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NUTRIA NEOTROPICAL EN HUMEDALES COSTEROS PRIORITARIOS PARA CONABIO EN EL NORTE DE VERACRUZ, MÉXICO

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INTRODUCCIÓN

La nutria neotropical (*Lontra longicaudis annectens*) es un mamífero semiacuático considerado como especie protegida a nivel nacional e internacional por el riesgo de desaparecer en el corto y mediano plazo (SEMARNAT, 2010; UICN-2017-3). Dicha amenaza se atribuye principalmente a la disminución de sus poblaciones debido a la reducción y deterioro de sus hábitats (Mayagoitia-González et al., 2013).

Para el Golfo de México se ha generado poca información sobre su distribución, de ahí surge el interés por conocer la localización actual de este mustélido en tres humedales costeros prioritarios para la CONABIO en el norte de Veracruz.

OBJETIVOS

General. Conocer la distribución actual e identificar los sitios de mayor uso de *L. longicaudis* annectens en tres humedales costeros del norte de Veracruz: Sitio Ramsar No. 1602, GM56 y GM39.

Específicos.

Registrar observaciones directas e indirectas de la presencia y actividad de *L. longicaudis* en los tres humedales costeros propuestos.

Identificar las comunidades vegetales en las que se registre presencia directa e indirecta de la especie

Caracterizar el hábitat terrestre y acuático de los esteros Jácome, Tumilco (Sitio Ramsar 1602) y Palma Sola (Sitio Tuxpan GM56).

METODOLOGÍA

El estudio se llevó a cabo en la zona norte del estado de Veracruz en los municipios de Tuxpan y Cazones de enero a octubre del 2019. En esta región se encuentran el Sitio Ramsar 1602: “Manglares y Humedales de Tuxpam” y dos sitios de manglar prioritarios por su relevancia biológica para la CONABIO, los cuales son: Tuxpan (GM56) y Estero Juan González (Temix) (GM39).

Para el registro de la presencia de nutria neotropical se realizaron navegaciones y exploraciones en tierra en 7 cuerpos de agua, tres en el Sitio Ramsar 1602: nacimiento de brazos del Canal de la Laguna de Tampamachoco; Esteros Tumilco y Jácome. Tres en el Sitio Tuxpan (GM56): esteros Palma Sola y El Salado y cuerpos de agua colindantes con el macizo de manglar y en el estero “El Chiquito” que pertenece al sitio Juan González (GM39). Durante las navegaciones se buscaron rastros directos e indirectos de actividad de *L. longicaudis annectens.* basándose en el método de Jeffres et al., 2011.

Las variables que se registraron para la caracterización del entorno terrestre y acuático en el que se hallaron rastros de actividad de esta especie fueron las propuestas por Hernández-Romero (2011).

Se aplicaron regresiones logísticas (Sheather, 2009), usando el programa R (R Core Team, 2019), para determinar si existía una relación entre la presencia de excretas de nutria y el hábitat terrestre y de rastros de la presencia de nutrias (excretas) con las variables del hábitat acuático (Johnson y Wichern, 2002).

En los dos casos se seleccionó el mejor modelo evaluando las variables explicativas con la función “step” de R que se base en probar subconjuntos de las variables, escogiendo el modelo que minimiza el criterio de información de Akaike (Sheather, 2009)

RESULTADOS

A través de excretas se registró la presencia de nutria en los esteros “El Salado” (Sitio Tuxpan- GM56) y Tumilco-Sitio Ramsar 1602. Los rastros muestran que los sitios de mayor uso fueron zonas con bosque de mangle compuestas por *Avicennia germinans Rhizophora mangle* y *Laguncularia racemosa,* con cobertura arbórea entre el 25% y el 75% ($X2=0.114$, $p<0.05$) y altura de los árboles entre 5m y 8m ($X2=0.480$, $p<0.05$), así como presencia de troncos caídos.

Se encontraron excretas individuales y letrinas exclusivas de nutria, así como, letrinas compartidas con *Procyon lotor.* No se encontraron relaciones significativas entre los valores de las variables físico-químicas del cuerpo de agua con respecto a la presencia de rastros de la nutria neotropical

DISCUSIÓN

Los rastros de nutria neotropical en los humedales estudiados se relacionaron con la disponibilidad de recursos como la cobertura de la vegetación, el nivel del cuerpo de agua y el estado de conservación del hábitat. Los resultados coinciden con Arellano et al., (2012).

