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Curve Number Map and Weighted Average CN Values: Case Study of the Río Grande Micro-Watershed, Chone River Basin, Ecuador

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ABSTRACT
Surface runoff estimation is a key component of hydrological modeling in watersheds exposed to flooding and land-use variability. In this context, the Soil Conservation Service Curve Number (SCS-CN) method has been widely adopted as an effective approach for representing watershed hydrological response based on terrain, soil, and land-cover characteristics. This study aimed to derive the Curve Number map and weighted average CN values for the Río Grande watershed, considered as a case study within the Chone River basin, Ecuador, through the application of Geographic Information System tools. The methodological framework integrated terrain hydrologic processing in ArcGIS 10.1 and HEC-GeoHMS 10.1 with a digital elevation model, satellite orthoimages, vector cartography, and soil texture data. The procedure involved watershed and micro-watershed delineation, generation of flow direction and flow accumulation maps, slope classification into the 0–3% and >3% ranges, assignment of hydrologic soil groups, and land-use vectorization. These thematic layers were subsequently integrated through geoprocessing to assign CN values according to the reference classification proposed by Ferrér et al. (1995). The results enabled the generation of the raster Curve Number map for the Río Grande watershed and the weighted average CN values for its micro-watersheds, which constitute essential inputs for infiltration-loss modeling in HEC-HMS. Overall, the integration of GIS and the SCS-CN method provides a robust technical framework for the hydrological parameterization of micro-watersheds and for supporting runoff assessment and flood-related studies in the Chone River basin.

Keywords: *curve number; Río Grande micro-watershed; Chone River; surface runoff; GIS; HEC-GeoHMS.*

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I. INTRODUCTION

Hydrological assessment of watersheds requires parameters capable of integrally representing the relationship among rainfall, infiltration, and surface runoff, as Sarker & Leta(2025) and Yan & Chang(2025). Among the most widely used methods for this purpose is the Soil Conservation Service Curve Number (SCS-CN), which estimates runoff as a function of watershed characteristics such as soil type, land use, slope, and antecedent moisture condition. Although originally developed for relatively simple hydrologic settings, the CN method remains a widely accepted reference for rainfall–runoff estimation because of its operational simplicity and adaptability to watershed-scale analysis, as Ferrér et al.(1995),Verma et al.(2020) and Panigrahi & Ramadas(2025).

The usefulness of the CN approach lies in its ability to synthesize the runoff potential of the land into a single numerical parameter. From a methodological perspective, Ferrér et al.(1995)showed that CN generation can be automated through Geographic Information Systems by integrating tabulated relationships among land use, slope, and hydrologic soil group. This GIS-based logic remains highly relevant in recent hydrologic studies, as Alsaidi et al.(2025) and Kumari et al.(2024), where CN grids and runoff surfaces are derived through spatial overlay techniques to improve watershed characterization and runoff estimation efficiency.

The relevance of this approach is especially evident in flood-prone areas, where hydrological modeling becomes a strategic tool for territorial planning and risk reduction(Kumari et al., 2024). Recent studies, as El Yousfi et al.(2023),Guduru& Mohammed(2024) andPeker et al.(2024), have emphasized that GIS preprocessing and HEC-HMS-based workflows provide a strong foundation for rainfall–runoff simulation, flood assessment, and watershed management, particularly where detailed terrain representation is needed. In the case of the Chone River, the city is located on a low-lying floodplain, at approximately 14 m above sea level, near the confluence of the Grande, Mosquito, and Garrapata rivers, and that recurrent flooding has historically been associated with deficient fluvial regulation and stormwater drainage deterioration(Mendoza et al., 2021).

Within this hydrographic system, the Río Grande micro-watershed is especially important because of its role as a main tributary within the Chone River basin. From a methodological standpoint, focusing on this unit makes it possible to apply and validate a spatial CN estimation procedure at the micro-watershed scale by integrating topographic, edaphic, and land-cover variables(Zhang et al., 2025). For the Río Grande sub-basin, the thematic intersection procedure generated 29 files, one for each micro-watershed, from which CN values were assigned and weighted averages were later computed. This type of spatial disaggregation is consistent with current watershed studies showing that runoff estimation improves when land-use and terrain heterogeneity are explicitly represented rather than treated as a single lumped unit, as Ajith & Kumar(2024) and Umukiza et al.(2024).

The incorporation of Geographic Information Systems into this type of study offers clear methodological advantages. First, it makes it possible to accurately delineate hydrologic units from digital elevation models(Osman et al., 2022). Second, it facilitates the spatial integration of slope maps, hydrologic soil groups, and land-use layers(Kumari et al., 2024). Finally, it enables the generation of cartographic products and synthetic values compatible with hydrological models such as HEC-HMS. In the analyzed case, the use of ArcGIS 10.1 and HEC-GeoHMS 10.1 made it possible to structure the project, process the terrain, and generate the territorial parameters required for CN assignment(Khattab et al., 2025).

Based on the foregoing, the objective of this study was to obtain the Curve Number map and weighted average values for the Río Grande micro-watershed, as a case study within the Chone River basin, Ecuador, through the integration of GIS tools and the automatic CN generation methodology proposed by Ferrér et al.(1995). In this way, the study seeks to provide a cartographic and hydrological basis useful for infiltration modeling, runoff potential assessment, and future watershed-scale analyses, in line with current efforts to improve runoff estimation through GIS-based CN applications and hydrologic modeling frameworks, as detailed Panigrahi &Ramadas (2025) and Khattab et al. (2025).

