

BAHIR DAR UNIVERSITY
Department of Geography and Environmental Studies
Course: Geocomputation and Spatial Science

LAB REPORT 4

Watershed Delineation and Morphometric Analysis of the Gilgel Abay Watershed Using ArcGIS Pro

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Table of Contents

Table of Contents 2
1. Introduction 4
2. Study Area and Data 4
Part I: Watershed Delineation 5
3.1 Methodology 5
3.1.1 DEM Preparation: Mosaicking and Projection 5
3.1.2 Pour Point Identification 5
3.1.3 Hydrologic Surface Derivation (Fill, Flow Direction, Flow Accumulation) 6
3.1.4 Snapping the Pour Point 6
3.1.5 Stream Network Extraction 6
3.1.6 Watershed Delineation and Stream-to-Feature Conversion 7
3.2 Results and Discussion 8
Question 1: Projection choice and raster data types 8
Question 2: Cell size and elevation statistics after mosaicking 8
Question 3: Why “Fill” is needed 8
Question 4: Difference between the original and filled DEM 9
Question 5: The D8 flow-direction method 9
Question 6: Unusual patterns in the extracted streams 9
Question 7: Are all of the extracted hydrographic features true streams? 10
Question 8: Total contributing area and other settlements 10
Question 9: Extracting major streams only (threshold > 4000) 10
Part II: Watershed Morphometric Analysis 12
4.1 Methodology 12
4.1.1 Stream Ordering 12
4.1.2 Micro-watershed Delineation 12
4.1.3 Aggregation into Third-Order Basins 12
4.1.4 Linear Parameters 13
4.1.5 Areal and Relief Parameters 13
4.1.6 Basin Prioritization 13
4.2 Results 15
4.3 Basin Prioritization Results 15
4.4 Summary Questions 17
Question 1: Dominant stream order and what it indicates 17

Question 2: Implications of the parameters for hydrology and watershed management 17
Question 3: Priority map and explanation 18
5. Conclusion 19
References 19
Appendix: List of Submitted Output Files 20

1. Introduction

This lab exercise was carried out to build practical skills in raster-based hydrological analysis using the Hydrology toolset and ModelBuilder in ArcGIS Pro, and to apply these skills to the morphometric characterization of a watershed for the purposes of planning and management. The exercise was completed in two parts. In Part I, a Digital Elevation Model (DEM) of the Gilgel Abay area was used to derive hydrologic surfaces (flow direction and flow accumulation), from which a stream network and the watershed boundary contributing to an outlet located southeast of Kunzila town were delineated. In Part II, the delineated watershed was subdivided into micro-watersheds, aggregated into a small number of third-order basins, and a set of linear, areal, and relief morphometric parameters were computed and used to prioritize the basins according to their relative erosion risk.

The specific objectives of the exercise were to: (i) generate hydrologically meaningful surfaces (filled DEM, flow direction, flow accumulation) from raw elevation data; (ii) delineate the watershed and stream network contributing to a specified outlet point; and (iii) compute and interpret morphometric parameters describing basin size, shape, and relief, and use them to prioritize sub-basins for conservation planning.

2. Study Area and Data

The study area is the catchment of the Gilgel Abay River, located southeast of Kunzila town in the Amhara National Regional State, Ethiopia, within the wider Lake Tana basin. The analysis was based on the following datasets, supplied in the Lab_Watershed folder:

- Two SRTM Digital Elevation Model (DEM) tiles covering the study area
- A point shapefile of towns (including Kunzila), used to derive the watershed outlet (pour point)
- A boundary polygon, used to constrain the processing extent of the merged DEM
- A supplementary pour-point shapefile (PourPoints_Micro), used for micro-watershed delineation in Part II

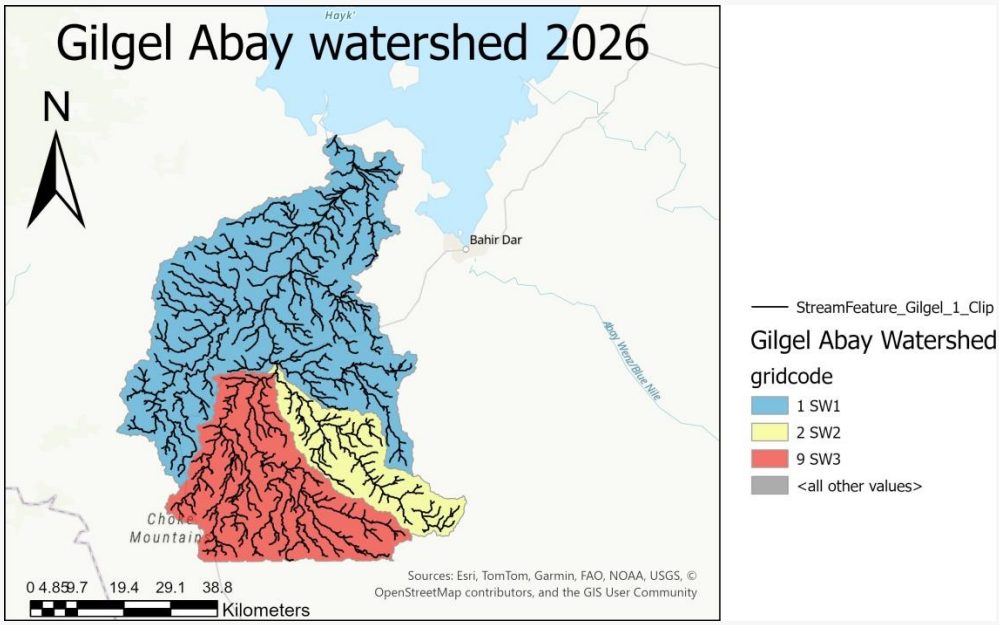

Figure 1. Location of the study area the Gilgel Abay catchment, Amhara Region, Ethiopia.

Part I: Watershed Delineation

3.1 Methodology

3.1.1 DEM Preparation: Mosaicking and Projection

The two SRTM DEM tiles were merged into a single continuous raster using the Mosaic to New Raster tool, which allowed the merge and the re-projection to be carried out in one operation. The output raster was projected to the Africa Lambert Conformal Conic coordinate system (WGS 1984 datum), stored as a 16-bit unsigned integer raster, and the processing extent was constrained to the boundary polygon supplied with the data. The merged, re-projected raster was saved as GilgelAbay_dem.

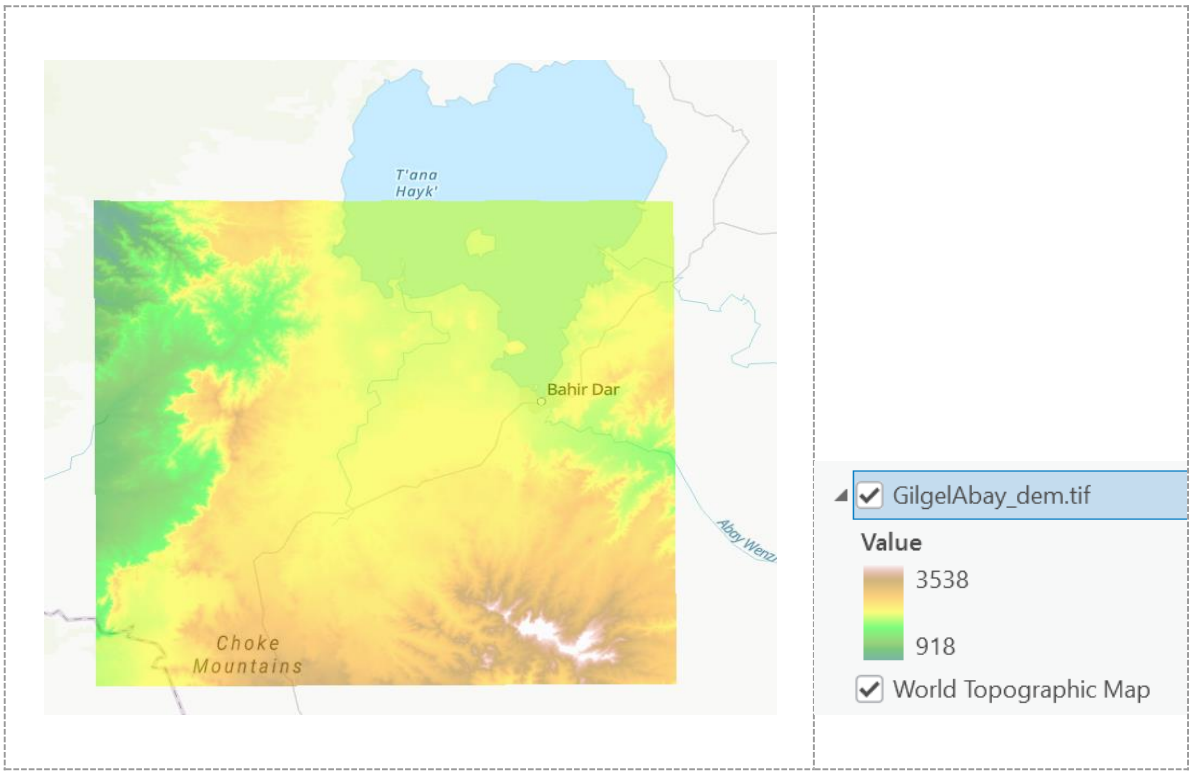

Figure 2. Mosaicked and re-projected Gilgel Abay DEM (GilgelAbay_dem), displayed with an elevation colour ramp. Laid with 50%Transperncy;over Topomap base layer

Table 1. Cell size and elevation statistics of GilgelAbay_dem after mosaicking and re-projection.

Parameter	Value
Output cell size (m)	*30m*
Minimum elevation (m a.s.l.)	*918*
Maximum elevation (m a.s.l.)	*3538*
Mean elevation (m a.s.l.)	*1938.45*
Standard deviation (m)	*355.64*

Values obtained from the raster's Properties → Source tab (cell size) and the Statistics histogram (elevation statistics) in ArcGIS Pro.