Los sitios en los que se hallaron los rastros (excretas) en el estero de Tumilco son similares a los señalados por Márquez (2017).

Los elementos del paisaje que sobresalieron fueron una buena cobertura de bosque con árboles de alturas de más de 5 m y la presencia de troncos caídos, esta última variable fue significativa ya que los troncos caídos son utilizados como letrinas y como mecanismos de marcaje de territorio. Se sabe que la nutria neotropical acostumbra a realizar sus actividades de marcaje en sitios altos y secos como troncos caídos y rocas junto a los cuerpos de agua (Arellano, 2012). En este sentido, además de las excretas halladas sobre troncos caídos, tenemos un registro de una letrina cuyas excretas estaban sumergidas en el agua, este dato resulta interesante dado que podría mostrar que los marcajes de la nutria no sólo los realizan en la zona aérea y seca del hábitat, pueden también establecerlos en la parte acuática.

CONCLUSIÓN

El 2019 fue un año en el que la zona norte de Veracruz experimento índices de sequía severos (D2) y extremos (D3), los cuerpos de agua poco profundos en los humedales se secaron y los esteros bajaron su nivel de agua, estas condiciones hidrológicas pueden explicar la ausencia de rastros de actividad de nutria en los sitios.

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Palabras clave: *Lontra longicaudis***,** distribución, humedal, mangle, hábitat, rastros.

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IMPLICACIONES SOCIOECONÓMICAS EN LOS ÍNDICE DE VEGETACIÓN DEL BOSQUE DE MANGLAR EN LAS COSTAS PACÍFICO Y CARIBE DE HONDURAS

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Los manglares son ecosistemas costeros que brindan diversos servicios ecosistémicos a la sociedad, sin embargo, se encuentran amenazados por perturbaciones antrópicas y el cambio climático. En Honduras el último cálculo de la cobertura de manglar fue de 51, 578 hectáreas de acuerdo con el Instituto de Conservación Forestal (ICF) en el 2014. En la presente investigación se calculó el área de manglares perdido en las costas Pacífico y Caribe de Honduras, durante el período del año 2014 al 2019, utilizando sistemas de información geográfica y datos obtenidos con sensores remotos. En el cálculo se utilizó un mapa de cobertura forestal de Honduras del Instituto de Conservación Forestal (ICF) producido en el año 2014 y un mapa del 2019 de la base de datos Dinámica Biogeoquímica del Centro de Archivo Activo Distribuido (ORNL DAAC) de la NASA. Además, se utilizaron 96 gráficas de series temporales del sentinel 2 y Landsat 8 de la plataforma LandViwer para identificar el estado de la vegetación del mangle con el uso de sensores remotos basados en índices de vegetación: el índice de Vegetación de Diferencia Normalizada (NDVI), el índice de agua de diferencia normalizada (NDWI) y el índice de diferencia normalizada de suelos (NDSI). También, se realizó una revisión de publicaciones científicas y reportes (N=275) sobre las principales actividades socioeconómicas relacionadas con la pérdida de área de mangle y el impacto sobre los servicios ecosistémicos en Honduras. Las principales actividades humanas que han impactado la costa Caribe son la expansión de cultivos de palma africana, ganadería, desarrollo de infraestructura turística y tala ilegal, en cambio, en la costa Pacífico están la camaronicultura, producción de sal y la urbanización. Estas actividades representan una diferencia de 23, 467.73 hectáreas de manglar del año 2014 al 2019 y el deterioro de impactos negativos principalmente sobre los servicios ecosistémicos, como la pesca. En la costa Caribe los manglares tienen una mayor biomasa fotosintéticamente activa y son más densos, en comparación al bosque de mangle de la costa Pacifico del Golfo de Fonseca en Honduras.

Palabras clave: Actividades socioeconómicas, cobertura de manglar, Golfo de Fonseca, sensores remotos.