II. MATERIAL AND METHODS

2.1. Study Area

The study was conducted in the Chone River basin, located in the province of Manabí, Ecuador, taking the Río Grande micro-watershed as the specific case study. The city of Chone, the cantonal administrative center, has an urban population of 52,810 inhabitants and an approximate area of 832 ha, and is located on a floodplain near the confluence of the Grande, Mosquito, and Garrapata rivers. This location gives particular relevance to the analysis of the hydrological dynamics of its tributaries, especially in a context of recurrent flooding and the need to improve stormwater drainage management.

2.2. Data Sources and Working Environment

For information processing, cartographic and alphanumeric data from the Military Geographic Institute, the Municipal GAD of Chone Canton, INAMHI, INEC, and other available public sources were used. The main input for topographic analysis was a digital elevation model in *.asc format, complemented by satellite orthoimages, vector maps of rivers, urban planimetry, and soil texture cartography. The project was developed in ArcGIS 10.1, configured in the WGS84, UTM Zone 17 South coordinate system, also using the HEC-GeoHMS 10.1 extension for terrain hydrologic processing.

2.3. Terrain Hydrologic Processing

The first methodological stage consisted of DEM preprocessing in order to correct information gaps and ensure topographic consistency. Once the model was validated, flow direction, flow accumulation, stream definition, stream segmentation, grid delineation of micro-watersheds, drainage lines, and adjacent catchments were generated. This sequence made it possible to establish the hydrographic framework required for the subsequent Curve Number analysis.

2.4. Determination of Variables for Curve Number Calculation

CN determination was carried out following the methodological logic proposed by Ferrér et al., which considers slope, soil type or hydrologic soil group, and land use as the main variables. In the 1995 methodological document, it is established that each class of these variables can be reclassified and combined within a GIS to produce the final CN map. In particular, slope was grouped into two ranges: less than 3% and greater than or equal to 3%.

In the case of the Río Grande micro-watershed, slope was derived from the DEM using the Slope tool and subsequently reclassified into the 0–3% and >3% ranges. The resulting map was then converted to vector format to facilitate its intersection with the other thematic layers. In this phase, the slope file is named Pend_Polygon_RG and corresponds to the Río Grande micro-basin.

Hydrologic soil groups were obtained from soil texture. In the study area, medium- and fine-textured soils were mainly identified and were associated with hydrologic soil groups B and C, respectively, in accordance with their infiltration capacity. At the same time, land use was constructed through manual vectorization based on orthoimages, generating polygons through spatial editing and incorporating the classifications proposed by Ferrér et al. in the corresponding methodological annex.

2.5. Spatial Integration and CN Assignment

Once the slope, hydrologic soil group, and land-use layers had been prepared, geoprocessing operations were applied for their intersection and spatial combination. First, the hydrologic soil group polygons and slope range polygons were intersected; then, the result was crossed with the land-use polygons previously adjusted to the watershed boundaries using the clip tool. As a result, polygon themes were obtained for each micro-watershed, in which each spatial unit contained hydrologic soil group, slope range, and land-use information.

For CN assignment, a new column was created in the attribute table of each file, and a data filtering procedure together with a subroutine in field calculator was used, based on the relationships in Annex A6 and the Ferrér et al. classifications. In the specific case of Río Grande, the process generated 29 files, one for each micro-watershed, from which the CN raster map was built and the area-weighted average values were calculated.

2.6. Final Product

The final product of this methodology consisted of the Curve Number map for the Río Grande watershed and the weighted average CN values for each micro-watershed. These results represent one of the most important contributions of the study, as they constitute fundamental data for the infiltration model in HEC-HMS and for future hydrological research in the area.

III. RESULTS

3.1. Terrain processing and hydrologic unit delineation

The terrain preprocessing carried out from the digital elevation model enabled the generation of the hydrologic base layers required for the subsequent Curve Number analysis. Using ArcGIS 10.1 and HEC-GeoHMS 10.1, the workflow produced flow direction, flow accumulation, stream definition, stream segmentation, grid delineation of micro-watersheds, drainage lines, and adjacent catchments. These products established the spatial framework for the Río Grande watershed and its internal hydrologic units, allowing CN assignment at the micro-watershed scale rather than at a single lumped-basin scale.

From a modeling standpoint, this step was essential because it transformed the DEM into a hydrologically conditioned terrain representation suitable for distributed or semi-distributed runoff parameterization. The resulting drainage structure also supported the clipping and intersection of the thematic layers used later in the CN computation process.

