same. The polished sections for selective samples of the flaky carbon lenses were analysed using Raman spectroscopy at National Centre of Excellence in Geoscience Researches, GSI Kolkata. Three point measurements each for two polished sections gave graphite band (G) (Figures 3 and 4; 1580 and 1581 cm^{-1} respectively)[6] establishing the prevalence of graphite (Figure 2 *d*). The graphite lenses extend for a cumulative 650 m length and 20 m average width. The fixed carbon values of systematic channel/groove sampling of graphite lenses ranged from 2.06% to 5.85% (Table 1), against the Indian Bureau of Mines cut-off of 2% for crystalline flake variety.

The documentation of graphite lenses within the Palaeoproterozoic Mahakoshal Group increases the possibility of unearthing of rare earth elements and vanadium usually associated with graphite. In addition, the presence of huge malachite stains (Figure 2 *b* and *c*) and at places malachite and azurite encrustations supported by encouraging copper values up to 1.4% in the CP, suggest the multi-mineral potential of the area. Although earlier explorations carried out in this area for base metals did not result in delineating any significant resource[7,8], the confirmation of graphite in this domain opens up new opportunities for re-evaluating graphite potential of the area.

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Light-weight unmanned aerial vehicle surveys detect dugongs and other globally threatened marine species from the Andaman and Nicobar Islands, India

Unmanned aerial surveys are used across the globe to study marine megafauna as they cover large spatial scales, reduce survey effort and time, and are cost-effective[1,2]. Due to their utility in covering large areas and accessing remote locations, aerial surveys act as excellent tools to monitor several marine taxa such as elasmobranchs[3,4], marine turtles[5], pinnipeds[6], cetaceans[7], and sirenians including manatees[8] and dugongs[9,10].

Dugong is a globally threatened species of order Sirenia, assessed as vulnerable according to IUCN Red List of threatened species[11]. Its distribution spans from the east coast of Africa, parts of the Red Sea to the Indo-Pacific region, including India, Sri Lanka, Indonesia, Thailand, Malaysia and Australia[12]. In India, dugongs are found along the coasts of Gulf of Kutch (Gujarat), Gulf of Mannar and Palk Bay (Tamil Nadu), and Andaman and Nicobar Islands[13,14]. Also, their population in the country is considered regionally endangered[11] and is estimated to be less than 200–300 individuals[14]. This has prompted the Government of India to initiate the Endangered Species Recovery Programme for their long-term conservation and persistence[15]. However, estimating dugong population through traditional methods such as boat surveys is difficult in India due to their low detectability on the sea surface (lack of a prominent dorsal fin like dolphins) and rare occurrence (low population size)[14]. Aerial surveys have been previously utilized to study dugong distribution, estimate populations and determine their habitat use patterns in Australia[10,16,17]. In India, though aerial surveys were recommended to study dugongs[12,18], no efforts were undertaken prior to this study.

In the present study, we conducted reconnaissance aerial surveys to detect dugongs with an aim to systematically estimate their populations from known habitats. These areas have been identified with the help of dugong volunteering network established at the Andaman and Nicobar Islands consisting of fisherfolk, divers, boat operators and other regular seafarers[15]. The surveys were carried out with the involvement of the Department of Environment and Forests, Andaman and Nicobar Islands within the Marine Protected Areas of Mahatma Gandhi Marine National Park and Rani Jhansi Marine National Park, and