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MAPEO DE MANGLARES A PARTIR DE SENSORES REMOTOS EN ZONAS DE ALTA NUBOSIDAD: CASO DE ESTUDIO PACÍFICO COLOMBIANO

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INTRODUCCIÓN

Debido a la importancia ambiental que ofrecen los bosques de manglar y a la pérdida acelerada que han sufrido los últimos años, se hace necesario contar con mapas de manglar actualizados y precisos que permitan monitorear el ecosistema y soporten las estrategias de sostenibilidad del mismo (Xia *et al.*, 2018). Los sensores remotos han sido relevantes para esta actividad por ofrecer múltiples beneficios en la detección y cuantificación de los manglares, sin embargo, aún existen limitaciones en zonas donde las condiciones de nubosidad recurrente dificultan su identificación a partir de imágenes satelitales ópticas. Más del 70% de los manglares de Colombia se encuentran localizados en la costa del Pacífico (INVEMAR, 2019), sector que se caracteriza por una constante nubosidad, por lo que se hace indispensable el desarrollo de metodologías alternativas para detección del manglar con mayor precisión y que se puedan aplicar en diferentes periodos.

OBJETIVOS

General: Delimitar la cobertura de bosques de manglar en el Pacífico colombiano a partir de datos de sensores remotos.

Específicos: 1. Minimizar la cobertura de nubes en un compuesto de imágenes ópticas. 2. Emplear índices espectrales y bandas derivadas de las imágenes ópticas y de radar como insumo a la clasificación supervisada. 3.Estimar y validar la cobertura de manglar en la costa Pacífica.

METODOLOGÍA

El área de estudio contempla la zona costera del Pacífico colombiano que incluye los departamentos de Chocó, Valle del Cauca, Cauca y Nariño. Se emplearon imágenes de libre acceso Sentinel 2 (ópticas) y Sentinel 1 (radar) de los años 2019 y 2020, además de la misión de topografía de radar *Shuttle Radar Topography Mission* (SRTM). El procesamiento digital de las imágenes se realizó en *Google Earth Engine* (GEE), las nubes se enmascararon con base al parámetro de porcentaje de probabilidad de nubes. Se utilizaron índices espectrales y derivados texturales para mejorar la detección del manglar. Los datos fueron clasificados en conjunto con

Random Forest. Se complementa el análisis con datos de campo e imágenes con resolución espacial (<3m), para entrenar la clasificación y validar el resultado.

RESULTADOS

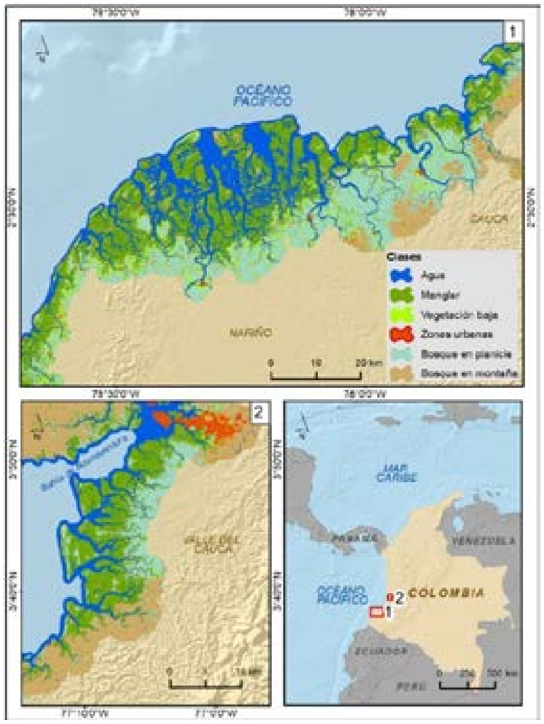

Figura 1. Clasificación de cobertura de manglar para dos zonas de estudio en la costa Pacífica. (1) Sanquianga Nariño (2) Buenaventura, Valle del Cauca.

Con el procesamiento de más de 3500 escenas satelitales, se obtuvo un mapa de coberturas de manglar y otras asociadas a una escala de 10 metros de resolución espacial con 6 clases temáticas, de las cuales el manglar cubre un 18% del área de estudio, siendo el departamento de Nariño con mayor extensión del mismo. La evaluación de calidad de la clasificación realizada a partir de una matriz de error, generó una exactitud global del mapa de 97%, un valor de *Kappa Coefficient* (KC) de 0.96 y una precisión de usuario de 97% para la clase manglar.

DISCUSIÓN

La metodología aplicada permitió separar satisfactoriamente la cobertura de manglar de otras coberturas. El uso de datos ópticos y de radar procesados en GEE presentó resultados similares frente a otros estudios; Ghorbanian et al., (2021) encontraron una precisión general del mapa de manglar de 93,23% y 0,92 de KC. Por su parte, Hu et al., (2020) validaron que Sentinel 2 es más eficaz que Sentinel 1 para la extracción de manglares, y que la combinación de estos datos mejoró la calidad de la clasificación, separando el manglar con una precisión de usuario de 94%, mismo enfoque empleado en esta investigación.