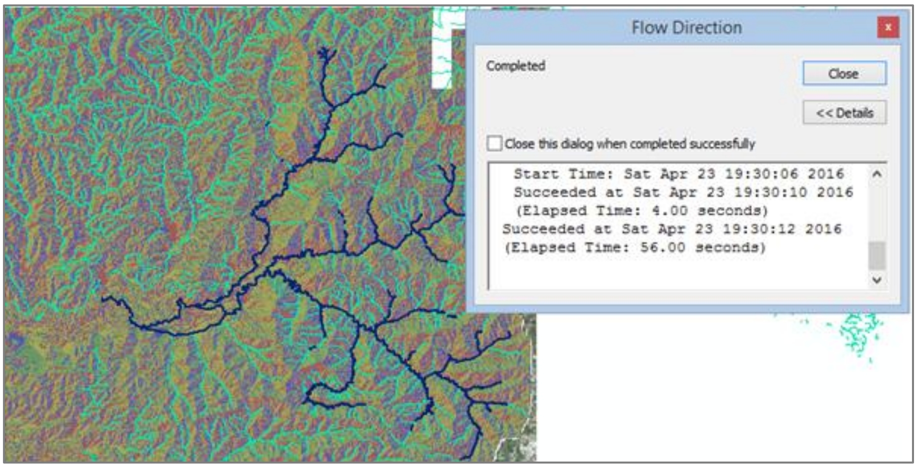

Figure 1. Terrain processing outputs for the Río Grande watershed: flow direction map
Source: Author's elaboration based on ArcGIS/HEC-GeoHMS processing.

According to Figure 1, the flow direction map illustrates the spatial routing of surface runoff throughout the Río Grande watershed, showing how water is distributed across the terrain according to topographic gradients. This output highlights the dominant drainage paths, flow convergence patterns, and the general movement of runoff toward the watershed outlet.

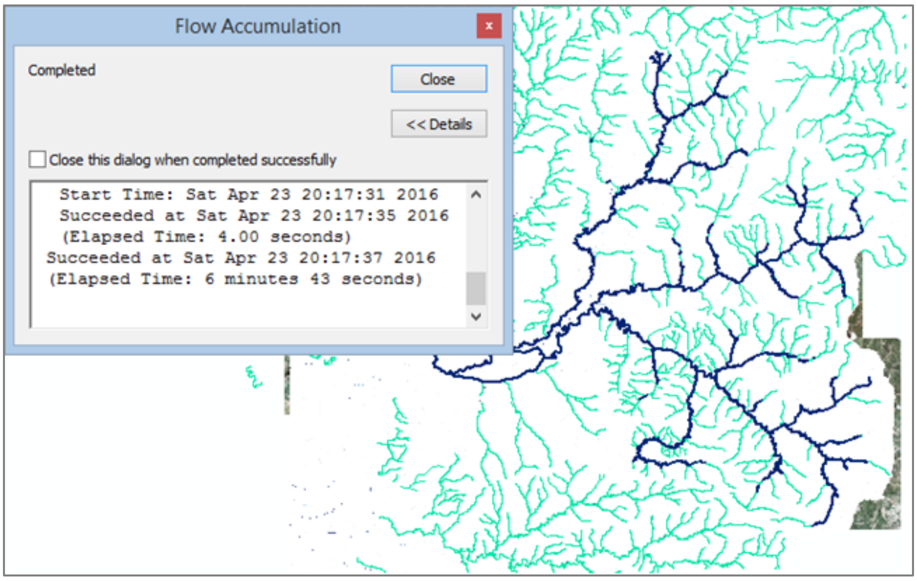

Figure 2. Terrain processing outputs for the Río Grande watershed: flow accumulation map
Source: Author's elaboration based on ArcGIS/HEC-GeoHMS processing.

According to Figure 2, the flow accumulation map reveals the sectors of greatest runoff concentration within the Río Grande watershed, clearly defining the hierarchical drainage network and indicating how surface water from upstream areas converges progressively toward the main downstream channels.

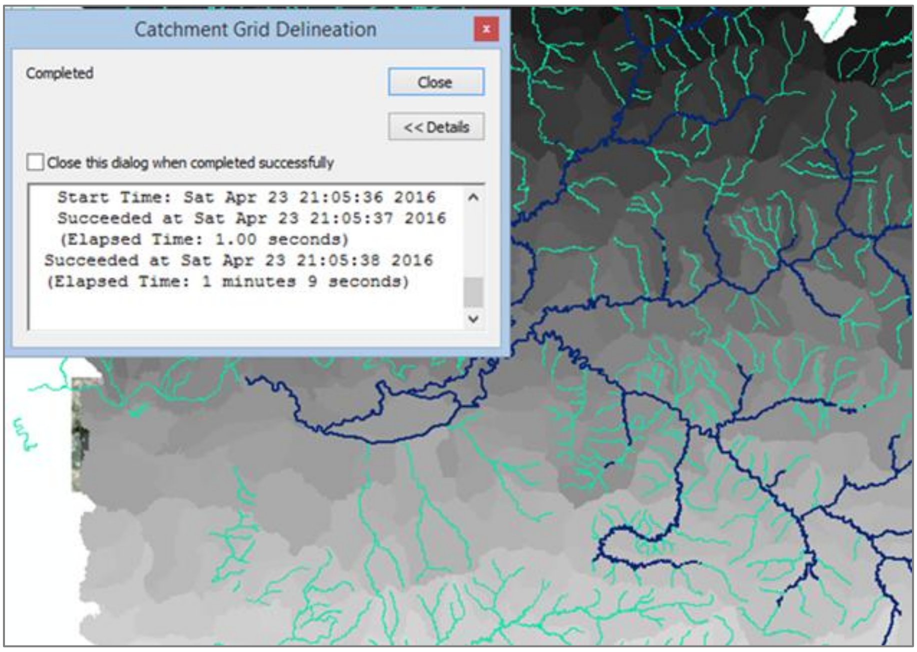

Figure 3. Terrain processing outputs for the Río Grande watershed: grid delineation of micro-watersheds
Source: Author's elaboration based on ArcGIS/HEC-GeoHMS processing.