3.1.2 Pour Point Identification

The watershed outlet (pour point) was established using the Towns layer. The Kunzila town point was selected from the attribute table and exported to the working geodatabase as GilgelAbay_pt. Because the actual outlet of the Gilgel Abay watershed lies approximately 15 km southeast of Kunzila town, the exported point was relocated using the Editor Modify toolbar to a position roughly 15 km to the southeast of the original town location, placing it on the main channel of the Gilgel Abay River.

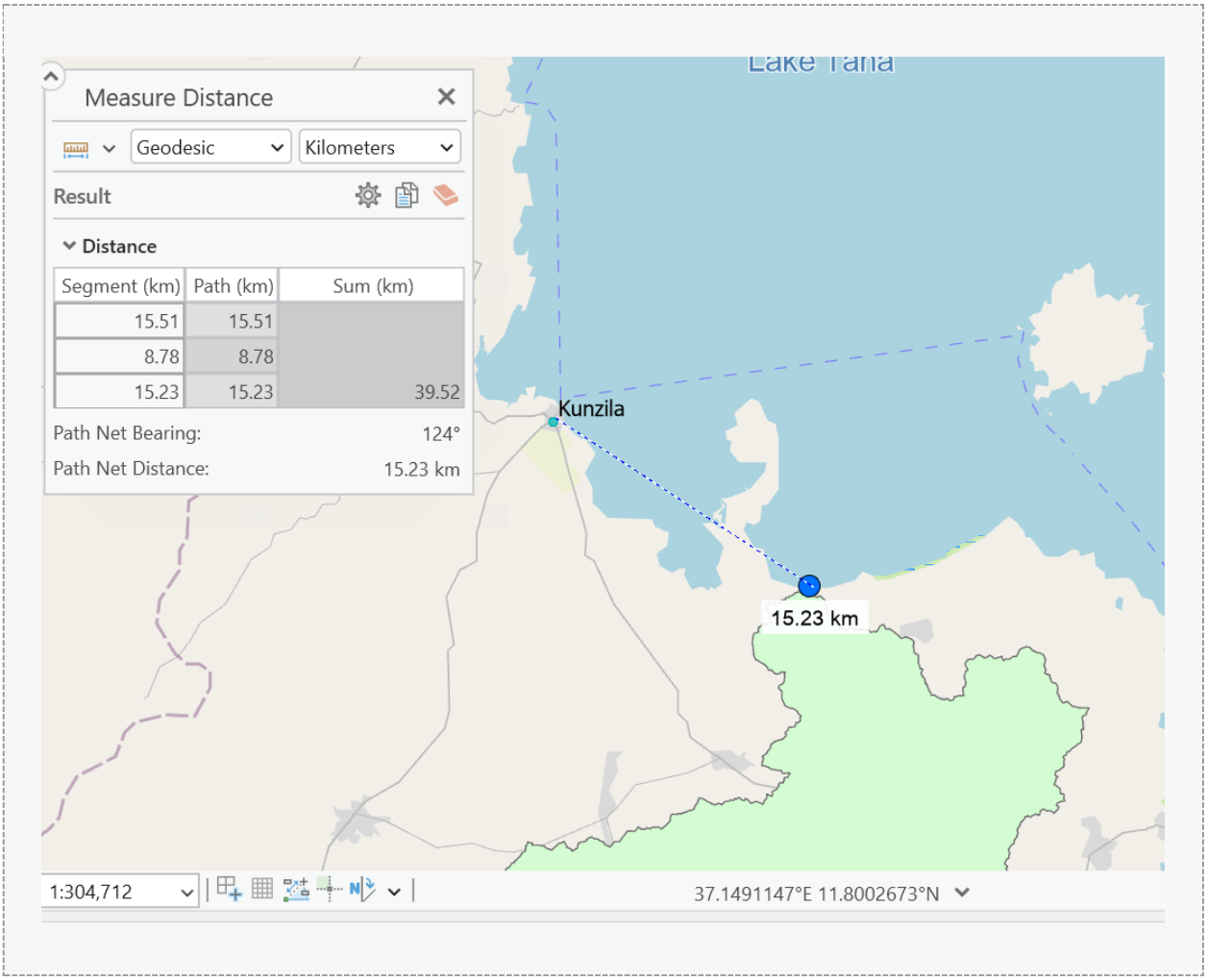

Figure 3. Location of Kunzila town and the relocated pour point (GilgelAbay_pt), approximately 15 km to the southeast.

3.1.3 Hydrologic Surface Derivation (Fill, Flow Direction, Flow Accumulation)

A geoprocessing model was built in ModelBuilder to automate the derivation of hydrologic surfaces from GilgelAbay_dem (Figure 4). The model consisted of three sequential steps:

1. A fill tool was applied to the input DEM to remove spurious sinks and ensure unbroken downslope flow paths; output saved as **DEMFill**.

2. Flow Direction tool was applied to DEMFill to compute, for each cell, the steepest-descent flow direction toward one of its eight neighbours; output saved as **fdr**.
3. Flow Accumulation tool was applied to **fdr** to compute, for each cell, the number of upstream cells draining into it; output saved as **FlowAccu**.
4. The model (Fig 4) also includes ***Snapping the Pour Point, stream network extraction, stream feature creation*** *which are discussed below.*

The model was validated and run, and the resulting Flow Direction, Flow Accumulation rasters,stream raster and vector were added to the map for inspection, experimenting with different colour ramps to highlight the drainage pattern in the Flow Accumulation layer and other layers accordingly.

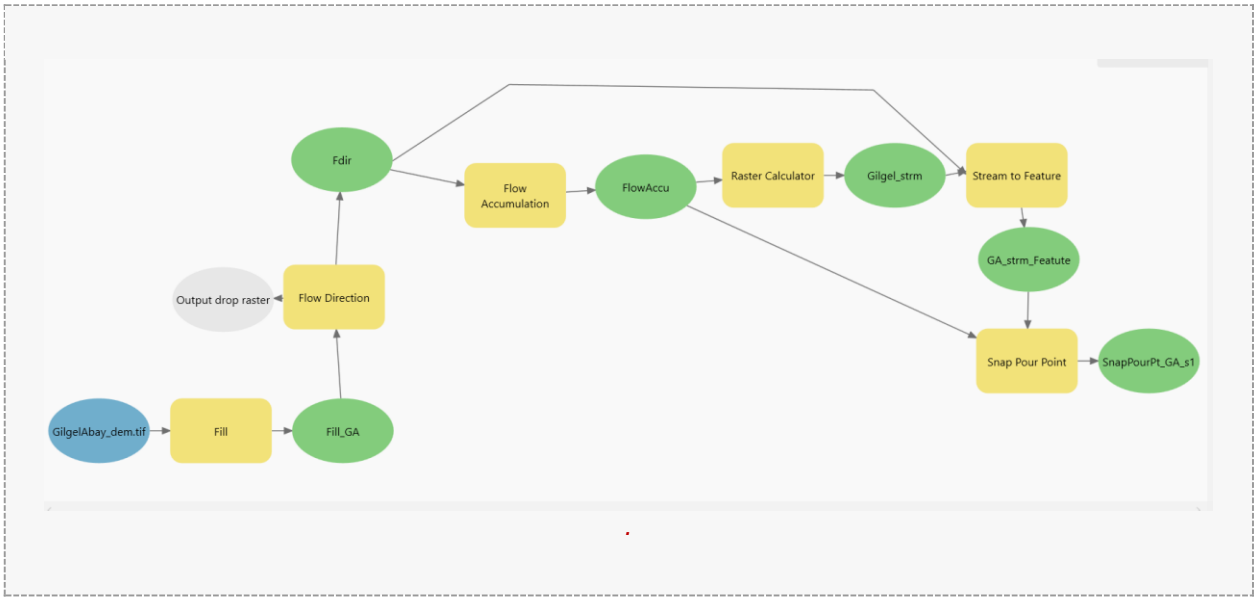

Figure 4. ModelBuilder workflow showing the Fill → Flow Direction → Flow Accumulation sequence.