Manglares de la costa del Pacífico, en Buenaventura, han sido mapeados empleando imágenes Sentinel 2 combinadas con ortofotografías de alta resolución (Perea-Ardila *et al.*, 2019), obteniendo 80% de exactitud global y 0,70 de KC. No obstante, el procesamiento múltiple de imágenes en GEE aplicado en este estudio, permitió obtener mosaicos con mínima cobertura de nubes para toda la costa del Pacífico, que en conjunto con datos de radar y elevación lograron un KC superior, por lo que se considera una alternativa con mayor potencial de precisión en la detección de bosques de manglar en zonas extensas con nubosidad recurrente y por ende, con potencial para el monitoreo periódico a menores costos para áreas extensas y de difícil acceso.

CONCLUSIONES

El enfoque propuesto permitió delimitar los bosques de manglar del pacífico colombiano con una precisión de usuario del 97%, y un KC de 0,96, con resultados comparables con estudios similares. Se superaron las limitaciones de la cobertura de nubes gracias al enmascaramiento de nubes y a la generación de un compuesto temporal con múltiples escenas que se considera adecuado bajo la premisa de que las zonas cartografiadas no presentan cambios considerables en el espacio y tiempo que puedan verse afectadas por el uso de múltiples fechas.

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Palabras clave: Manglares, sensores remotos, nubes, Pacífico colombiano.

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MANGROVE MAPPING USING MULTITEMPORAL, MULTISPATIAL AND MULTISPECTRAL REMOTE SENSING IMAGES

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INTRODUCTION

Coastal mapping programs are becoming a priority for governments and scientific organizations worldwide and the current context of global changes (enhanced environmental dynamism and large-scale human sea use) induces new challenges for digital wetlands coastal mapping and monitoring to better define and understand the land/sea interface is based on several interrelated factors. New methods of coastal mapping have been developed and implemented over the last decade. Unmanned Aerial Vehicle (UAV) in particular, affords an opportunity to improve upon satellite imagery for coastal management because of the very high spatial resolution, multispectral capability, and opportunity to collect real-time observations. Moreover, one of the key aspects of mapping habitats is the gathering and management of different types of data and information using the same platform for multi-scale and multi-layer analysis. In addition, spatial data management is still the subject of methodological and technological development, especially regarding systems for the organization, information, and data integration in coastal ecosystems (Hamylton, 2017). Thus, the creation and development of data management systems within the context of a multidisciplinary project is an important complementary step towards defining methodological remote sensing solutions to characterize coastal habitats and their interrelations for governance and management. In this work, high-resolution images from a UAV system with multispectral sensor were integrated with images from high and medium resolution satellites (Planetscope) on eight different dates to analyse and establish a time change detection methodology for a well-preserved mangrove protected area in "Cardoso Island State Park", part of the Cananeia-Iguape Coastal System (CICS) southern region of São Paulo State - Brazil, (25°03'S/47°53'W). The CICS is formed by the confluence of two estuarine channels (Cananeia Channel and de Cubatão Channel) and the Cananeia inlet, forming a bay-shaped water body locally called "Trapandé Bay". The CICS coastal plain is very important as it contains the most extensive Quaternary coastal sedimentation in the State of São Paulo. The study site, Perequê

River mangrove, located in the Cardoso Island State Park is formed by a set of continuous or discontinuous mangrove forests drained by the Perequê River.

