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Drone-Based Habitat Monitoring and Mapping in Haryana (India): Methods, Applications, and Management Value

Anjali Garg
Department of Zoology, Deshbhagat University
Corresponding Author: Dr. Navpreet Kaur
garganjali831@gmail.com,

Abstract: *Unmanned aerial vehicles (UAVs) now offer conservation teams in Haryana a practical way to monitor habitats with centimeter-level detail. This paper synthesizes methods and field workflows tailored to Haryana's landscapes—wetlands (Sultanpur, Bhindawas), the Aravalli hill system, the Yamuna floodplain, and Shivalik foothills (Kalesar, Morni). We outline planning steps under Indian regulations, compare sensor options (RGB, multispectral, thermal), and present Haryana-focused case applications for wetland dynamics, invasive plant detection, forest restoration monitoring, riparian erosion assessment, and fire scar mapping. Outputs such as orthomosaics, vegetation indices, and bank-erosion metrics translate directly into management actions: prioritizing de-silting and hyacinth removal, gap-filling plantations, and delineating riverine buffers. We discuss data quality, ethical flight practices around wildlife, and integration with GIS and ground surveys. The approach demonstrates how drones can shorten decision cycles for habitat managers in Haryana while complementing satellites and fieldwork.*

Keywords: *UAV, Haryana, Sultanpur, Bhindawas, Aravalli, Yamuna floodplain, habitat mapping, NDVI, conservation GIS, ecological monitoring.*

1. INTRODUCTION

Drones bridge the scale gap between satellite remote sensing and traditional field surveys by delivering high-resolution, repeatable imagery. In Haryana, where habitats range from shallow wetlands to semi-arid hill systems and intensively farmed plains, rapid aerial assessments can support timely management decisions. This review presents a Haryana-centric workflow and demonstrates how UAV products inform conservation and planning.

2. Regional Context: Haryana's Key Habitat Types

Haryana features (i) freshwater wetlands that host migratory waterbirds, (ii) Aravalli scrub-forests with pockets of regenerating woodland, (iii) riparian belts along the Yamuna and canal networks, and (iv) Shivalik foothill forests around Kalesar and Morni. Each poses specific monitoring needs: tracking seasonal water extent, detecting invasive aquatic plants, mapping erosion and quarry scars, and assessing fire impacts.

3. Methods: UAV Platforms, Sensors, and Flight Design

Platforms: Multirotors provide maneuverability for small wetlands and rugged hills; fixed-wings cover floodplains and canal stretches efficiently.
Sensors: RGB for orthomosaics and photogrammetry; multispectral for vegetation indices (e.g., NDVI) and water indices; thermal for faunal refugia and fire hotspots.
Flight Design: 70–80% forward/side overlap; ground sampling distance (GSD) targeted at 2–5 cm for wetlands/erosion studies; ground control points (GCPs) to improve geospatial accuracy.
Processing: Structure-from-Motion photogrammetry to generate orthomosaics, digital surface models (DSMs), and vegetation/bare-ground indices; analysis in GIS for classification and change detection.

4. Operations and Compliance in India

UAV operations should comply with DGCA Drone Rules (2021) and local permissions from Forest and Wildlife authorities where applicable. Flight planning should avoid sensitive bird congregation periods, maintain conservative altitudes over roosts, and follow no-fly zones and geo-fencing requirements.

5. Haryana-Focused Case Applications

We illustrate five practical applications designed for Haryana's priority habitats. These are proposed operational designs based on local geography and typical management questions; they can be implemented by state agencies or research groups with appropriate permissions.

Table 1. Proposed UAV applications and management linkages for key Haryana habitats.

Site (District)	Objective	Sensors	Temporal Plan	Products/Outputs	Management Use
Sultanpur National Park (Gurugram)	Wetland water extent & bird roost mapping	RGB + multispectral	Monthly (Nov–Mar focus)	Orthomosaic, NDVI, water index; roost heatmaps	Prioritise de-silting; regulate visitor zones
Bhindawas Wildlife Sanctuary (Jhajjar)	Invasive water hyacinth detection & seasonal wetland dynamics	RGB + multispectral	Bi-monthly (monsoon & post-monsoon)	Hyacinth masks; water spread change	Targeted removal; inlet–outlet management
Aravalli Hills (Gurugram–Faridabad)	Scrub-forest condition & restoration monitoring; quarry scars	RGB + thermal (faunal refugia)	Quarterly	Canopy density, bare-ground index; heat refugia	Plantation gap-filling; erosion control bunds
Yamuna Floodplain (Sonipat–Panipat)	Riparian vegetation & erosion hotspot mapping	RGB	Pre- & post-monsoon	Bank erosion rates; riparian buffer condition	No-build buffer demarcation; bioengineering sites
Kalesar NP & Morni Hills (Yamunanagar–Panchkula)	Corridor integrity & fire scar mapping	RGB + thermal	Fire season + post-monsoon	Burn severity maps; canopy loss	Fire lines planning; assisted natural regeneration