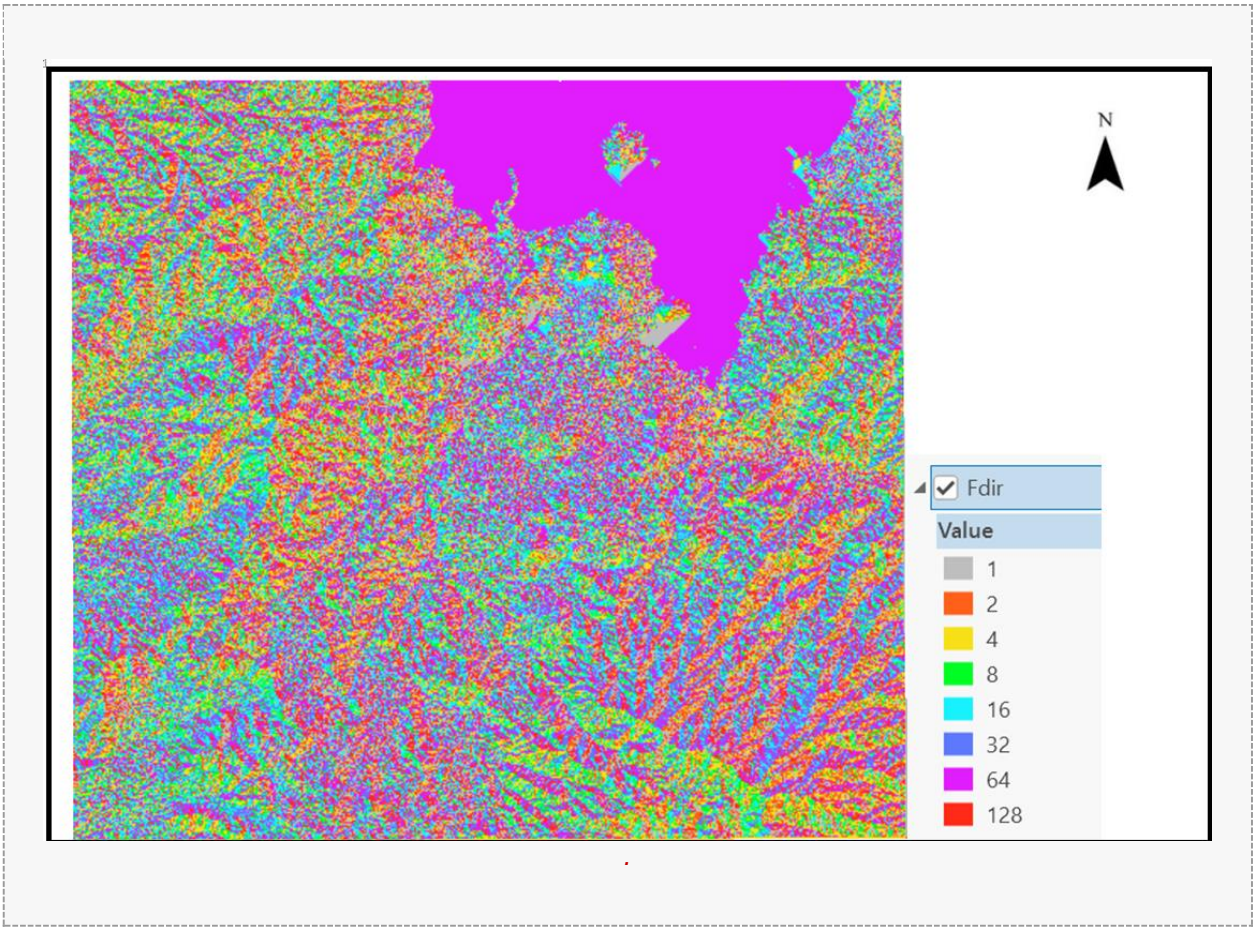

Figure 5. Flow Direction raster (fdr) derived from the filled DEM.

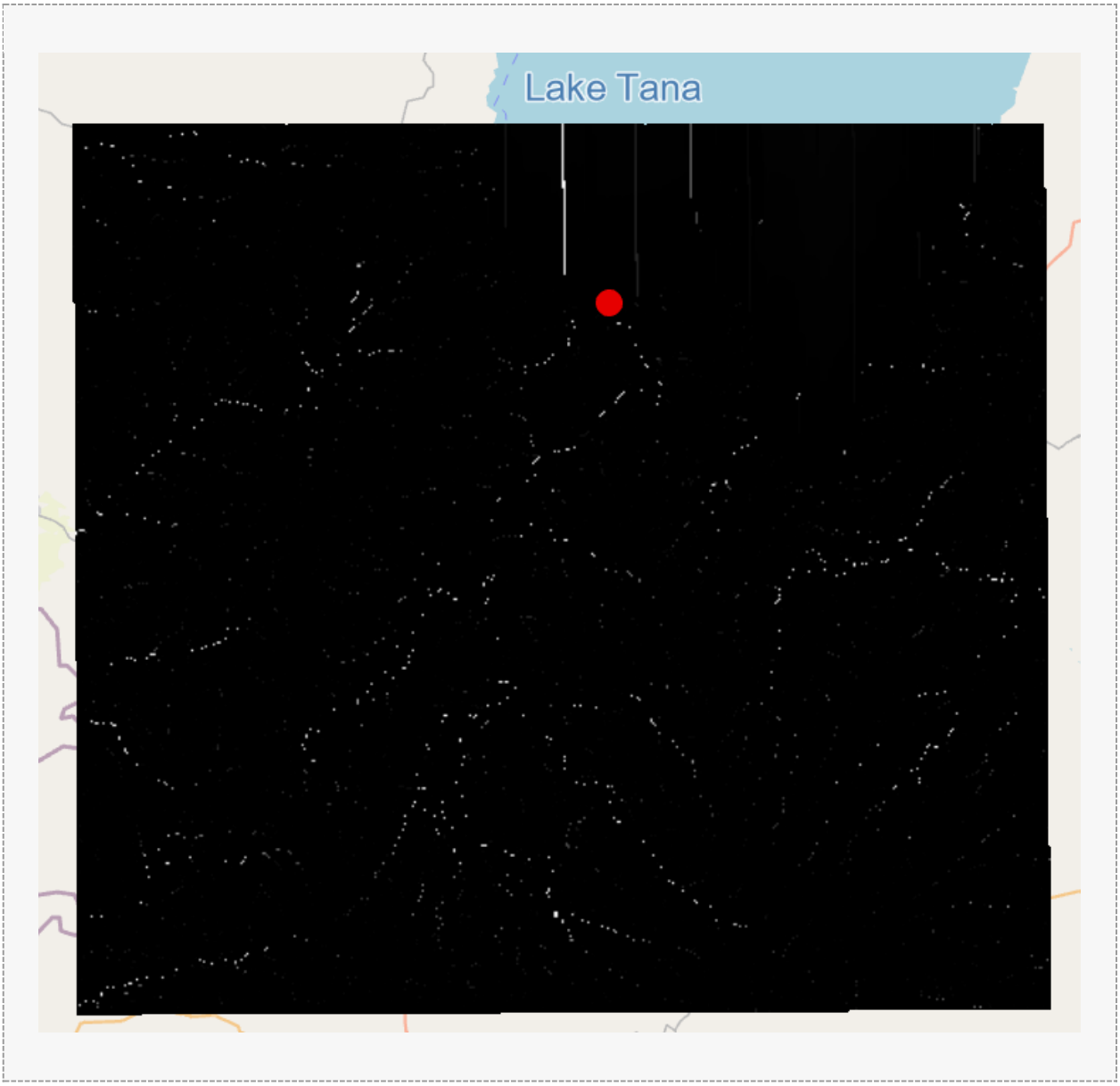

Figure 6. Flow Accumulation raster (FlowAccu) derived from the flow direction raster, displayed with a stretched colour ramp to highlight the drainage network.

3.1.4 Snapping the Pour Point

The relocated pour point did not necessarily coincide exactly with a cell of high flow accumulation, so the Snap Pour Point tool was used to relocate it to the nearest cell of high accumulated flow, using FlowAccu as the input flow accumulation raster and a search distance of 1,800 m. This step ensures that the pour point used for watershed delineation corresponds to an actual concentrated flow path rather than an arbitrary cell on a hillslope.

3.1.5 Stream Network Extraction

A preliminary stream network was extracted from the Flow Accumulation raster using the Raster Calculator, applying the conditional expression Con([FlowAccu] > 2000, 1) to flag all cells with more than 2,000 contributing upstream cells. The output binary raster was saved as **Gilgel_strm** and visually inspected against the Flow Accumulation layer to confirm that it produced a reasonable representation of the drainage network.

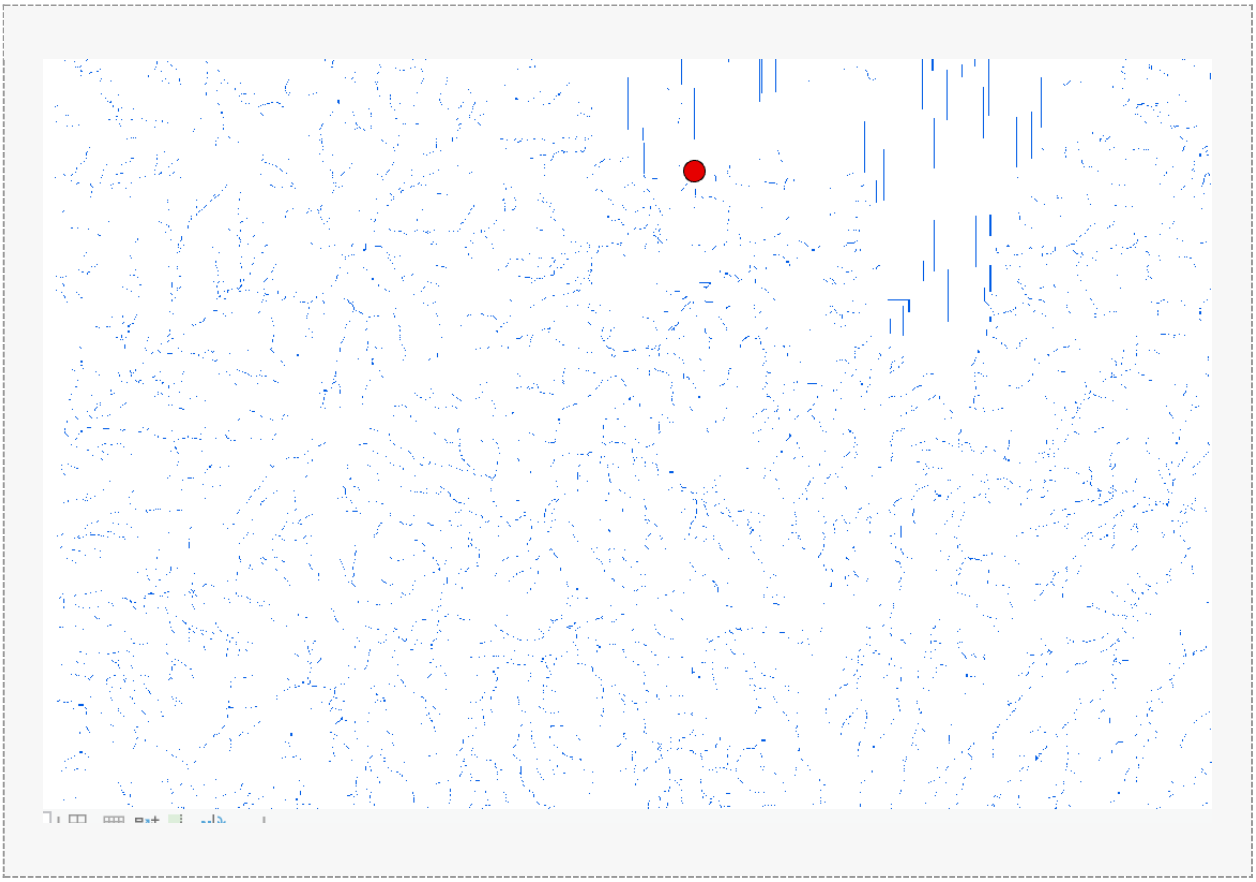

Figure 7. Stream network extracted at a flow-accumulation threshold of 2,000 cells (Gilgel_strm), with pour point put for reference.