According to Figure 3, the grid delineation of micro-watersheds shows the spatial subdivision of the Río Grande watershed into smaller hydrologically connected units. This output identifies internal catchment boundaries and their relationship with the drainage network, providing the territorial basis for distributed runoff analysis and Curve Number assignment.

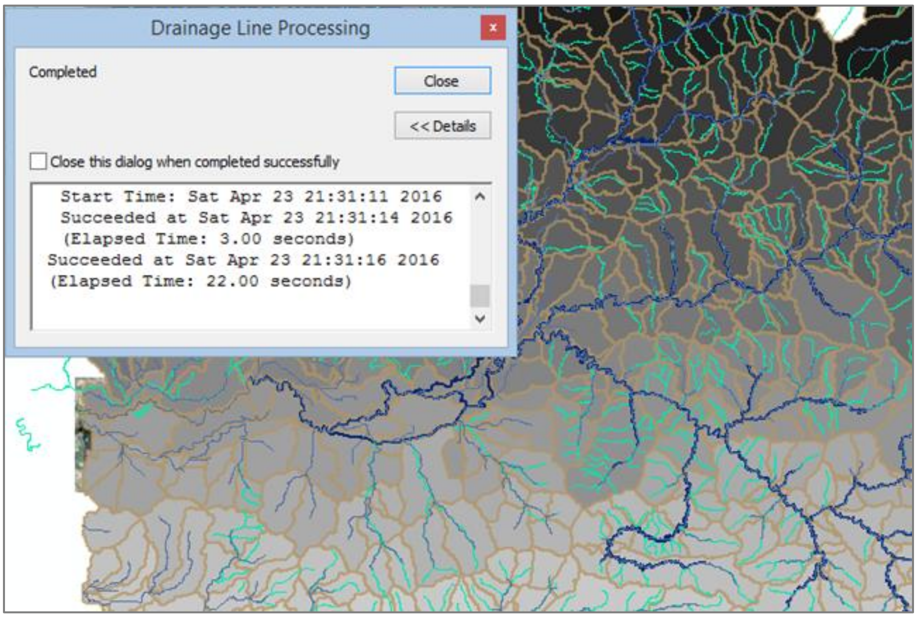

Figure 4. Terrain processing outputs for the Río Grande watershed: drainage line map
Source: Author's elaboration based on ArcGIS/HEC-GeoHMS processing.

According to Figure 4, the drainage line map displays the extracted channel network of the Río Grande watershed, representing the main and secondary flow paths derived from terrain processing. This output defines the spatial organization of surface drainage, supports hydrologic connectivity analysis, and provides a key basis for watershed characterization.

3.2. Hydrologic soil group assignment

Hydrologic soil groups were derived from the available soil texture map. In the study area, only medium-textured and fine-textured soils were identified. Medium-textured soils were assigned to Hydrologic Soil Group B, whereas fine-textured soils were assigned to Hydrologic Soil Group C (Table 1). This indicates that the Río Grande watershed is dominated by soils with moderate to slow infiltration capacity, a condition directly relevant to runoff generation and CN assignment.

This classification reduced the number of hydrologic soil groups actually represented in the watershed from the four theoretical SCS classes (A, B, C, and D) to two functional groups, simplifying the local implementation while preserving the hydrologic meaning of the method.

Table 1. Hydrologic soil group assignment used in the Río Grande watershed

Soil texture	Assigned hydrologic soil group	Hydrologic interpretation
Medium	B	Moderate infiltration capacity
Fine	C	Slow infiltration capacity

3.3. Slope reclassification and polygon generation

Slope was calculated from the DEM and then reclassified into the two ranges required by the adopted methodology: 0–3% and >3%. The results showed that slopes between 0% and 3% are mainly concentrated in the lower part of the watershed, whereas the rest of the basin is characterized predominantly by slopes greater than 3%, with low-slope zones appearing only sporadically outside the downstream sector.

After reclassification, the raster slope layer was converted to polygon format in order to enable spatial intersection with the hydrologic soil group and land-use layers. For the Río Grande watershed, the polygon slope layer was stored under the shapefile name Pend_Polygon_RG, which became the reference input for the CN overlay workflow.

