

Linking Environmental Security, Water Security and Food Security for Sustainable management of Chepkoilel-Sergoit Water Catchment

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Abstract

Due to the steadily increasing population of Eldoret Town, which forms part of Chepkoilel-Sergoit Catchment (CSC), CSC has undergone unprecedented land use and land cover transformations. The catchment is progressively becoming a small-scale farming area, with irrigation farming taking precedence over rain-fed agriculture. The intensification of agriculture will inevitably require more water resources. For sustainable development and management of resources in CSC there is, therefore, need to recognise the link in the life supporting systems. This study linked land/water and water/biodiversity systems as an integrated catchment-based approach to sustainable development. The catchment was delineated and subdivided into three zones based on land use/land cover (LULC) and topography: Upper zone (UZ), Middle zone (MZ) and Lower zone (LZ). The Catchment characteristics investigated, included i) the geology, ii) land use/land cover change, iii) the soils, iv) the hydrology, and v) the ecosystem. Overall, there is a 46% loss in forest cover accentuated by increasing levels of land cultivation. There is therefore urgent need for a landscape restoration approach that links environment security to water and food security.

Key words: Chepkoilel-Sergoit Catchment, Environmental Security, Kenya, Sustainable resource Management

Résumé

En raison de l'augmentation constante de la population de la ville d'Eldoret, qui fait partie du bassin versant de Chepkoilel-Sergoit (CSC), le CSC a subi des transformations sans précédent de l'utilisation et de la couverture des terres. Le bassin versant devient progressivement une zone d'agriculture à petite échelle, l'agriculture irriguée prenant le pas sur l'agriculture pluviale. L'intensification de l'agriculture nécessitera inévitablement plus de ressources en eau. Pour un développement durable et une gestion des ressources dans le CSC, il est donc nécessaire de reconnaître le lien dans les systèmes de soutien à la vie. Cette étude a relié les systèmes terre/eau et eau/biodiversité comme une approche intégrée basée sur le bassin versant pour le développement durable. Le bassin versant a été délimité et subdivisé en trois zones en fonction de l'utilisation des terres/la couverture des terres (LULC) et de la topographie : zone supérieure (UZ), zone intermédiaire (MZ) et zone inférieure (LZ). Les caractéristiques du bassin versant étudiées comprenaient i) la géologie, ii) le changement d'utilisation des terres/la couverture des terres, iii) les sols, iv) l'hydrologie, et v) l'écosystème. Dans l'ensemble, il y a une perte de 46% de la couverture forestière accentuée par des niveaux croissants de culture des terres. Il y a donc un besoin urgent

Mots-clés: Bassin versant de Chepkoilel-Sergoit, sécurité environnementale, Kenya, gestion durable des ressources

Chepkoiel-Sergoit Catchment (CSC) is bounded by 00°27'N and 00°43'N; 35°30'E and 35°34'E), and drained by Chepkoiel and Sergoit rivers both part of Lake Victoria catchment area in Kenya. Rivers Chepkoiel, Sergoit and Sosiani form the upper catchment of River Kipkaren, which is part of the larger Nzoia catchment, one of the major catchments of Lake Victoria, the largest fresh water lake in Africa. The Northern periphery of Eldoret Town lies within the CSC. Due to the steadily increasing population of Eldoret Town, CSC has undergone unprecedented land use and land cover transformations (Chibole, 2013). This area also supports steadily expanding agricultural production characterised by small scale, medium and large-scale farming activities that include cereals (maize, wheat), horticulture (vegetables, flowers, and fruits) and animal farming (dairy and poultry). For sustainable development and management of resources in CSC it is important to link the life supporting systems. These include land/water and water/biodiversity systems linkages as an integrated catchment-based approach. The catchment was delineated and subdivided into three zones based on LULC and topography: Upper zone (UZ), Middle zone (MZ) and Lower zone (LZ) (Figure 1, Table 1). The Catchment characteristics investigated included i) the geology, ii) the soils, iii) the hydrology, and iv) the ecosystem.