3.1.6 Watershed Delineation and Stream-to-Feature Conversion

The watershed contributing to the snapped pour point was delineated using the Watershed tool, with the flow direction raster (fdr) and the snapped pour point as inputs.

3.1.6 Stream Feature

The raster stream network was converted to a vector polyline feature class using the **Stream to Feature tool,** with the “Simplify polylines” option enabled, using the flow direction raster to establish connectivity between stream segments.

3.1.7 Delineate Watershed: Finally,the Watershed tool was run with fdr(lowdirection)as Input raster and the snapped pour point output; and saved the final raster output as GilgelAbay_Watershed.

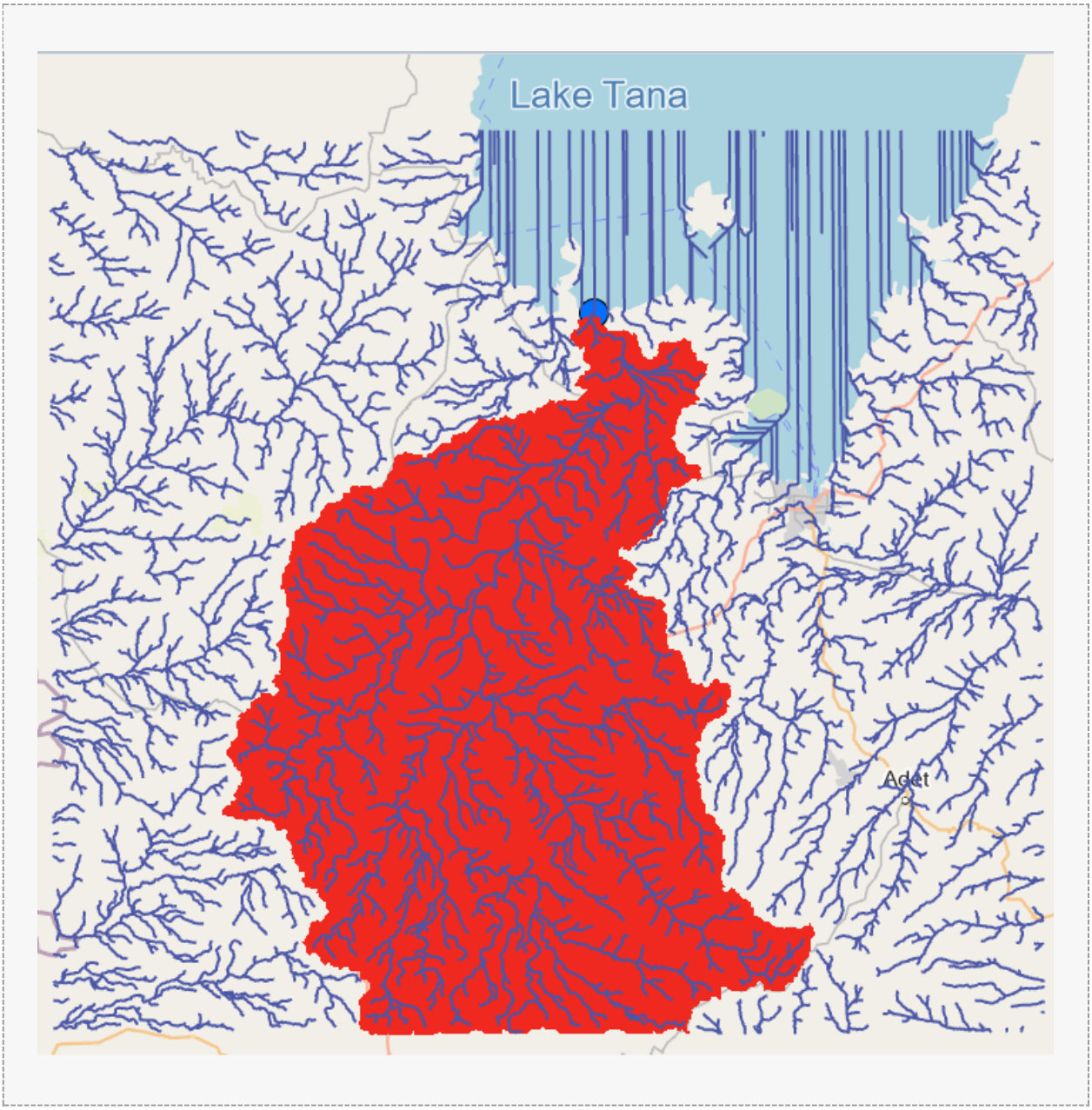

Figure 8. Delineated Gilgel Abay watershed boundary with the vectorized stream network and Pour point superimposed on openstreet map as baselayer.

3.2 Results and Discussion

Question 1: Projection choice and raster data types

The merged DEM was projected to the Africa Lambert Conformal Conic coordinate system, referenced to the WGS 1984 datum. A conformal projection preserves local angles and shapes, which matters for this exercise because the Flow Direction calculation depends on accurately measuring the angular relationship between each cell and its eight neighbours; a projection that distorted angles would bias the direction in which the model routes simulated flow. Lambert Conformal Conic is also well suited to land areas with a predominantly east–west extent at mid-latitudes, such as the African continent, which is why it is widely used as a standard continental projection for African datasets.

Regarding raster data types: integer rasters were used for the Flow Direction, extracted-stream, and stream-order outputs because these represent discrete categorical values (Flow Direction can only take values 1, 2, 4, 8, 16, 32, 64, or 128), while the elevation raster was stored as a 16-bit unsigned integer to accommodate the positive elevation range (918–3,538 m) without negative values. Floating-point types would be appropriate where values are continuously variable with meaningful decimal precision (e.g. slope in degrees), or where negative values are possible (e.g. elevations below sea level). The choice of bit depth (8-, 16-, or 32-bit) trades off the representable value range against file size and processing performance.

Question 2: Cell size and elevation statistics after mosaicking

After mosaicking and re-projecting, the output cell size and elevation statistics for GilgelAbay_dem are reported in Table 1 above.

Question 3: Why "Fill" is needed

SRTM-derived DEMs commonly contain small, spurious depressions ("sinks") — single cells or short runs of cells that are surrounded by higher-elevation neighbours and therefore have no downslope outlet. These artifacts arise from sensor noise, interpolation error during DEM generation, and obstructions such as dense vegetation canopy or buildings present at the time of data acquisition. If left uncorrected, these sinks interrupt the flow path computed by Flow Direction: a cell with no lower neighbour has nowhere to route simulated flow, so the derived drainage network becomes fragmented and Flow Accumulation values immediately downstream are understated. The Fill tool resolves this by identifying each sink and raising its elevation (and that of any cells inside the depression) up to the elevation of its lowest outlet — the pour point on the rim of the depression. This produces a hydrologically continuous surface in which every cell has a defined downslope path to the edge of the DEM, which is a necessary precondition for reliable flow direction, flow accumulation, and watershed delineation.

Question 4: Difference between the original and filled DEM

A different raster named **Fill_Diff** was created in the Raster Calculator (GilgelAbay_dem − DEMFill) to identify cells whose elevation changed during filling.

Because Fill can only raise (never lower) cell elevations, all values in the difference raster are ≤ 0. ArcGIS Pro reports a range of 0 to −60 m: zero indicates no change was made, while negative values record the depth of the sink that was removed. Modified cells render black on the map, revealing a widespread “salt-and-pepper” pattern of small, scattered pits across the catchment—the classic signature of SRTM sensor noise—alongside denser clusters in two low-relief areas: near the watershed outlet and along the Lake Tana shoreline, where flat terrain and SRTM’s known difficulty measuring open water produce a disproportionately high frequency of spurious depressions. The single largest correction (−60 m) most likely reflects a genuine data anomaly in the SRTM tile at the lake margin rather than a real closed basin, and confirms that Fill modification was concentrated in the flattest, lowest-lying parts of the catchment rather than on the steeper interior slopes.