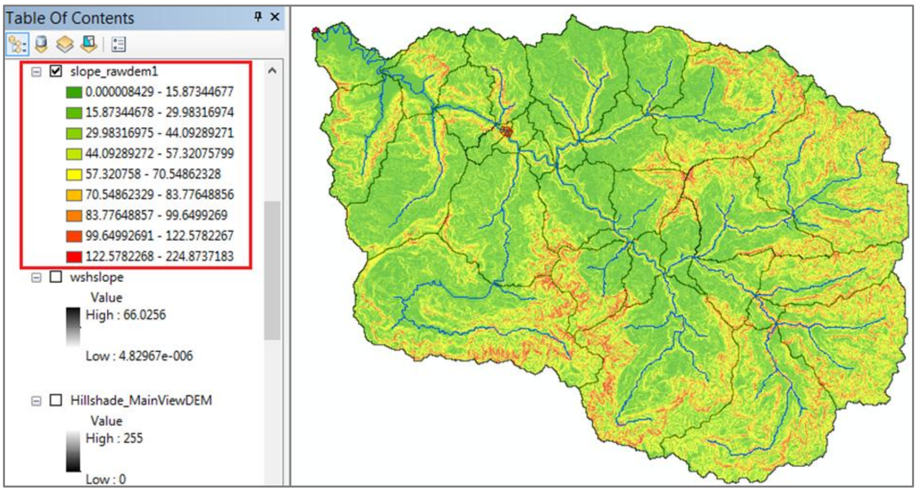

Figure 5. Slope processing for the Río Grande watershed:slope map in percent

According to Figure 5, the slope map in percent shows the spatial variation of terrain gradients within the Río Grande watershed. Gentle slopes predominate across most of the basin, while steeper sectors are concentrated along elevated and dissected areas, influencing runoff velocity, infiltration capacity, and the hydrologic response of the watershed.

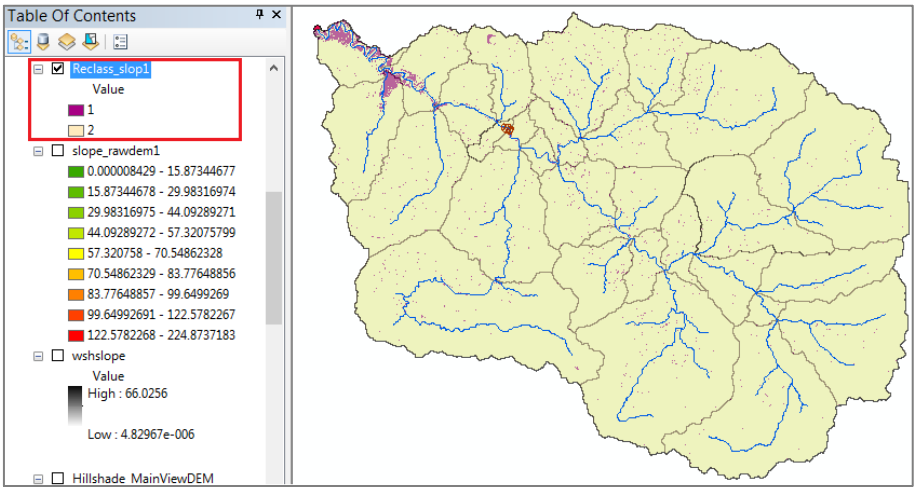

Figure 6. Slope processing for the Río Grande watershed: reclassified slope map

According to Figure 6, the reclassified slope map groups terrain gradients into two hydrologically significant classes, identifying gentle and steeper areas that influence infiltration, runoff generation, and Curve Number assignment.

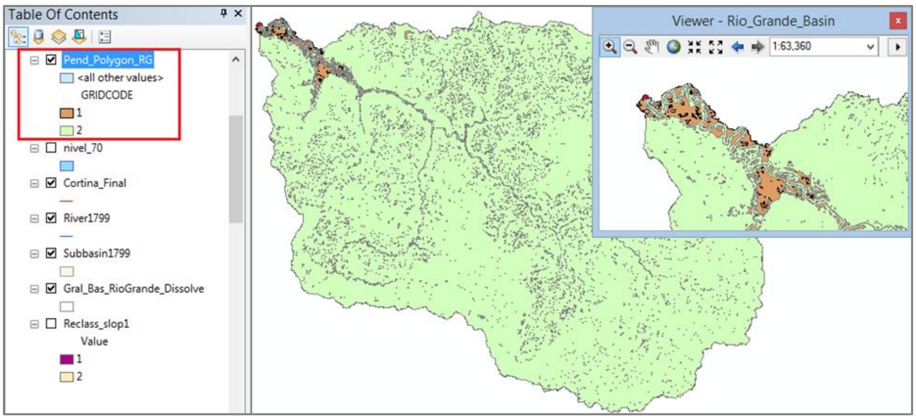

Figure 7. Slope processing for the Río Grande watershed: polygonized slope classes

According to Figure 7, the polygonized slope classes represent the reclassified terrain gradients as vector units within the Río Grande watershed. This process improves spatial organization of slope information. It also enables overlay analysis with soil and land-use layers for Curve Number estimation.

3.4. Land-use vectorization and thematic integration

Land use was obtained through manual vectorization using orthoimages as the visual basis for polygon creation. The land-use classes followed the classification proposed by Ferrér et al.(1995) and referenced in Appendix I. Once digitized, the land-use polygons were clipped to the watershed boundary, generating the shapefile Uso_de_suelo_RG_clip.shp for the Río Grande case.

The clipped land-use layer was then intersected with the polygon layers containing hydrologic soil group and slope-range information. As a result, new polygons were generated in which each spatial unit simultaneously stored three key attributes: hydrologic soil group, slope range, and land use. These integrated polygons formed the direct basis for CN assignment through the attribute table calculation procedure.