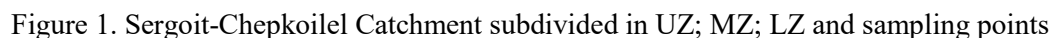


Table 1. Chepkoilel-Sergoit key catchment characteristics

S. No	Parameter	Value
1.	Upper Catchment	329.4 km ²
2.	Middle zone	156.7 km ²
3.	Lower zone	227.6 km ²
4.	Total no. of streams	15
5.	Total length of main stream	85 km

Materials and Methods

Approach. The geological study involved Desk review; Field observation and sample collections and Laboratory analysis. A review of the regional and local geology of the study area from literature was done to understand the nature of the basement complex and the Lower- and Upper Uasin Gishu phonolites, which are the main rock types that underlie the study area. This was followed by;

Field observation and sample collections and Laboratory analysis. Exposures of the different rocks were observed in the field and their characteristics recorded. The characteristics of interest were mainly the rock structure, i.e., massiveness, fractures and joints, and weathering. Due to the uneven occurrence of the exposures, fresh rock samples were taken at convenient points in a random manner. Similarly, water samples were collected at spaced but convenient locations along the river course as indicated on the map. Whole rock analysis using XRF method was done at the Geology and Petroleum Department in Nairobi for major and selected trace elements. The water samples were analyzed for F, Fe, Cu, and Zn.

Land use/Land cover. Land use and Land cover changes in the catchment were examined and quantified using supervised classification of medium-resolution, dry-season Landsat imagery of January 1995, 2014 and 2020 in ArcGIS, and ground-truthing undertaken to verify the results. Soil study was undertaken to understand the soil-related factors impacting stability of river/ stream base flow, to understand the soil-related factors impacting year-round availability of water in the upper catchment and the seasonal fluctuations in available water in wells in the mid and lower zones of the catchment. The research was carried out through review of existing published studies (Sanders, 1963; Jaetzold, 1987; Lomurut, 2014), reconnaissance visits of the study area, and close observation of exposed soil profiles such as road cuts, quarries, river channel cuts and photography.

The Ecosystem. To assess the health of River Chepkoilel-Sergoit based on its riparian vegetation condition and physical condition, 50 m line transects were randomly constructed along the river banks. Ten sampling points were selected at random along each transect. At each sampling point, a perpendicular projection across the river was estimated from either corresponding opposite banks. This projection served as the basis for data collection. Riparian vegetation condition (vegetation intactness and extent of vegetation degradation) and physical condition (extent of soil erosion and water clarity) at each sampling point were scored. Scores were categorized into 5 Likert scales of each magnitude of degradation for each parameter: 0%, 1-25%, 26-50%, 51-75%, 76-100% their sum computed for each zone (lower, middle, and upper).

Hydrology. Hydro-meteorological data spanning three decades were analysed using hydrological time series. The river discharges at key strategic sampling points were gauged using current meter, and selected water quality parameters: Dissolved Oxygen (DO), pH, Total Dissolved Solids (TDS), Turbidity, Conductivity were measured in situ. Macronutrients, however, were analysed in the laboratory. Brucine method was used for nitrates, while Vanadomolybdophosphoric acid colorimetric method was used to determine phosphate levels. Areas with high and low water potential and pollution hotspots were also identified. Water Quality Index (WQI) was used to characterize water quality in the three zones. DO with its weight factor of 0.22 was used as the key indicator parameter.

Results and Discussion

Geology. The area (UZ) is underlain mostly by the Upper Uasin Gishu phonolites, which are generally massive in structure and therefore impervious and hence poor in aquifer formation. MZ and LZ is underlain by the Lower Uasin Gishu phonolites and Basement Complex. These formations are less massive and form aquifers where they are intensely fractured and weathered to depths up to 30 m. The fractured areas constitute good unconfined aquifers during rainy season and rapidly drain when the dry season sets in.

Land use/Land cover. The results of the LU/LC study showed that the catchment had lost 69% of its forest cover, while farmland increased by 44%; settlement in the catchment increased by 261% and wetland declined by 64% during the period. Significantly, the upper zone, the main source of the water supply in the catchment, lost 46% of its forest cover during the period. The UZ is the mainstay of the flow of the River, therefore the rapid loss of vegetation cover needs to be reversed urgently for future water availability (Figure 2).