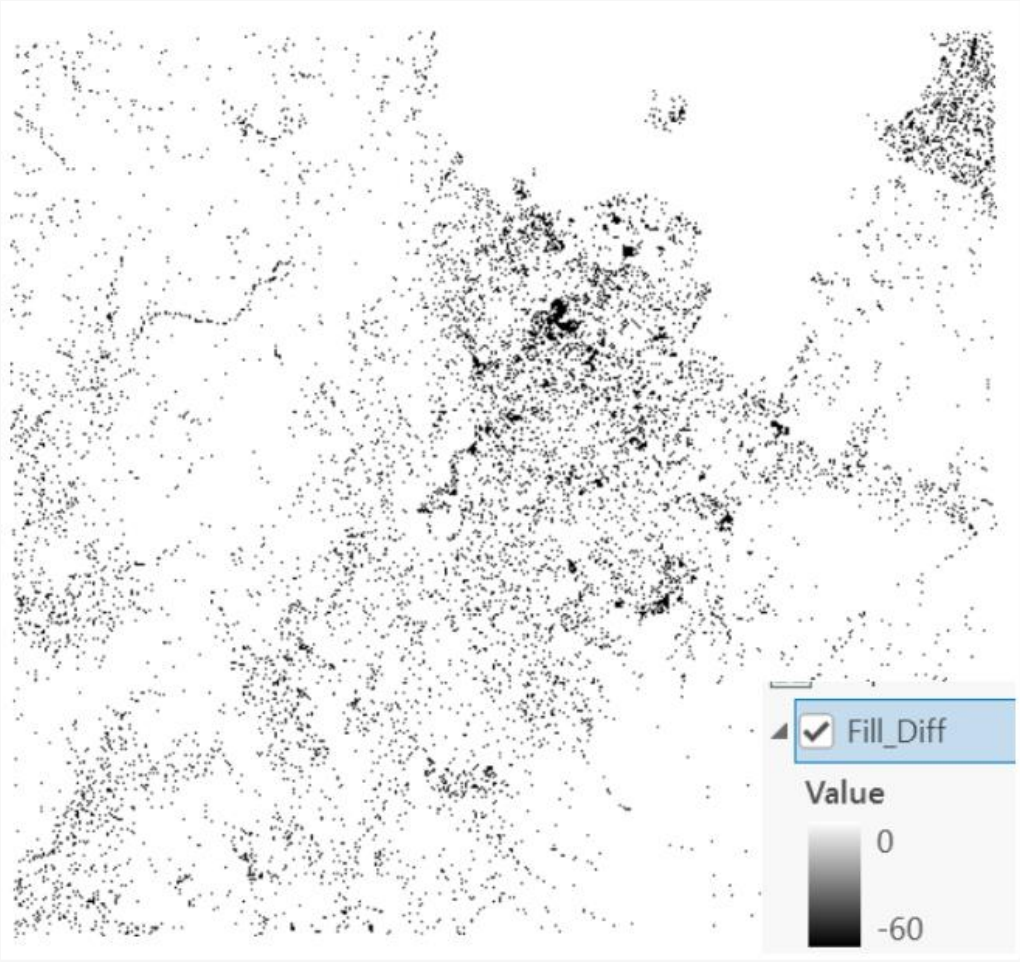

Figure 9. Difference surface between the original and filled DEM (GilgelAbay_dem − DEMFill), highlighting locations modified by the Fill operation.

Question 5: The D8 flow-direction method

ArcGIS Pro's Flow Direction tool uses the D8 (deterministic eight-neighbour) method by default. For each cell, the algorithm examines its eight immediate neighbours — the four that share an edge and the four that share only a corner — and computes the slope (elevation drop per unit distance) toward each one. Flow is then routed entirely toward the single neighbouring cell with the steepest downhill slope, which is why the method is described as a single-flow-direction algorithm, in contrast to multiple-flow-direction methods that can split flow between several downslope neighbours.

The output direction codes (1, 2, 4, 8, 16, 32, 64, 128) are successive powers of two, assigned clockwise starting from due east, so that each of the eight possible flow directions can be stored and later decoded uniquely. In ArcGIS Pro's default encoding: 1 = East, 2 = Southeast, 4 = South, 8 = Southwest, 16 = West, 32 = Northwest, 64 = North, and 128 = Northeast.

Question 6: Unusual patterns in the extracted streams

The most notable unusual pattern observed in the extracted stream network is the appearance of long, straight, parallel stream segments along the Lake Tana shoreline and immediately downstream of the watershed outlet. Unlike the sinuous, dendritic channels found across the interior of the catchment, these segments form near-geometric straight lines that do not follow natural terrain contours.

Such artifacts typically occur in very flat or low-relief areas, including those affected by the Fill operation. Because Fill resolves a depression by raising it to a single, flat outlet elevation, the Flow Direction algorithm can then produce a somewhat arbitrary, straight-line flow path across the levelled area rather than a route reflecting genuine micro-topography. As a result, the unusual stream segments observed near the Lake Tana margin and the outlet coincide spatially with the same areas identified in Question 4 as having the largest difference between the original and filled DEM, supporting the conclusion that they are a by-product of the Fill correction rather than genuine channel features.

Question 7: Are all of the extracted hydrographic features true streams?

Not necessarily. The threshold-based extraction method used here, Con([FlowAccu] > 2000, 1), flags every cell whose accumulated upslope area exceeds a single fixed numeric threshold, regardless of whether that flow path corresponds to a perennial river, an intermittent or ephemeral drainage line that only carries water in the rainy season, or an artifact of the filling process such as those discussed in Questions 4 and 6. A single global threshold cannot reliably distinguish between these cases, because the contributing area genuinely required to initiate a channel varies across a landscape with differing soil, land cover, slope, and rainfall conditions. Some of the extracted lines may also follow human-modified features, such as roadside ditches or field drainage channels, that mimic natural flow paths in a DEM. The extracted network is therefore

best treated as a hydrologically plausible drainage network rather than a verified inventory of real streams, and ideally would be cross-checked against topographic maps, orthoimagery, or field observation before being used for purposes such as buffer-zone delineation.

Question 8: Total contributing area and other settlements

The raster watershed delineated for the snapped pour point was converted to a polygon feature using the Raster to Polygon tool, and its area was obtained from the polygon's geometry (via Calculate Geometry). The total contributing area of the Gilgel Abay watershed at this outlet was found to be ***3378 km²*****.** Overlaying the Towns layer on the delineated watershed boundary shows that *the overlay confirms that the Kunzila town point lies at the watershed boundary, as expected;*

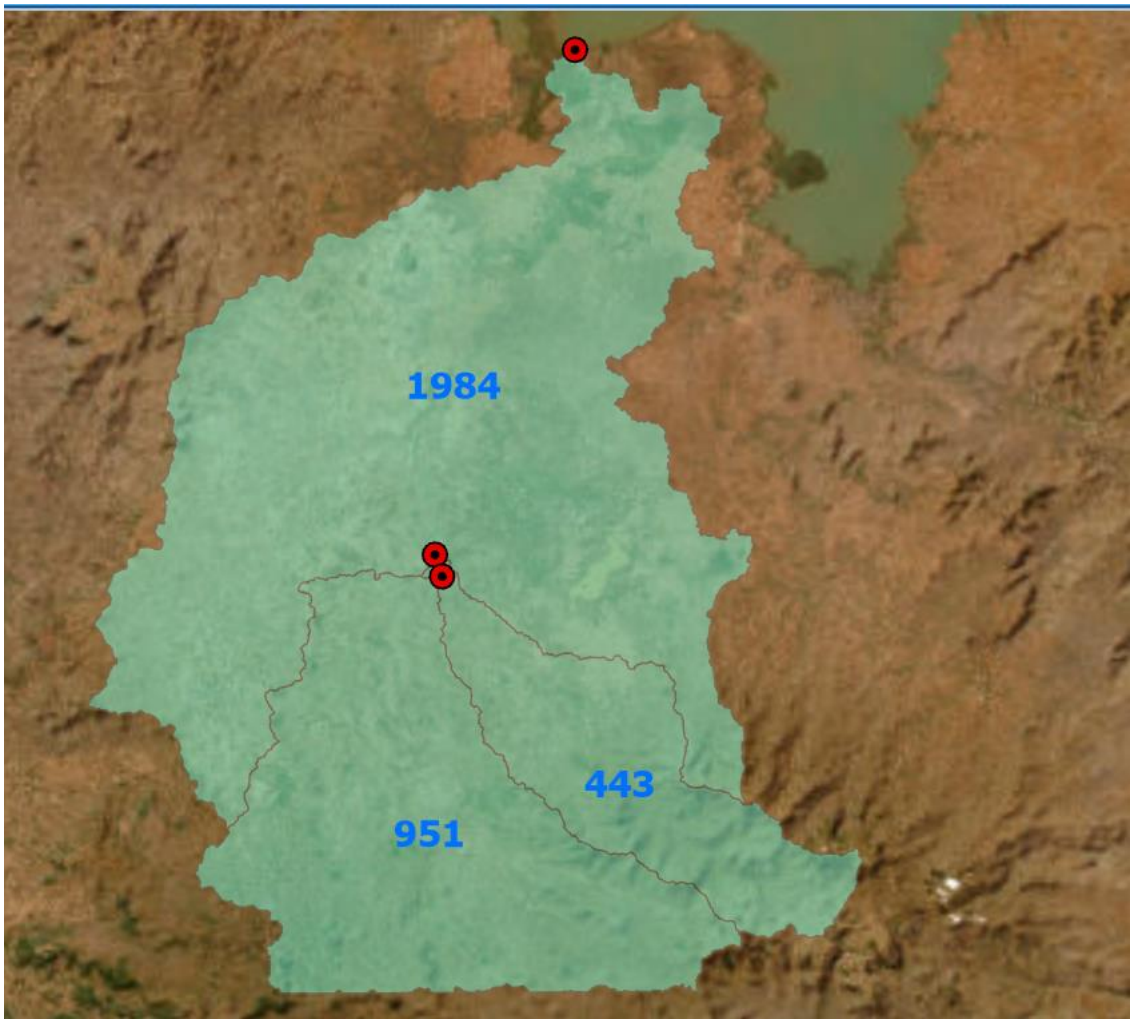



Figure 10. Gilgel Abay watershed boundary (converted to polygon) shown with area(Top), overlaid and zoomed in to Town .transparency 43%

Question 9: Extracting major streams only (threshold > 4000)

The stream-extraction step was repeated using the conditional expression Con([FlowAccu] > 4000, 1) by simply reconfiguring in mode builder, producing a sparser network representing only the larger, higher-order drainage features (Figure 11). Because a higher accumulation threshold requires a larger contributing upslope area before a cell is classified as a stream, this version of the network omits most of the small, low-order tributaries present in the >2,000 threshold network and retains mainly the main trunk channel(s) of the Gilgel Abay system.

