5.34
	15.3	7.9	34	58.1	57.79	0.43	5.58

Table 3: Average values of bulk density (BD), field capacity (FC), permanent wilting point (PWP), and available water capacity (AWC) for plants.

Soil	Depth (cm)	BD (g/cm^3)	FC (pF 2.5%) (vol/vol)	PWP (pF 4.2%) (vol/vol)	AWC for plants % (vol/vol)
Gleyic Alisol	0–20	1.36	7.7	1.8	5.9
	20–45	1.43	8.3	2.6	5.7
Dystric Gleysol	0–18	1.44	8.6	3.1	5.5
	18–32	1.47	9.4	4.1	5.3
Ferric Luvisol	0–20	1.1	10.1	2.7	7.4
	20–45	1.45	12.8	5.5	7.3
Dystric Plinthosol	0–15	1.41	19	8.5	10.5
	15–30	1.57	19.5	5.4	14.1

Bulk density (BD), field capacity (FC), and permanent wilting point (PWP) data were obtained from the WASCAL database (https://wascal-dataportal.org/wascal_searchportal2/).

4.3. Implication for Land and Water Management. Agricultural expansion has been considered as one of the main factors affecting land degradation in Northern Benin [51]. Indeed, conversion of natural vegetation to croplands modified the topsoil and modified the soil hydrological process. Knowing that Benin has mainly agricultural-based economy, appropriate strategies and techniques are needed for soil and water conservation. Our study indicated that change in natural vegetation to croplands induced a low infiltration rate and macropore connectivity. Fallow lands tend to provide higher water storage capacity through the improvement of mesopores, while soil compaction through agricultural activities reduces soil porosity and therefore soil infiltration. This situation could impact water yield and groundwater recharge.

For better water management for agricultural use, including household water supplies, afforestation and agroforestry system might be suitable perspective for soil and water conservation to promote infiltration and water storage capacity. Finally, this study was in line with the UN-Water and Sustainable Development in goal 6, to increase by 2030 the water use efficiency across all sectors and ensure thereby sustainable withdrawals and supply of freshwater to address water scarcity substantially.

5. Conclusions

The impact of LU on soil infiltration revealed that infiltration rates were reduced in cropland compared to fallow land or natural vegetation. The abundance of macropores in fallow lands appears to be related to these observed differences, while in cropland, the macropores are relatively lower. Infiltration was high in *Ferric Luvisol* compared to other soil classes due to the structure of the soils. In addition, the degree of loosening during tillage depicted low soil moisture in cropland as compared to fallow lands. The results further indicate that soil infiltration varied highly within the same LU class. Finally, in the Ouriyori watershed, land conversion from fallow/natural vegetation to cropland has the potential to increase infiltration overland at plot scale. In addition, this situation added to the rapid conversion in LU may amplify the surface runoff generation, leading to more soil loss and loss in soil fertility through soil erosion or flood occurrence in the watershed. This study accounts for the sustainable development of watershed management. Future studies may focus on the temporal linkage of soil infiltration rate, unsaturated hydraulic conductivity, and changes in land use. To better address the complexity of hydrological processes in the watershed, the use of hydrological model for simulation is recommended.

Data Availability

Some data used in this study can be found at https://wascal-dataportal.org/geonetwork/apps/search/.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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Supplementary Materials

Table in supplementary stands for the descriptive statistics of K_s and Log K_s in both cropland and fallow land. (*Supplementary Materials*)

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