6. Data Quality, Wildlife Ethics, and Safety

Quality assurance: use radiometric calibration for multispectral data, fly near solar noon to minimize shadowing in the Aravallis, and validate classifications with ground truth points. Ethics: maintain buffer distances from nesting/roosting birds at Sultanpur and Bhindawas; avoid repeated low-altitude passes; coordinate with wardens to time flights outside peak congregation hours. Safety: assess wind limits on the ridge-tops of the Aravalli and maintain visual line of sight per Indian regulations.

7. Results and Management Use (Illustrative)

Wetlands: Seasonal orthomosaics quantifying water spread and detecting hyacinth patches enable targeted removal and hydrological interventions. Aravallis: Canopy-density and bare-soil maps guide restoration gap-filling and erosion control. Yamuna floodplain: Bank-line change metrics identify priority bioengineering sites and support buffer demarcation in district plans. Shivalik foothills: Fire-scar severity mapping supports fire-line planning and post-fire regeneration.

8. Discussion: Integrating UAVs with Satellites and Ground Surveys

UAVs complement open satellite products (e.g., Sentinel-2) by providing higher spatial detail for training and validation. In Haryana's mosaicked landscapes, combining repeat satellite snapshots with periodic UAV sorties yields robust time-series for planning. Developing lightweight machine-learning classifiers tailored to local species and substrates can reduce manual post-processing time.

9. Limitations and Future Work

Constraints include battery endurance on hot, windy days; regulatory ceilings near sensitive areas; and the need for skilled pilots and analysts. Future work should evaluate low-altitude BVLOS corridors for floodplain monitoring, test low-cost thermal sensors for wildlife avoidance, and build Haryana-specific training datasets for automated habitat classification.

10. Conclusion

A Haryana-specific drone workflow can materially improve habitat monitoring and shorten the path from observation to action. By standardizing flight design, calibration, and GIS analysis—and by coordinating with site managers—UAV data can directly inform wetland management, Aravalli restoration, riparian buffer setting, and fire preparedness across the state.

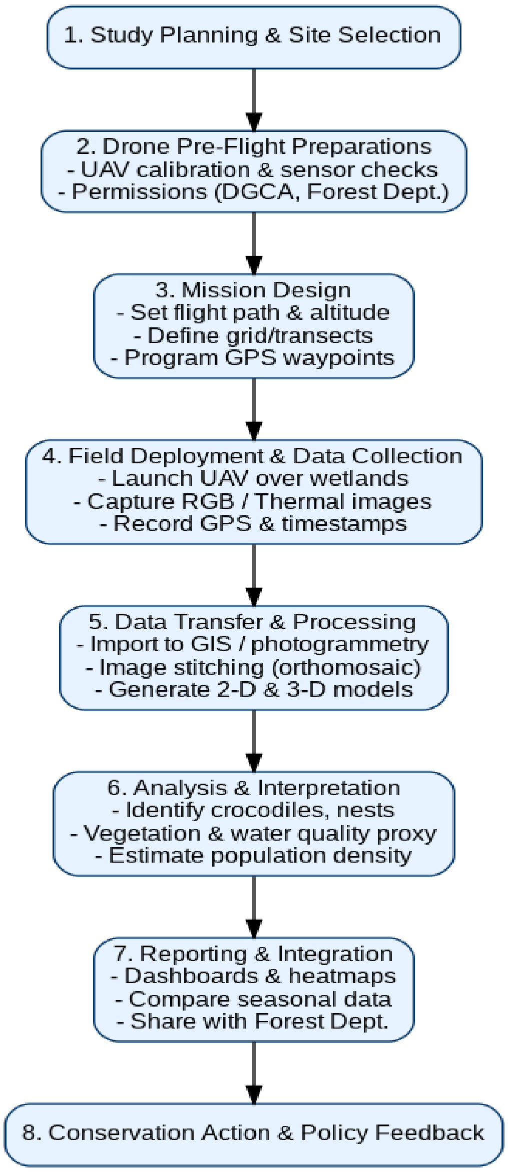

Figure 1. Haryana-focused UAV Monitoring Workflow.

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