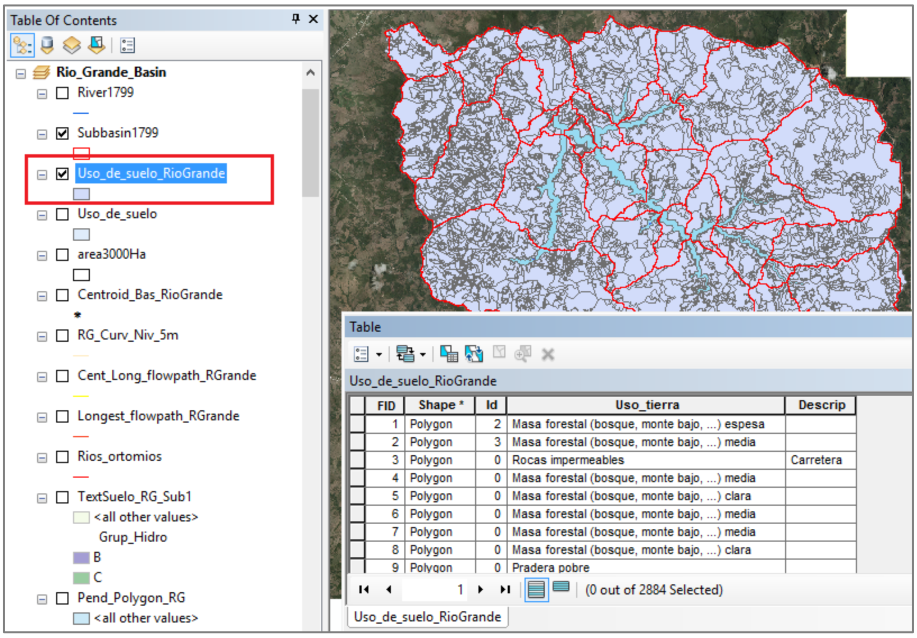

Figure 8. Land-use polygon layer and integrated thematic units for the Río Grande watershed.

According to Figure 8, the land-use polygon layer displays the spatial distribution of thematic units in the Río Grande watershed, including forest cover with different densities, poor grassland, and permeable or impermeable rock areas. These polygons were integrated with slope classes and hydrologic soil groups to assign Curve Number values according to the reference table. Thus, the figure represents a key intermediate stage for runoff characterization and subsequent hydrologic modeling.

3.5. Curve Number map generation

The final CN assignment was performed by creating a new attribute field named CN in each polygon file and populating it using a filtering procedure and a subroutine implemented in the ArcGIS Field Calculator, based on the relationships defined in Appendix I(Ferrér et al., 1995). Once all CN values had been assigned, thematic symbology was applied so that polygons with different CN values could be represented by different colors.

For the Río Grande sub-basin, this procedure generated 29 files, one for each micro-watershed. The file RG_Sub1_CN.shp corresponds to Micro-watershed 1, and the same logic was applied to the remaining units. The resulting set of files was then used to create the CN raster map of the Río Grande watershed.

According to Figure 9, the raster Curve Number map shows the spatial distribution of CN values throughout the Río Grande watershed, obtained from the combination of land-use classes, slope categories, and hydrologic soil groups based on the Ferrér et al.(1995)reference table. Areas with lower CN values represent surfaces with greater infiltration potential, whereas higher CN values indicate reduced infiltration and greater runoff generation. Therefore, the map summarizes the hydrologic response of the watershed and provides a key input for runoff and infiltration modeling.