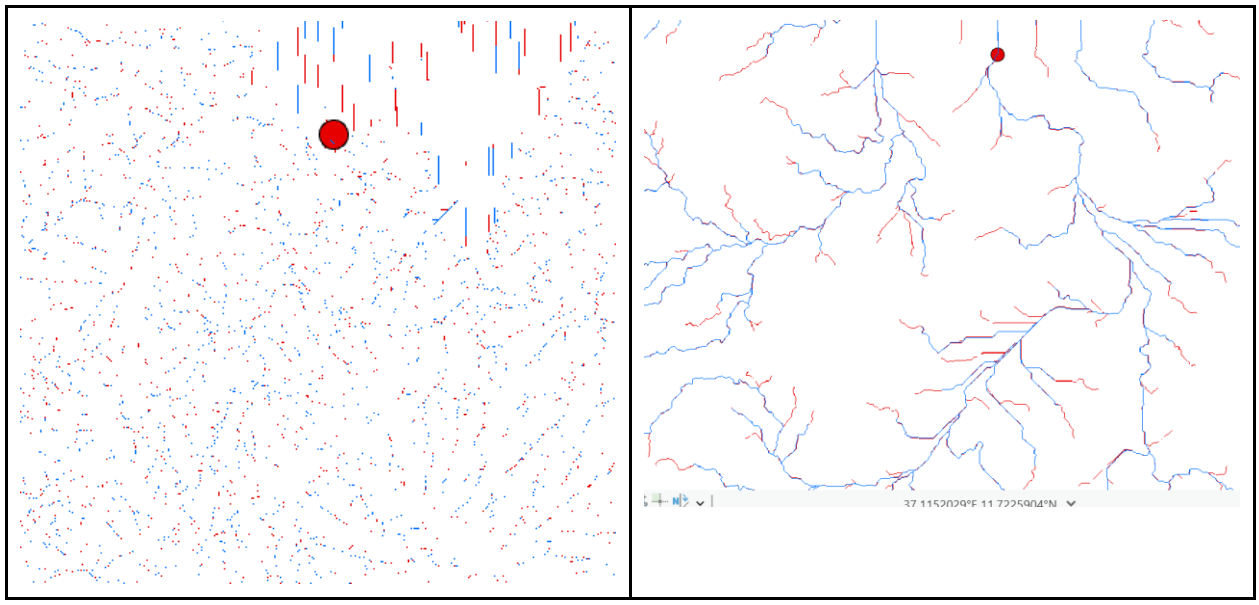

Figure 11. Comparison of Stream network extracted at a flow-accumulation threshold of 2000 cells (red) and 4,000 cells(Blue) overlaid, highlights how much shorter the 4000 network is relative to the 2000 network of drainage features.

Part II: Watershed Morphometric Analysis

4.1 Methodology

4.1.1 Stream Ordering

Working within the boundary of the delineated Gilgel Abay watershed (clipped to the GilgelAbay watershed polygon), the stream raster was first converted into discrete stream segments using the Stream Link tool, and the Strahler stream-ordering system was then applied to this stream-link raster using the Stream Order tool. Under the Strahler system, headwater segments with no upstream tributary are assigned order 1; when two segments of the same order meet, the resulting downstream segment is assigned the next higher order, while a junction between segments of different order retains the higher of the two orders. The resulting ordered-stream raster reflects the branching hierarchy of the drainage network, from small headwater tributaries (low order) to the main trunk channel (highest order).

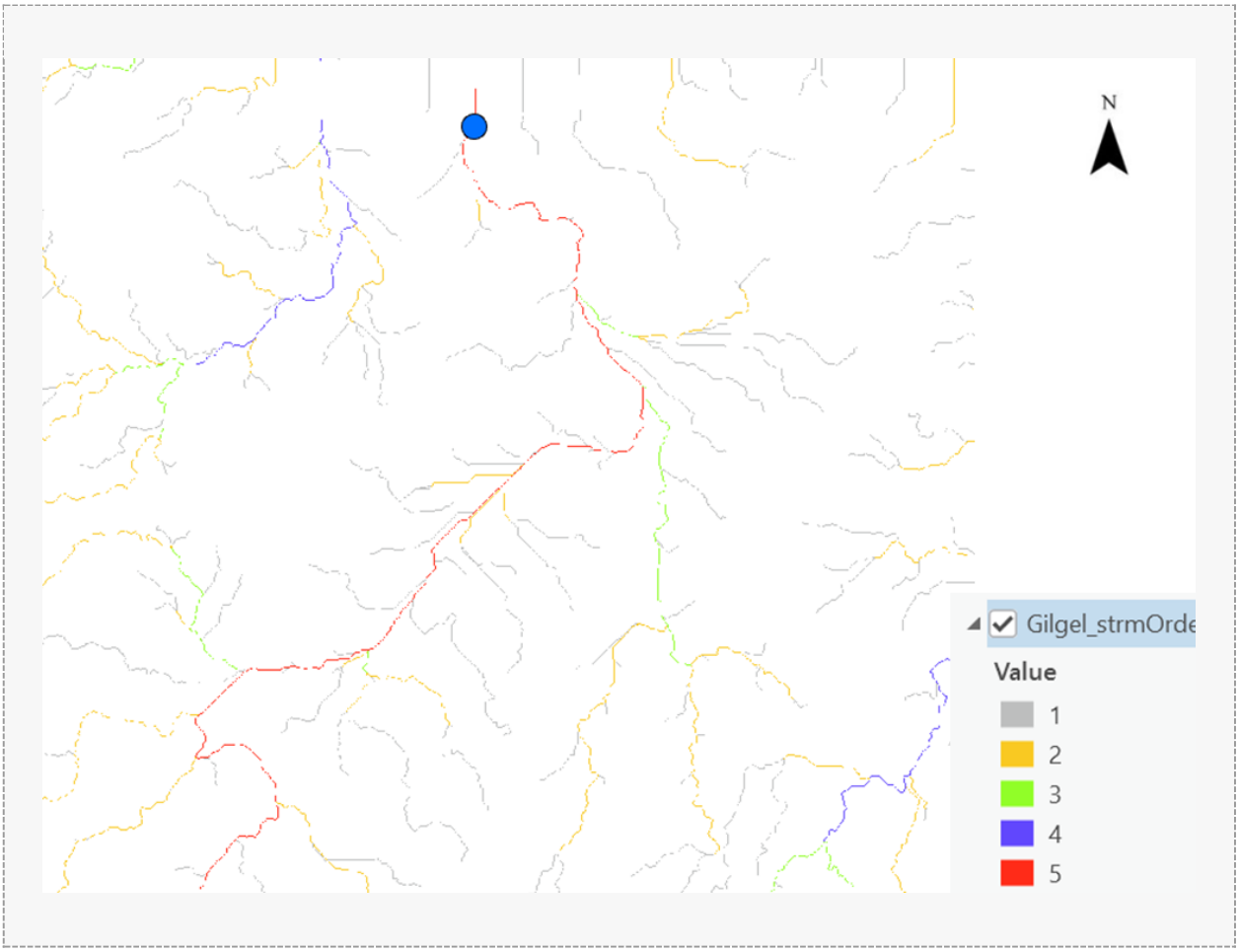

Figure 12. Strahler stream-order map for the Gilgel Abay watershed.partial zoomed view.

4.1.2 Micro-watershed Delineation

A set of pour points provided were established at outlets of interest within the watershed — by adjusting some manually at the centre of high-flow-accumulation cells in a new point shapefile, and taking some directly from the supplied PourPoints_Micro feature class — and used, together with the flow direction raster, as input to the Watershed tool to delineate a corresponding set of micro-watersheds. The ordered-stream raster was already converted to a polyline feature class, and the micro-watershed raster was converted to polygon features, to allow subsequent vector-based geometric and attribute analysis.