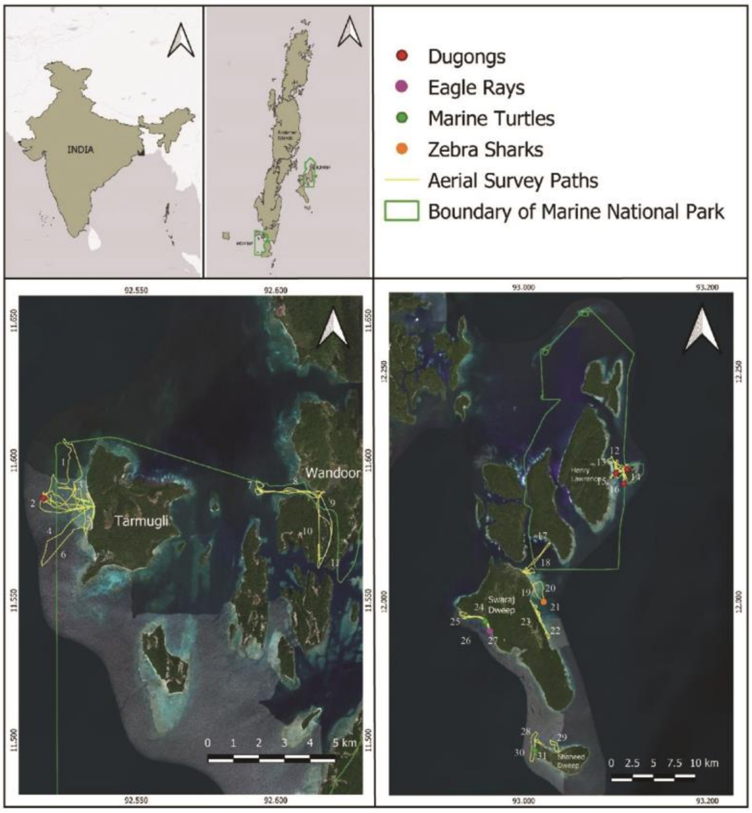

Figure 1. Unmanned aerial vehicles flight paths and detection of marine megafauna in South Andaman Islands. (Bottom left) Mahatma Gandhi Marine National Park, Wandoor. (Bottom right) Rani Jhansi Marine National Park, Ritchie's Archipelago.

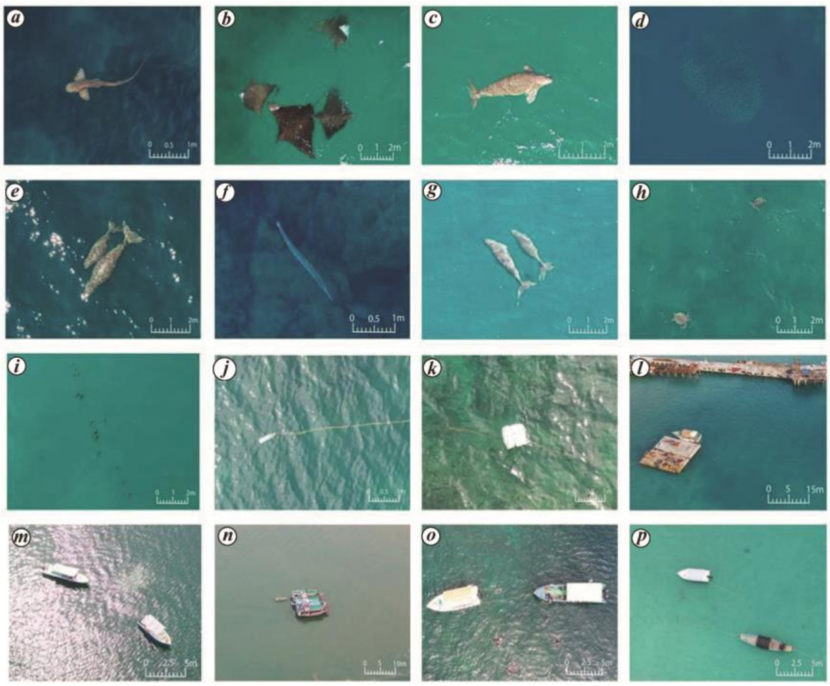

Figure 2. Detections made from light-weight unmanned aerial surveys in South Andaman Islands. ***a***, Zebra shark; ***b***, spotted eagle rays; ***c***, dugong; ***d***, shoal of fish; ***e***, mother–calf pair of dugongs; ***f***, needle fish; ***g***, mother–calf pair of dugongs; ***h***, marine turtles; ***i***, squids; ***j***, floating litter; ***k***, floating buoy; ***l***, dredging at jetty; ***m***, game fishing boats; ***n***, anchored ferry boats; ***o***, diving boats; ***p***, fishing boats.

adjoining areas (Figure 1). We used a light-weight 905 quadcopter (DJI Mavic 2 Pro, SZ DJI Technology Co., Ltd, Shenzhen, Guangdong) flown at a constant altitude (80–120 m) and speed (~35 km/h).