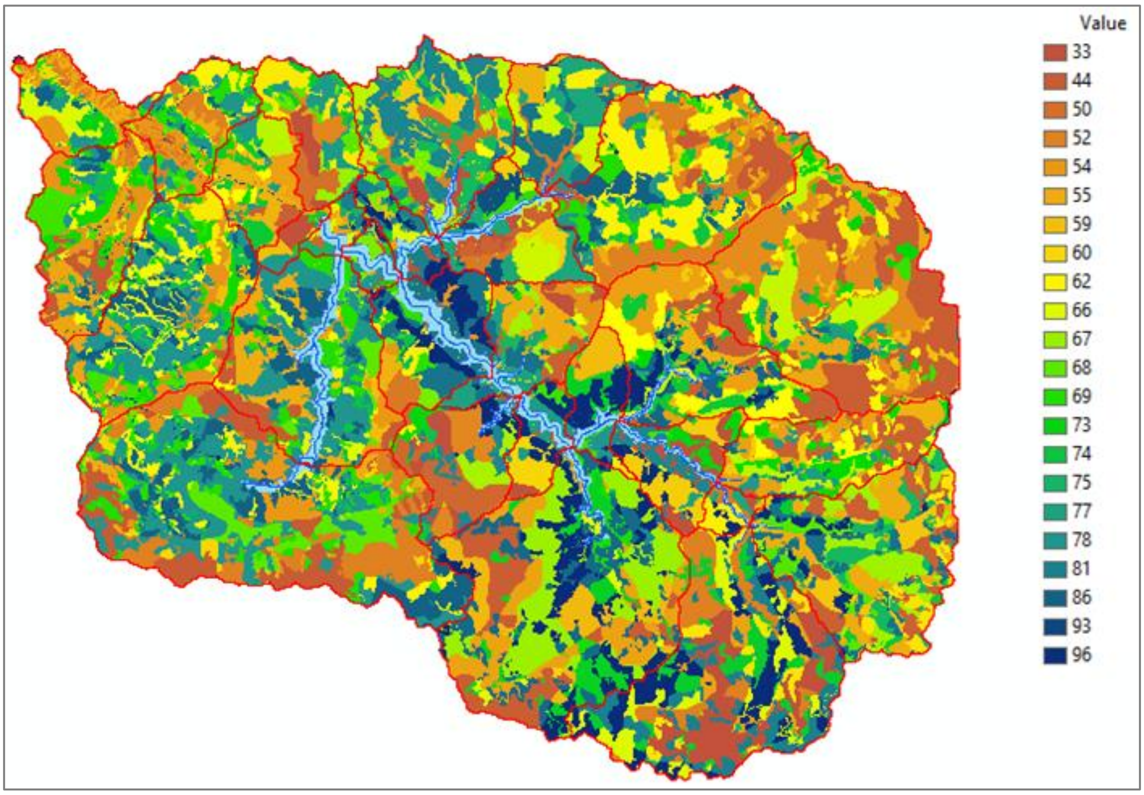

Figure 9. Raster Curve Number map of the Río Grande watershed.

IV. DISCUSSION

The results confirm that GIS-based terrain preprocessing is a robust foundation for hydrologic characterization at the micro-watershed scale. In this study, the generation of flow direction, flow accumulation, drainage lines, and micro-watershed delineation from the DEM provided a spatially consistent representation of the Río Grande watershed. This is in line with the watershed-management perspective discussed by Satterlund& Adams(1992), who emphasize that hydrologic interpretation must begin with a sound understanding of terrain controls on drainage organization. Similarly, recent GIS preprocessing studies using HEC-HMS highlight that DEM conditioning and watershed subdivision are essential for rainfall-runoff simulation because they define the physical structure through which runoff is routed, as detailed by El Yousfi et al.(2023) and Guduru and Mohammed(2024).

A major strength of the present work is the adoption of the micro-watershed scale rather than a lumped representation of the entire basin. This decision is methodologically important because runoff generation is spatially heterogeneous and depends on local combinations of topography, soils, and land use. Clavijo et al. (2013) had already stressed the need for hydrometeorological and hydrologic characterization in the Chone system to support flood prevention, while Cabrera et al. (2016)reinforced the importance of rainfall analysis for hydrologic response assessment in Chone. In that same direction, recent studies using GIS-based SCS-CN methods have shown that sub-basin or micro-watershed parameterization improves the estimation of runoff volumes and enhances the capacity to identify hydrologically sensitive sectors within a watershed, as Osman et al.(2022) and Kumari et al.(2024) stated.

The hydrologic soil group classification obtained in the Río Grande watershed also has clear interpretive value. The predominance of groups B and C indicates soils with moderate to slow infiltration capacity, which helps explain the spatial tendency toward moderate and high runoff response in different sectors of the basin. This finding is consistent with the conceptual basis of Ferrér et al.(1995), who treated soil type as one of the key variables controlling CN values, together with land use and slope. More recent evaluations of the SCS-CN method continue to identify soil properties and land-cover conditions as central controls on runoff estimation accuracy(Panigrahi & Ramadas, 2025), especially when CN is used as an operational parameter for watershed management and flood studies(Khattab et al., 2025).

Slope processing represented another important contribution of the methodology. By reclassifying terrain gradients into the 0–3% and >3% classes, the study incorporated topographic variation explicitly into the CN assignment process. This choice follows the approach of Ferrér et al.(1995)and remains hydrologically relevant because slope affects runoff velocity, infiltration opportunity time, and the connectivity between hillslopes and channels. Contemporary research has continued to refine the Curve Number approach by emphasizing that slope adjustment can reduce uncertainty in runoff prediction, particularly in heterogeneous and steep watersheds(Panigrahi & Ramadas, 2025). In this sense, the present study does not merely reproduce a classical procedure; it applies a still-valid slope-sensitive framework to a local basin with practical flood-management relevance(Alsaidi et al., 2025).

Land-use vectorization and thematic integration were also decisive for the final hydrologic interpretation(Ajith y Kumar, 2024). The polygon layer derived from orthoimages captured the spatial distribution of forest cover, grassland, and rocky areas, which were then combined with slope and hydrologic soil groups to assign CN values. This result is consistent with the broader hydrologic literature showing that land-use change modifies runoff generation by altering imperviousness, interception, soil protection, and infiltration conditions(Umukiza et al., 2024). Öztürk et al. (2013)had already demonstrated that land-use change significantly affects watershed hydrology, and more recent studies confirm that GIS-based SCS-CN mapping is particularly useful for quantifying how land-use and land-cover patterns influence runoff response.

The final raster CN map constitutes the main synthetic output of the study because it converts multiple spatial controls into a hydrologically meaningful representation of runoff potential. In engineering terms, the map is valuable not only as descriptive cartography but also as a direct model input for HEC-HMS infiltration-loss calculations(Guduru & Mohammed, 2024). This operational significance agrees with recent flood and watershed studies in which GIS, HEC-HMS, and related hydraulic tools are integrated to support runoff simulation, flood hazard analysis, and basin planning(Peker et al., 2024). In particular, current research shows that CN-based parameterization remains useful when its spatial variability is explicitly represented and linked to physically interpretable watershed properties.