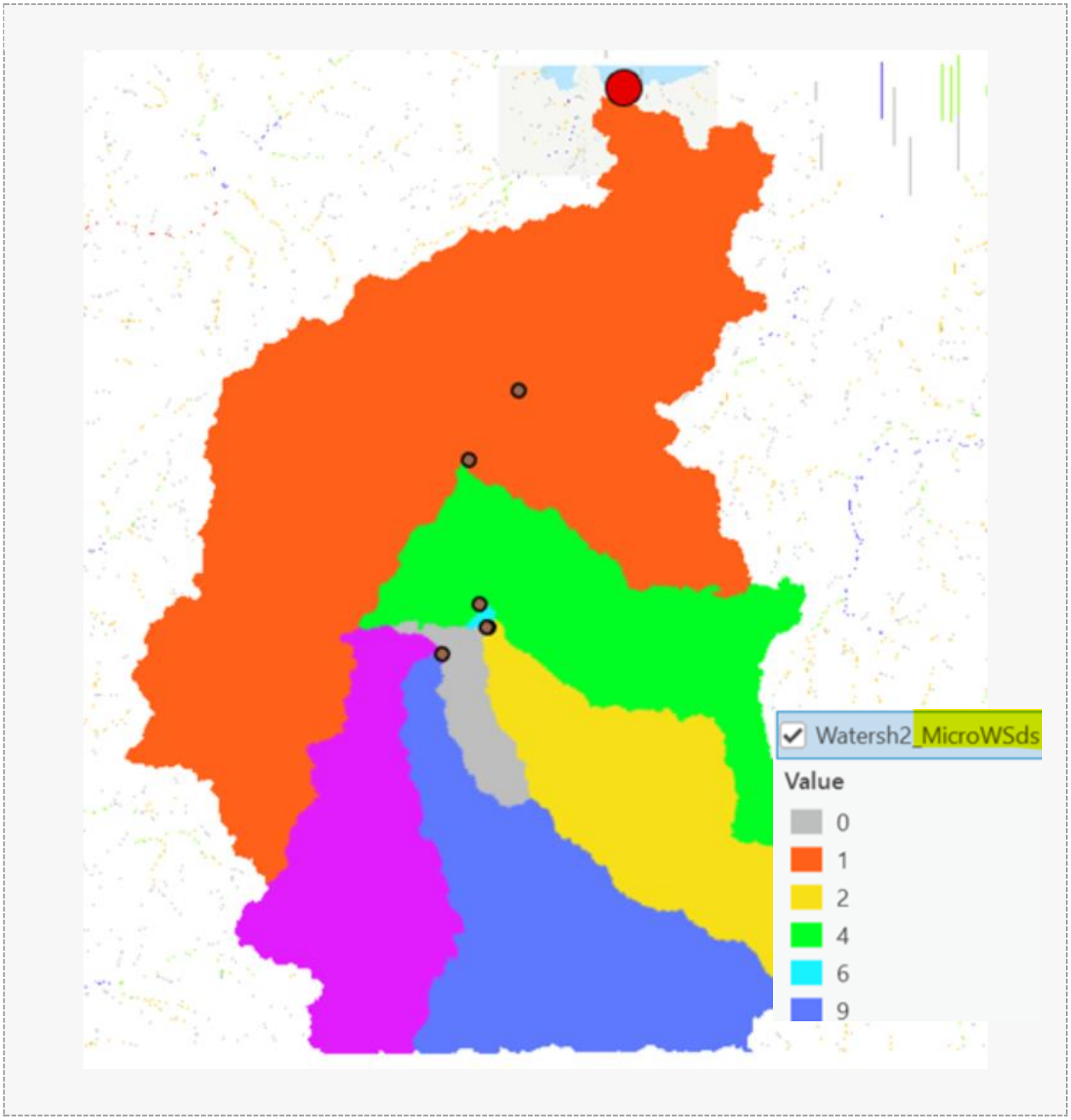

Figure 13. Micro-watershed pour points and the resulting micro-watershed delineation.

4.1.3 Aggregation into Third-Order Basins

Because the initial micro-watershed delineation produced a relatively large number of small catchments, neighbouring catchments were merged, guided by their Strahler stream order, into a smaller set (no more than five) of third-order basins suitable for comparative morphometric analysis and basin management. Adjacent micro-watersheds were merged manually using the Editor toolbar in ArcGIS Pro. Zonal Statistics as Table was then used, with the aggregated micro-watersheds as the zone layer and the Strahler order raster as the value layer, to summarize stream-order statistics within each merged basin, and again with the filled DEM as the value layer to obtain the basin's elevation range (used for basin relief in Section 4.1.5).

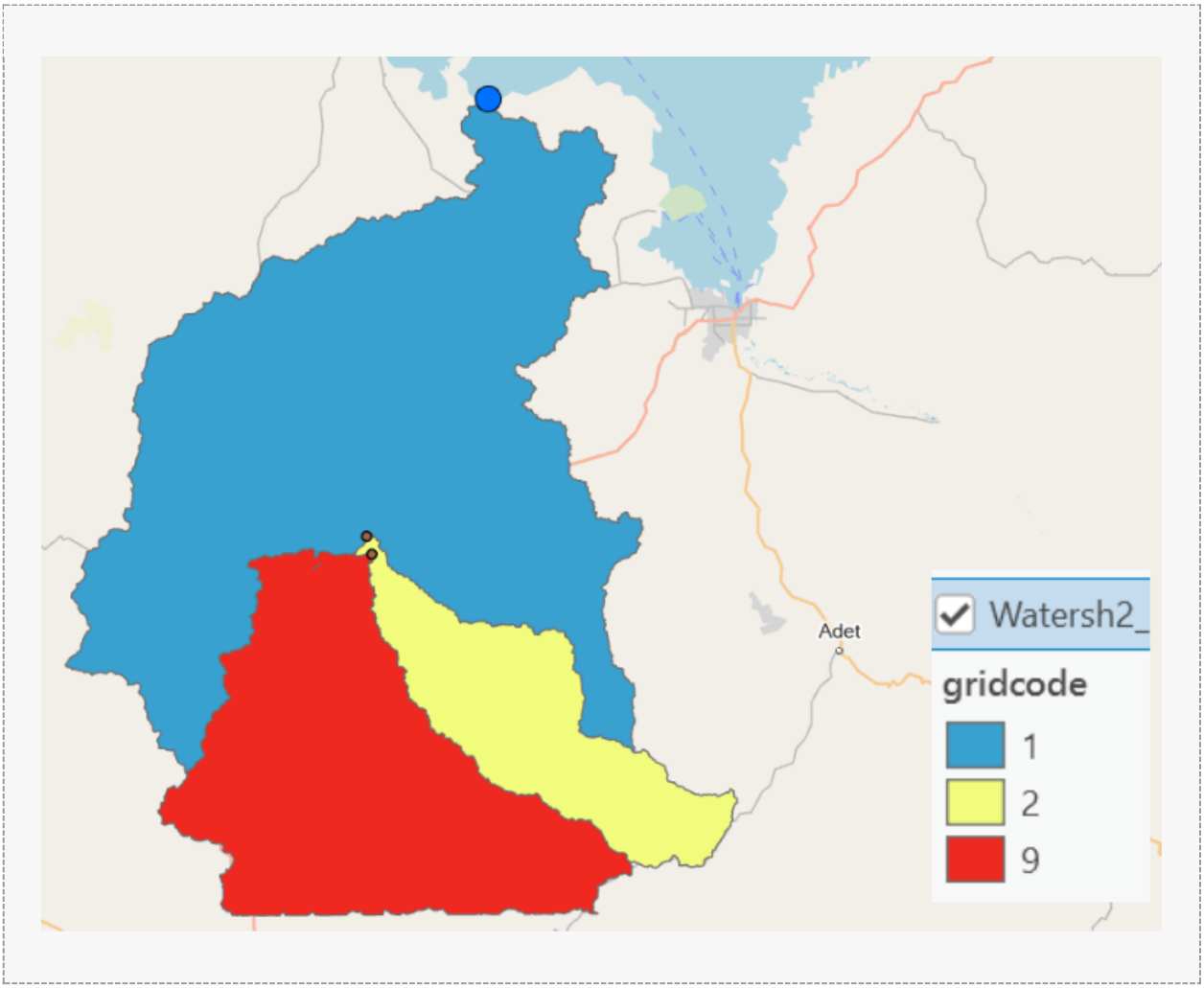

Figure 14. Aggregated third-order micro-watersheds used for the morphometric comparison.

4.1.4 Linear Parameters

The stream feature class was spatially joined to the aggregated micro-watershed polygons using a sum-based join, so that the Count field in the joined attribute table represents the number of stream segments per basin (Nu), and the Sum_Length field represents the total stream length per basin. Sum_Length was converted from metres to

kilometres in the Field Calculator (Sum_Length / 1000) to obtain Lu, and the mean stream length per order (Lum) was derived by dividing the total stream length of a given order by the number of segments of that order. The Flow Length tool was used to compute the maximum flow-path length for each basin (taken as the basin length, Lb), and Zonal Statistics as Table and Microsoft Excel were used to summarize this by basin. Drainage density (Dd = Lu / A) and stream frequency (Fs = Nu / A) were then calculated for each basin from Lu, Nu, and basin area A.

Obj_ID	Name	Basin AreakM 2(A)	Perimeter in km (P)	Stream length in km (Lu) SUM	Drainage density (Dd) Dd = Lu/A	Number of Streams (Nu)Count	Stream frequency (Fs)= Nu/A	BasinLength KM Lb	FormFactor Ff = A /Lb2	Elongation Ratio Re= (2*SQRT(A /pi))/2	DEM RANGE (Bh)	relief ratio (Rh = Bh / Lb)	Ruggedness Number (Rn) = Bh × Dd
8	sw1	1984	350	2946.50	1.49	145829.00	73.50	75.19	0.35	0.67	1359.00	18.07	2018.29
9	sw2	443	140	638.71	1.44	31470.00	71.04	47.36	0.20	0.50	1649.00	34.82	2377.51
11	sw3	951	178	1487.59	1.56	73652.00	77.45	38.03	0.66	0.92	1216.00	31.98	1902.12

Figure above shows the spreadsheet used to calculate parameters all in one place.

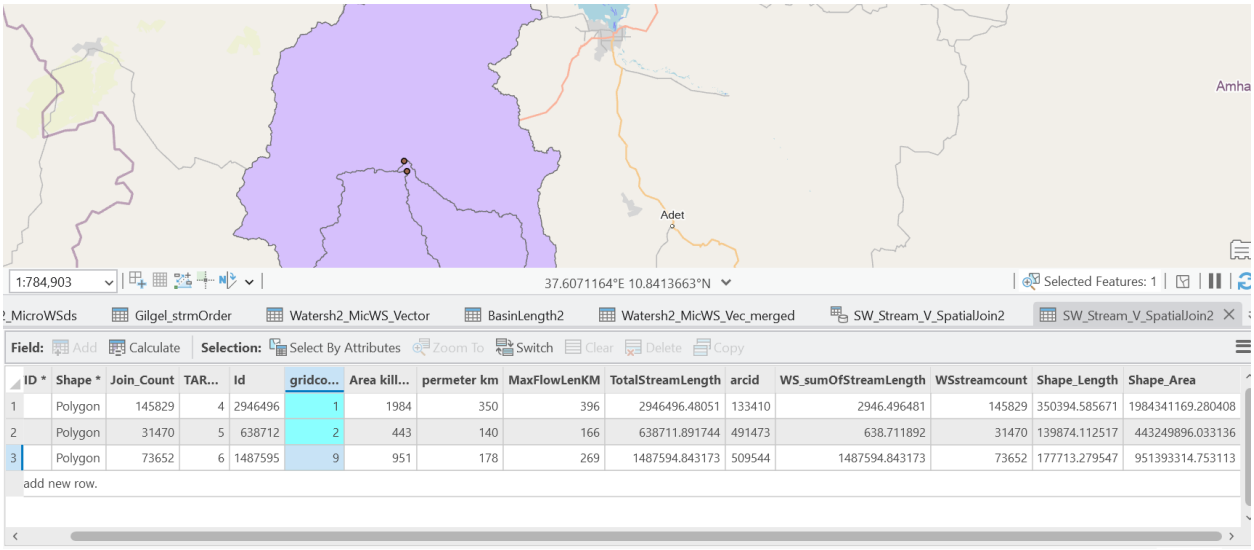

Figure above shows the three aggregated subbasins where the attribute table further developed through spatial joined and zonal statistics.