MATERIALS AND METHODS

PlanetScope satellite (PS) and unmanned aerial vehicles (UAVs) images were used in this work. The PlanetScope constellation includes more than 180 small satellites and covers almost 200 million km2 per day. PS images consist of four spectral bands (Red, Green, Blue, Near-infrared - NIR), and have a spatial resolution of ~ 3 m and a radiometric resolution at 12-bit (additional information at www.planet.com). For this research, eight images were used with acquisition dates between 2018 and 2022 with conditions of low (0.7m) and high tide (1.1m). Two series of multispectral UAV images taken by a DJI P4 Multispectral drone with bands in the wavelengths Blue 450nm - Green 560nm, Red 650nm, RedEdge 730nm and InfraRed 840 nm (+/- 16nm) were used. The flights were performed at two altitudes: 100m and 50 m (with images at pixel resolution ~ 5cm / 1.5 cm respectively). The surveys took place in September 2021 and April 2022. Both surveys were conducted at low tide conditions. The AUV images are spectrally calibrated from a light sensor on the drone. In the case of PS, the images are made available spectrally calibrated with the Sentinel images. Nevertheless, as indicated by Frazier & Heminghway (2021), the images were normalized in a manner from the empirical linear method - ELM (Deng et al 2018). Vegetation indices (NDVI, SAVI, GVIS) were generated for all images. To understand the variations within the analysis period three methodologies were used: subtraction of vegetation Indices (image to image), Principal Component Analysis between bands, and Vegetation Indices for each of the analysed dates. To evaluate the change trends in pixel values of each band and in vegetation indices a "Change Detection and Classification" (CCDC) was conducted.
The structural attributes of the mangrove (ground truthing) were obtained in six delimited plots of variable size adopting the methodology of Rovai et al. (2016). Measurements of basal area, mean height, density, and basal area dominance per species, of live and dead trunks were calculated.

RESULTS AND DISCUSSION

Dominant mangrove species in the study area include red mangrove (*Rhizophora mangle*), white mangrove (*Laguncularia racemosa)* and black mangrove *(Avicennia schaeriana*) on the core areas of the forests and *Spartina alterniflora*, the cordgrass, colonizing depositional fringes of mangrove. The basin forests are dominated by *R. mangle* showing a higher structural development due to the high inundation frequency in depositionally stable sites. The multitemporal analysis indicated a tendency of stability characterized with constant values of vegetation indices also expressed on PC1 of the set of multitemporal images, even with different tidal conditions. Fringe forests were dominated by *L. racemosa* and *S. alterniflora* with low structural development, according to Cunha-Lignon et al. (2011) presented significant variability, specifically associated with morphosedimentary processes linkrd with the channels variability between the image acquisition periods, the tidal differences also show influence in the spectral response contributing to significant variations between images with different conditions.
Transitional areas, submitted to lower inundation frequency, predominantly sandy substrate and low salinity showed significant variability, however at lower frequencies (seasonal signal) and not between distinct tidal conditions. This may indicate the specific spectral response of coastal forest species (e.g. *Hibiscus pernamburcensis)* that may have a distinctive phenological response. The textural information provided by the UAV images enhanced the definition of the edges, adding qualitative information on tree height, especially in the transition regions. It was also possible to identify variations in texture and tree height around clearings. This different spectral behaviour suggests greater dominance of different species at the mangrove contacts with higher (northern) and lower lying or deforested areas (southern and clearings). Examination of magnified portions of the image shows frequent correlation of canopy texture (size and shape of canopies, very visible at 0.05 cm spatial resolution) with the shades provided by the Planet images, that should represent, at least part, phenological behaviour of the species in this mangrove forest ecosystem.

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KEYWORDS: Unmanned Aerial Vehicles, remote sensing, Planetscope Images, Southeastern Brazil**.**

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LA APLICACIÓN DE VEHÍCULOS AÉREOS NO TRIPULADOS(UAV) PARA LA IDENTIFICACIÓN DE COBERTURA DE MANGLARES: CASO HUMEDAL LAGUNA DE COYUCA

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Los humedales son de gran importancia en los ecosistemas debido a su extensión, biodiversidad, así como por los valores sociecológicos que proporcionan a los seres vivos (Castillo, 2018). Sin embargo, son uno de los ecosistemas más amenazados en el mundo, en México, por ejemplo, se están tomando medidas para conocer el grado de impacto antropogénico que estos guardan, así como de la creación de medidas para su conservación y protección (Heynes-Silerio *et al*., 2017). En esta sinergia, en el Estado de Guerrero existen humedales costeros que se encuentran bajo amenaza antrópica, tal es el caso del humedal de la Laguna de Coyuca, mismo, que es de suma importancia socioeconómica y ecológica para las comunidades aledañas a él (Cortés-García *et al*., 2016).