Another relevant aspect is the replicability of the procedure. The generation of 29 CN files for the Río Grande micro-watersheds shows that the methodology can be reproduced systematically for each internal hydrologic unit. This gives the study practical value for future scenario analysis, especially under land-use transformation or flood-risk assessment(Khattab et al., 2025). Verma et al.(2020)argued that improved CN procedures can enhance the practical reliability of runoff estimation, and recent reviews likewise indicate that the CN approach continues to be widely used because of its adaptability, physical interpretability, and compatibility with GIS-based workflows. Therefore, the present study contributes not only a local hydrologic product, but also a replicable technical framework for watershed assessment within the Chone River basin.

Overall, the discussion supports the idea that the GIS-based implementation of the SCS-CN method remains technically valid and practically useful for medium-scale watershed characterization(El Yousfi et al., 2023). In the case of the Río Grande watershed, the integration of terrain processing, hydrologic soil group assignment, slope reclassification, and land-use mapping produced a spatially explicit runoff characterization that is consistent with both the classical framework of Ferrér et al.(1995)and more recent developments in GIS-supported hydrologic modeling. For a basin context such as Chone, where flood-related concerns have been noted in local planning and technical reports, this type of spatial hydrologic information is especially relevant for informed decision-making(Peker et al., 2024).

V. CONCLUSION

Hydrologic preprocessing of the digital elevation model produced the core spatial layers required for runoff analysis, including flow direction, flow accumulation, drainage lines, and micro-watershed delineation. Together, these outputs established a coherent hydrologic framework for the Río Grande watershed and enabled Curve Number assignment at the micro-watershed scale rather than through a single lumped basin representation.

The Río Grande watershed was represented by only two hydrologic soil groups, B and C, derived from medium- and fine-textured soils. This classification defined the study area as having moderate to slow infiltration conditions and provided a clear edaphic basis for interpreting runoff behavior and assigning Curve Number values across the watershed.

Slope processing classified the watershed into two hydrologically relevant ranges, 0–3% and >3%, showing that gentle slopes are concentrated mainly in the downstream sector, while steeper gradients dominate most of the basin. This spatial differentiation strengthened the hydrologic sensitivity of the method and improved the territorial consistency of Curve Number allocation.

The GIS-based integration of land use, hydrologic soil groups, and slope classes generated the thematic polygons required for Curve Number calculation and supported the production of the final raster CN map. This map synthesized the spatial variability of runoff potential in the Río Grande watershed and provided a direct technical input for infiltration-loss modeling in HEC-HMS.

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Appendix I

Curve Number (CN) Values as a Function of Land Use, Slope, and Hydrologic Soil Group

Land Use	Slope	HSG A	HSG B	HSG C	HSG D
Fallow R	>= 3%	77	68	89	93
Fallow N	>= 3%	74	82	86	89
Fallow R/N	< 3%	71	78	82	86
Row crops R	>= 3%	69	79	86	89
Row crops N	>= 3%	67	76	82	86
Row crops R/N	< 3%	64	73	78	82
Winter cereals R	>= 3%	63	75	83	86
Winter cereals N	>= 3%	61	73	81	83
Winter cereals R/N	< 3%	59	70	78	81
Poor crop rotation R	>= 3%	66	77	85	89
Poor crop rotation N	>= 3%	64	75	82	86
Poor crop rotation R/N	< 3%	63	73	79	83
Dense crop rotation R	>= 3%	58	71	81	85
Dense crop rotation N	>= 3%	54	69	78	82
Dense crop rotation R/N	< 3%	52	67	76	79
Poor grassland	>= 3%	68	78	86	89
Fair grassland	>= 3%	49	69	78	85
Good grassland	>= 3%	42	60	74	79
Very good grassland	>= 3%	39	55	69	77
Poor grassland	< 3%	46	67	81	88
Fair grassland	< 3%	39	59	75	83
Good grassland	< 3%	29	48	69	78
Very good grassland	< 3%	17	33	67	76
Regular forest-production plantations, poor	>= 3%	45	66	77	83
Regular forest-production plantations, fair	>= 3%	39	60	73	78
Regular forest-production plantations, good	>= 3%	33	54	69	77
Regular forest-production plantations, poor	< 3%	40	60	73	78
Regular forest-production plantations, fair	< 3%	35	54	69	77
Regular forest-production plantations, good	< 3%	25	50	67	76
Forest cover (woodland, scrub, etc.), very sparse	All slopes	56	75	86	91
Forest cover (woodland, scrub, etc.), sparse	All slopes	46	68	78	83
Forest cover (woodland, scrub, etc.), medium	All slopes	40	60	69	76
Forest cover (woodland, scrub, etc.), dense	All slopes	36	52	62	69
Forest cover (woodland, scrub, etc.), very dense	All slopes	29	44	54	60
Permeable rock	>= 3%	94	94	94	94
Permeable rock	< 3%	91	91	91	91
Impermeable rock	>= 3%	96	96	96	96
Impermeable rock	< 3%	93	93	93	93

Source: Ferrér et al. (1995)