The surveys were conducted in clear weather conditions (sunny or partly cloudy skies) and favourable wind conditions (wind speed <10 km/h). We encountered loss of signal in areas with dense canopy; thus the quadcopter was flown from vantage points (such as elevated ground, watch towers, etc.), wherever available. We used random aerial scan sampling methods to detect dugongs in coastal habitats with a variable camera angle to scan more area and maximize detections. Five sorties were flown over Rani Jhansi Marine National Park and six over Mahatma Gandhi Marine National Park. Another 20 flights were undertaken in different forest areas of South Andaman, including Swaraj Dweep and Shaheed Dweep islands. The average flight time conducted for each aerial sortie was about 18.14 ± 3.24 min. All surveys were video recorded for further analysis.

We obtained a total of four detections of dugongs from the surveys (Figure 2). Mother and calf pairs were detected twice from inside the Marine National Parks. We were also successful in detecting a wide range of globally significant marine species. This included first live sightings of spotted eagle ray (*Aetobatus ocellatus*; *n* = 1, 4 individuals observed, IUCN status – vulnerable) and zebra shark (*Stegostoma fasciatum*; *n* = 1, IUCN status – endangered) from the Andaman and Nicobar Islands. Prior records of these species from these Islands have been from fish landing centres[19]. We also recorded sea turtles (*n* = 6) and other species such as squids, needlefish, sting rays and fish shoals during our surveys. Details of transect surveys (date, time, area, sightings, number of individuals and time of sightings) are provided in the Supplementary Table 1.

The encounter rate (number of detections/total survey time) calculated for the marine species detected more than once during the study was 0.42/h (*n* = 4) and 0.63/h (*n* = 6) respectively, for dugongs and sea turtles. Fifty per cent of dugong detections was of a mother–calf pair.

Three detections were from inside the Rani Jhansi Marine National Park and near the boundary of the Mahatma

Gandhi Marine National Park. During the survey we also detected potential threats to dugong populations like marine litter, fishing boats and high-speed vessels used for SCUBA diving and game fishing.

In this study we conducted a survey using light-weight unmanned aerial vehicles (UAVs) to detect marine megafauna and study dugongs in India. Our observations show that light-weight UAVs can be effectively used to detect a wide range of marine species, understand species distribution patterns, estimate their populations and quantify threats. Given the lack of a reliable population estimate for dugongs in the country, we strongly recommend UAV surveys to be implemented at all dugong distribution sites to aid their conservation. Further, UAV surveys should be adopted as a tool by State Forest Departments to monitor marine fauna of conservation concern and for tackling illegal activities in the Marine Protected Areas.

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Soil matric potential-based irrigation using tensiometer for conserving irrigation water

Intensively cultivated rice–wheat cropping sequence has several sustainability issues[1,2]. GRACE-NASA, the US gravity mapping satellite, has detected a 30 cm yr^{-1} drop in subsurface water in North India over a 440,000 km^2 area, resulting in a 4 cm decline of under groundwater[3]. In Punjab, India, the water table is declining at an alarming rate because of increase in the area under rice to 60% (in 2015) compared to 6% in the 1960s. In addition, each year in Punjab, more than 13 lakh ha-m of extra water worth US$ 39 million is provided for irrigation purposes. Resource conservation technologies (RCTs), viz. direct seeded rice[4], bed planting, mechanical transplanting[5], laser levelling[6], soil matric potential-based irrigation using tensiometers, etc. could reduce water footprint in rice[4–8]. Tensiometer is the only instrument in the hands of the farmers which guides them when and how much to irrigate[9]. Interpretation of tensiometer readings is easy and farmer-friendly, which helps the farmers decide on the timing of water application based on crop need and soil textural class which also cover the effects of other conditions like rainfall, etc. It is the first gadget of its kind which helps in deciding how much stress could be given to a crop without affecting land productivity[10]. Different tensiometers are available for recording soil matric potential at different depths. Further, these readings are not affected by temperature, and variations, thus the instrument could be effectively used in different parts of world experiencing different temperatures without any difficulty.

The matric potential is one of the components of the total soil water potential that also includes gravitational (position with respect to a reference elevation plane), osmotic (salts in soil solution),