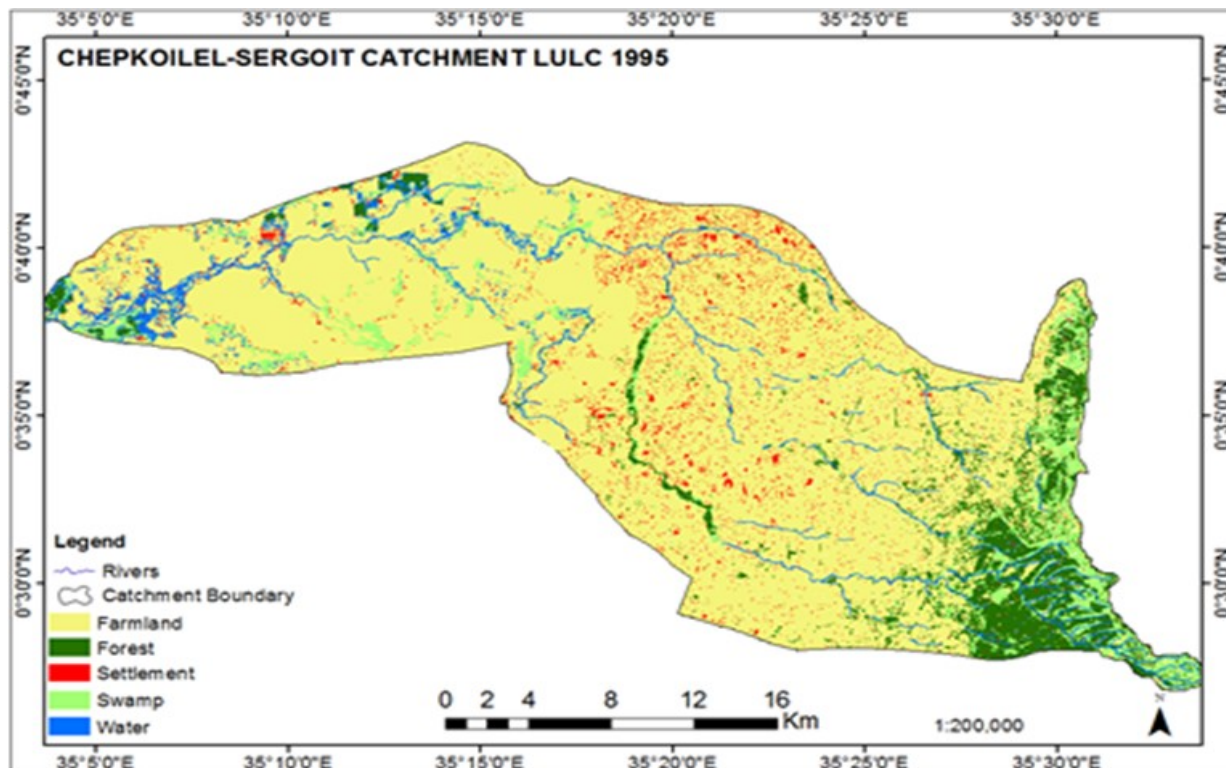


Figure 2 (a). Land Use and Land Cover in 1994

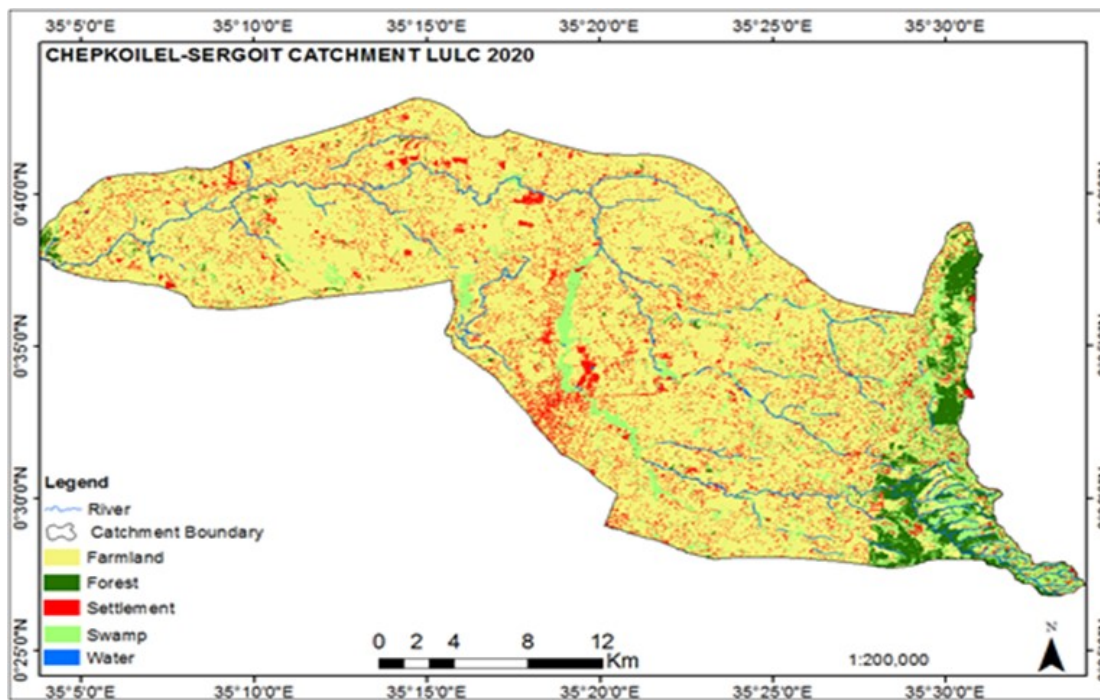


Figure 2 (b). Land Use and Land Cover in 2020

Soils. Well-developed Nitosols, with deep well-drained profiles (1.5 m) in gentle slopes dominate UZ. These are red, tropical soils, which are developed under high rainfall and dense vegetation, with blocky and well aggregated structure which allow steady infiltration and percolation of rain-water. In UZ, they are responsible for the base flow of the river, and keep the streams and springs in the upper catchment flowing year-round. In the MZ and LZ the predominant soils are Ferralsols, red and yellow strongly weathered soils with high content of aluminum and iron oxides. In the MZ they have a depth of up to 90 cm, thinning out to 20 cm in the LZ. In areas which have been repeatedly cultivated they are much less than 20 cm, partly because they are easily eroded due to their granular structure. In both zones, the ferralsols are underlain by laterites, a slightly-to-very slightly permeable layer of partially decomposed rock that is typical of tropical zones with wet and dry season. In the upper areas of MZ, the laterites appear to be slightly permeable, as evidenced by the thicker soil profile above them. In the lower section of this zone the soil above the laterite becomes progressively thinner and less permeable as evidenced by shallower soil profiles and proliferation of seasonal wetlands. This is the factor that occasions dry river beds during extended dry seasons, as well as the drying up of shallow wells.

The Ecosystem. Overall combined condition (health indicator) assessment showed that (i) Lowest extent of degradation (0%) was observed at the upper catchment (= 48.44%), (ii) Highest extent of degradation (76-100%) was observed at LZ (28.97%), followed by MZ (21.37%). There was no difference in combined extent of degradation among the zones. All the zones were equally degraded. The study recommends the ecological restoration of the riparian zones.

Hydrology. The upper zone has a generally good WQI rating (70 – 80), middle zone WQI rating ranges from poor to medium (30 – 60), while the lower zone has generally poor WQI (25 – 50). It is important also to understand the implications of these parameters on the agricultural productivity of the study area and this should form part of the follow up study.

Conclusion

Environmental security of CSC is threatened by the increasing scale of land degradation and food insecurity is increasing. There is a loss of 46% of the forest cover of UZ, the mainstay of the flow of the river. Linking the environmental security to water and food security as one of remedial measures will go a long way in meeting human demand for ecosystem services and therefore, enhance sustainable development in the catchment.

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