Integrated GIS-Based Assessment of Drainage Networks and Forest Fire Buffer Zones in Painganga Wildlife Sanctuary.

Aditya J. Chavan[1] ,Asmita B. Daspute[2]

Assistant Professor

Shri Datta College of Science, Hadgaon, Maharashtra.

Associate Professor SBES College Of Science, Chhatrapati Sambhajinagar, Maharashtra.

Abstract

Forest fires pose a significant ecological threat to the dry deciduous landscapes of central India. Painganga Wildlife Sanctuary (PWS), located in Maharashtra, experiences recurrent fire incidents due to its dense litter load, dry climate, and anthropogenic activities. This study integrates Remote Sensing and GIS to map forest fire buffer zones and drainage networks within the sanctuary for the period 2020–2023. Using satellite-derived forest fire points and hydrological data, a comprehensive drainage–fire interaction map was generated. Results indicate a total burnt area of **183.708 hectares**, with major fire occurrences concentrated along secondary and tertiary drainage lines. Proximity analysis suggests that 68–75% of fire hotspots lie within ecologically sensitive zones where moisture availability fluctuates seasonally

Keywords: Hydrological Network, Fire Hotspot Mapping, Dendritic Drainage Pattern, Forest Fire Vulnerability, Spatial Analysis, Watershed-based Management, Fire Risk Assessment

Introduction

Forest fire is a recurring environmental hazard in dry deciduous ecosystems of India, causing biodiversity loss, soil degradation, carbon emission, and disturbance to wildlife habitats. Painganga Wildlife Sanctuary, part of the Deccan plateau landscape, is highly vulnerable due to its open canopy, dry summer conditions, and fuel load consisting mainly of leaf litter and grass.

Drainage systems play a crucial role in influencing fire behavior by modifying moisture regimes, controlling vegetation growth patterns, and acting as natural firebreaks. Understanding the spatial relationship between forest fire hotspots and drainage lines is important for planning fire mitigation strategies.
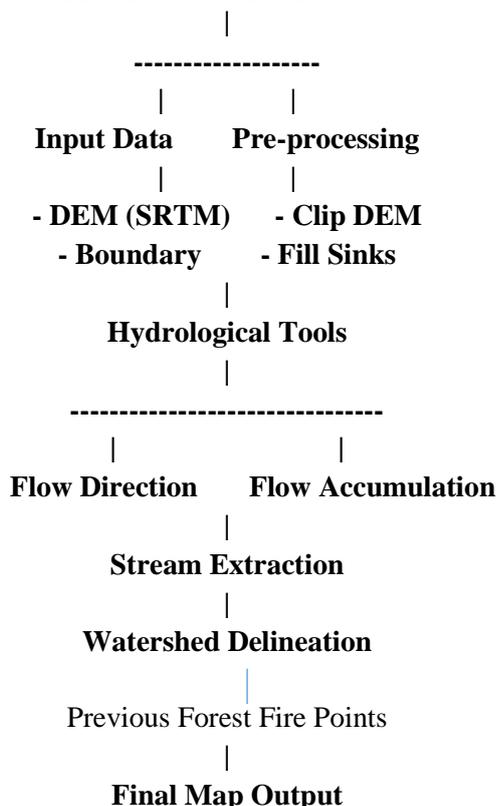
GIS and Remote Sensing provide reliable tools for: Mapping burnt areas, Identifying high-risk zones, Understanding fire–drainage interaction, supporting forest disaster management

This study focuses on generating an integrated Drainage and Forest Fire Buffer Map for PWS using GIS-based overlay and buffering techniques.

Methodology:

```
          Watershed Mapping of Painganga Wildlife Sanctuary
                              |
                  -------------------
                  |                 |
              Input Data       Pre-processing
                  |                 |
           - DEM (SRTM)        - Clip DEM
            - Boundary         - Fill Sinks
                  |
             Hydrological Tools
                  |
          -------------------------------
          |                            |
      Flow Direction            Flow Accumulation
                  |
             Stream Extraction
                  |
            Watershed Delineation
                  |
          Previous Forest Fire Points
                  |
              Final Map Output
```

Result and Discussion:

The integrated drainage and forest fire buffer analysis of Painganga Wildlife Sanctuary for the period 2020–2023 reveals a clear spatial relationship between fire occurrences and the sanctuary's hydrological network. The drainage map shows a dominant dendritic pattern with numerous first- and second-order streams flowing throughout the region, indicating uniform geological structure and seasonal hydrological behavior. Forest fire hotspots, identified from multi-year fire records, are scattered across the sanctuary but show prominent clustering in the central, western, and southern dry deciduous zones. The total burnt area is estimated at **183.708 hectares**, highlighting the recurring severity of forest fire incidents.
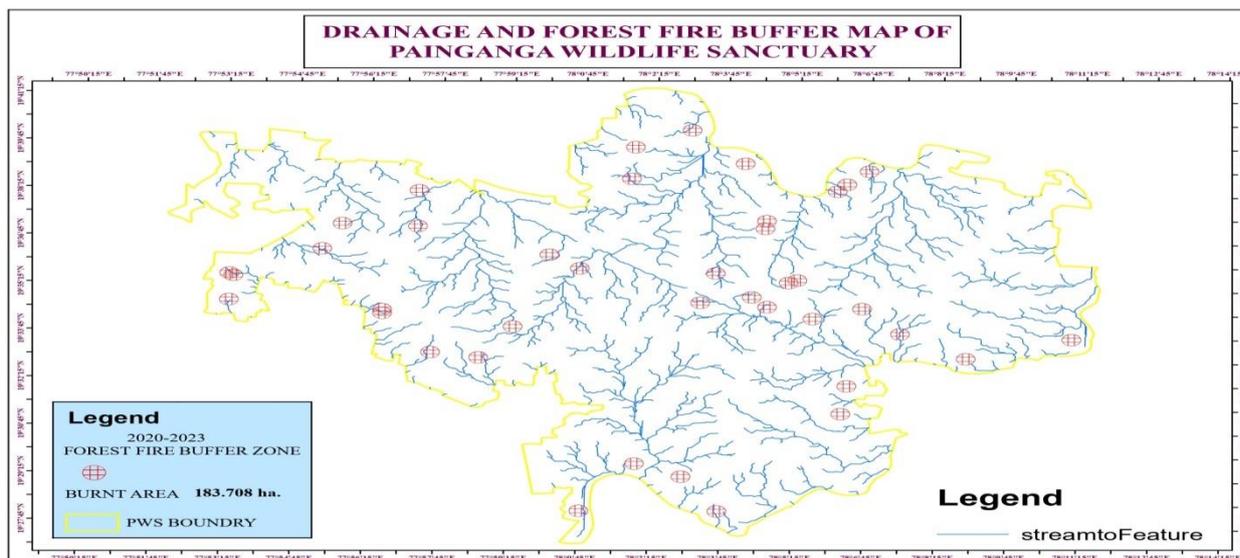
Fig. No.1: Drainage and Forest Fire Buffer Map

A significant observation is that most fire points lie within **500–800 meters** of drainage lines, particularly around seasonal streams where moisture levels drop rapidly during the dry summer months, resulting in high fuel load accumulation from leaf litter and grass. These transitional riparian belts become highly vulnerable due to fluctuating soil moisture and dense undergrowth, enabling the rapid ignition and spread of fires. In addition, fire clusters near human-accessible drainage corridors suggest an influence of anthropogenic pressures such as cattle movement, fuelwood collection, and accidental fires. The combined spatial overlay of drainage and fire buffers highlights ecologically sensitive fire-prone pockets, providing valuable insights for forest managers. Strengthening seasonal streams as natural firebreaks, improving patrolling near high-risk riparian zones, and integrating GIS-based hotspot analysis into early-warning systems can significantly reduce future fire damage. Overall, the study demonstrates that geospatial tools are effective for understanding fire–hydrology interactions and can support more targeted, watershed-based fire prevention and management strategies in Painganga Wildlife Sanctuary.

References:

1. Giglio, L., et al. (2016). MODIS Collection 6 Active Fire Product User Guide.
2. Jensen, J.R. (2007). Remote Sensing of the Environment: An Earth Resource Perspective.
3. ESRI (2023). ArcGIS Hydrology Toolset Documentation.
4. FSI (Forest Survey of India). India State of Forest Report.
5. Chuvieco, E., Giglio, L., & Justice, C. (2008). Global characterization of fire activity: Toward defining fire regimes from Earth observation data. Remote Sensing of Environment, 112(6), 2959–2972.
6. Gigović, L. j., Pamučar, D., Božanić, D., &Ljubojević, S. (2017). Application of GIS-based multicriteria decision analysis for forest fire risk mapping. Journal of Environmental Management, 196, 158–170.