4.1.5 Areal and Relief Parameters

Basin area (A) and perimeter (P) were obtained directly from the polygon geometry of the aggregated basins (Calculate Geometry). Form factor (Ff = A / Lb²) was then calculated to characterize basin shape, recalling that a perfectly circular basin has the maximum possible form factor of 0.754, and that progressively smaller values indicate a progressively more elongated basin. Basin relief (Bh = Hmax − Hmin) was derived from the zonal maximum and minimum elevation of the filled DEM within each basin; relief ratio (Rh = Bh / Lb) was calculated from basin relief and basin length; and the

ruggedness number (Rn = Bh × Dd) was calculated as the product of basin relief and drainage density. These areal and relief calculations were carried out in Microsoft Excel using the zonal-statistics and geometry outputs exported from ArcGIS Pro.

4.1.6 Basin Prioritization

To prioritize the aggregated basins for soil-and-water conservation planning, each morphometric parameter was first converted to a basin-level raster and then reclassified into three priority classes (1 = high, 2 = medium, 3 = low) using the Natural Breaks (Jenks) classification method. Following Nooka Ratnam et al. (2005), drainage-related parameters — drainage density (Dd), stream frequency (Fs), ruggedness number (Rn), and relief ratio (Rh) — have a direct relationship with erodibility and were therefore ranked so that the highest value received rank 1. The form factor (Ff) has an inverse relationship with erodibility and was ranked so that the lowest value received rank 1. The compound value (Cp) for each basin was computed as the arithmetic mean of all five parameter ranks, and basins were assigned final priority classes based on ascending Cp score (lowest Cp = highest erosion risk).

4.2 Results

The morphometric parameters computed for each of the aggregated third-order basins are summarized in Tables 2 and 3 below.

Table 2. Linear morphometric parameters of the aggregated micro-watersheds.

Basin	Stream order (U)	No. of streams (Nu)	Stream length, Lu (km)	Drainage density, Dd (km/km²)	Stream frequency, Fs (no./km²)
Basin SW 1	*5*	*145829.00*	*2946.50*	*1.49*	*73.50*
Basin SW 2	*5*	*31470.00*	*638.71*	*1.44*	*71.04*
Basin SW 3	*5*	*73652.00*	*1487.59*	*1.56*	*77.45*

Table 3. Areal and relief morphometric parameters of the aggregated micro-watersheds.

Basin	Area, A (km²)	Perimeter, P (km)	Basin length, Lb (km)	Form factor, Ff	Basin relief, Bh (m)	Relief ratio, Rh	Ruggedness no., Rn
Basin SW 1	*1984*	*350*	*75.19*	*0.35*	*1359.00*	*18.07*	*2018.29*
Basin SW 2	*443*	*140*	*47.36*	*0.20*	*1649.00*	*34.82*	*2377.51*
Basin SW 3	*951*	*178*	*38.03*	*0.66*	*1216.00*	*31.98*	*1902.12*

Comparing basin area and perimeter with stream length and number across Tables 2 and 3, Basin SW 1 is the largest basin (1,984 km²) and has the greatest total stream length (2,946.5 km) and highest number of stream segments (145,829), while Basin SW 2 is the smallest (443 km²) with the shortest total stream length (638.7 km). Basin SW 3 has the highest drainage density (Dd = 1.56 km/km²) and stream frequency (Fs = 77.45

per km²), indicating the most dissected terrain, whereas Basin SW 2 has the lowest drainage density (1.44 km/km²) despite having the greatest basin relief (1,649 m), highest relief ratio (Rh = 34.82), and highest ruggedness number (Rn = 2,377.51).

4.3 Basin Prioritization Results

The reclassified factor maps for drainage density, stream frequency, ruggedness number, and form factor were combined by linear overlay to produce the final basin-prioritization map (Figure 15).

Figure 15. Final basin-prioritization map showing each aggregated basin's overall erosion-risk priority class (High / Medium / Low).

Table 4. Summary of basin prioritization results.

Table 4. Summary of basin prioritization results.

Basin	Dd rank	Fs rank	Rn rank	Rh rank	Ff rank	Cp (mean)	Priority class	Erosion-risk rank
Basin SW 1	2	2	2	3	2	2.20	Low	3
Basin SW 2	3	3	1	1	1	1.80	High	1
Basin SW 3	1	1	3	2	3	2.00	Medium	2

4.4 Summary Questions

Question 1: Dominant stream order and what it indicates

Zonal statistics was done to extract all possible statistics about the stream orders. First-order (headwater) streams are by far the most numerous in all three basins: they account for approximately 51%, 51%, and 47% of all stream cells in Basins SW 1, SW 2, and SW 3, respectively, with all basins reaching a maximum Strahler order of 5. A network dominated by low-order (1st–2nd order) streams generally indicates a well-dissected, headwater-dominated terrain in which runoff is generated and concentrated quickly across many small channels, producing a rapid, peaked hydrologic response and a relatively high erosion potential (Horton, 1945; Strahler, 1964). Conversely, a network with proportionally more high-order streams indicates a basin in which flow has already been integrated into fewer, larger trunk channels, producing a more attenuated, longer-duration discharge response and comparatively lower sediment-generating potential per unit area. In Strahler's (1964) hierarchical scheme, the dominance of a particular order therefore reflects the overall drainage texture and the relative balance between headwater (erosion-generating) and trunk-channel (transport-dominated) processes within the catchment.

Question 2: Implications of the parameters for hydrology and watershed management

Drainage density (Dd) is a key indicator of landscape dissection and runoff potential: a high Dd, as found in basins with weak, impermeable subsurface material, sparse vegetation, and high relief, indicates rapid runoff concentration, a flashy hydrologic response, and elevated erosion risk, while a low Dd suggests permeable substrate, denser vegetation cover, and a greater role for infiltration and groundwater recharge relative to surface runoff. Stream frequency (Fs) reinforces this signal, since basins with many stream segments per unit area tend to respond to rainfall more quickly. Form factor (Ff) and the related elongation/circularity ratios describe basin shape and therefore the timing of peak discharge: more circular basins (higher Ff) tend to concentrate runoff from across the basin at nearly the same time, producing higher but shorter-duration flood peaks, whereas elongated basins (lower Ff) generate flows that arrive at the outlet over a longer period, producing lower but more sustained peak flows. Basin relief (Bh), relief ratio (Rh), and the ruggedness number (Rn), which combines relief and drainage density, together capture the energy available for erosion and sediment transport: basins with high Bh, Rh, and Rn are associated with steeper slopes, faster overland flow velocities, and a greater capacity to mobilize and transport sediment.

For watershed management, basins that combine high drainage density, high stream frequency, high ruggedness, and low (elongated) form factor are the strongest candidates for prioritized soil-and-water conservation interventions — such as check dams, terracing, contour bunding, and afforestation — because they combine a high capacity to generate rapid, erosive runoff with limited opportunity for that runoff to attenuate before reaching the basin outlet. Conversely, basins with low drainage density and low relief are generally lower priority for erosion control but may instead warrant

attention for groundwater recharge enhancement or flood-storage planning, given their greater infiltration capacity and more delayed discharge response.

5. Conclusion

This exercise demonstrated the full ArcGIS Pro Hydrology workflow, from raw DEM tiles to a delineated, morphometrically characterized watershed. Mosaicking, projecting, and filling the DEM produced a hydrologically consistent surface from which flow direction, flow accumulation, a stream network, and the Gilgel Abay watershed boundary were successfully derived. Subdividing the watershed into micro-watersheds and aggregating these into *three* third-order basins made it possible to compute and compare linear, areal, and relief morphometric parameters across the catchment, and ultimately to prioritize sub-basins for erosion-risk management using a multi-criteria overlay. The results show that *Basin SW 2 was identified as the highest-priority sub-basin for conservation intervention, driven by its high ruggedness number (Rn = 2,377.51) and elongated form factor (Ff = 0.20), which together indicate steep, highly energetic terrain with concentrated erosion potential. Basin SW 3 ranked as medium priority due to the highest drainage density and stream frequency, while the large Basin SW 1 presented the lowest overall erosion risk despite its greater total stream network.* These findings illustrate how DEM-derived morphometric parameters provide an efficient, reproducible basis for watershed prioritization and conservation planning, particularly in data-scarce settings such as the Gilgel Abay catchment where SRTM data and free GIS tools can substitute for more resource-intensive field survey.

References

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Appendix: List of Submitted Output Files

The following ArcGIS Pro outputs are included in the accompanying zipped folder submitted alongside this report:

- GilgelAbay_dem — mosaicked and re-projected DEM
- DEMFill, fdr, FlowAccu — filled DEM, flow direction, and flow accumulation rasters
- GilgelAbay_pt — relocated and snapped pour point
- Gilgel_strm and the >4000-threshold stream raster
- Watershed polygon (Part I) and stream feature class (Stream to Feature output)
- Ordered stream raster/feature class, micro-watershed and aggregated-basin polygons (Part II)
- Zonal statistics tables, morphometric parameter spreadsheet, and reclassified factor/priority rasters
- ModelBuilder model(s) (.tbx) used for the Fill → Flow Direction → Flow Accumulation workflow

Remember to zip all listed outputs together with this write-up before submission, as required by the assignment instructions.