La Laguna de Coyuca, es un cuerpo de agua somero de volumen variable, dependiente de las épocas de lluvias y estiaje, se extiende paralelamente al litoral del Pacífico cerca de la bahía de Acapulco. Desemboca al oeste por un canal de aguas salinas y abundante en peces, el cual está separado del mar por una barrera de arena conocida como Barra de Coyuca. Es un sitio de alta biodiversidad. Dentro del cual se encuentra una amplia extensión de bosque de Manglar, el cual proporciona diversos servicios ecosistémicos, dentro de los cuales destacan: captura de CO_2, refugio de flora y fauna, barrera natural contra tormentas y huracanes, filtros naturales para el agua, entre otros. En este sentido, el objetivo del presente trabajo de investigación tiene por fin identificar la cobertura de manglar del humedal para determinar su estado actual.

Para ello, se utilizó una metodología basada en Sistemas de Información Geográfica (SIG) para la elaboración de cartografía temática de los Manglares, para diagnosticar el uso de suelo y vegetación y así coadyuvar a su conservación. Como resultado se han obtenido mapas específicos en los cuales se muestra en estatus actual, la pérdida y la ganancia, así como una comparativa de antecedentes de años pasados proporcionados por

CONABIO con los actuales, todo esto con el fin de tener datos nuevos y de calidad para conservar los manglares del humedal Laguna de Coyuca.

Figura 1
Cobertura de Manglar CONABIO

Figura 2
Ganancia de Cobertura

Figura 3
Pérdida de Cobertura

En conclusión, con los mapas generados se puede determinar que el bosque de manglar del humedal se encuentra en buen estado, esto debido a que no se visualiza hectáreas de pérdida, todo esto en base a la cobertura inicial proporcionada por Conabio.

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Palabras clave: Manglar, UAV, cobertura, imágenes satelitales.

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RIVERMOUTH MORPHODYNAMICS AND THE INFLUENCE OF MANGROVES DEVELOPMENT: AN EXAMPLE FROM THE GUYANA COAST

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ABSTRACT

The river mouth, the confluence of a river system and the ocean, reflects the influence of both sediment inputs and the way these inputs are organised by marine processes. The river mouths of the Guiana coast in South America are strongly influenced by large mud banks and migrating alongshore from the Amazon River and other rivers. This study analysed and probed the influence of the riverine and marine influences on rivermouth morphological developments. In this study, the morphological dynamics of the system were carried out from satellite images through the comparison of the inter-annual morphodynamics of the river mouths and inlets, complemented by data from hydrodynamic processes among others. Here, this study demonstrates that the recent advancement and availability of Synthetic Aperture Radar (SAR) remote sensing data allow for (i) classification of migrating rivermouth action and processes; (ii) effective monitoring of mudflats development and spit formation; and, (iii) the exhibition of rivermouth transitioning and infilling with the help of mangrove restoration project. Sentinel-1 images of the Mahaica-Mahaicony river mouth in Guyana were processed and analysed using Google Earth Engine (GEE) and ArcGIS to observe the mud-shoal movement and its effects on shoreline dynamics and river mouth deflection. The results of the analyses show that the dynamics of the mud shoal and river mouth are governed by feedback from various estuarine and hydrodynamic processes resulting from the interactions between river and seas. The influence of the mangrove restoration projects in the vicinity also contributes to the mud trapping, spit development and sediment build-up in this study site. The results of this study have not only highlighted the importance of mud infilling and sediment build-up for spit development and river-mouth deflection but the influence and morphological dynamics of the sediment (principally mud at the study site) with mangrove restoration project associated with the river mouth in addition to influencing the marine ecosystem processes at the study site.

Biographical Note:
Dr Temitope Oyedotun is a graduate of the University College London (UCL) where he obtained his doctoral degree (PhD) in Physical Geography (Coastal Geomorphology). His first academic degree was in Geography (BSc), and he later obtained two Masters of Science degrees in Geography (Hydrology Option) and Geographical Information System (GIS) respectively, from the University of Lagos, Nigeria and the University

of Leeds, United Kingdom respectively. Dr Oyedotun has years of international academic engagements in different countries, and over 30 publications in diverse fields of Geography and Environmental Sciences, in journals and conference proceedings. He is currently a Reader (Associate Professor) at, and the Dean of, the Faculty of Earth and Environmental Sciences, University of Guyana.

Keywords: Accretion; Google Earth Engine; mud shoal morphodynamics; Remote sensing of river mouth; Synthetic Aperture Radar (SAR); Guyana.

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INDIVIDUAL TREE DETECTION AND MANGROVE CANOPY COVER ESTIMATION USING UAV (UNMANNED AERIAL VEHICLE)

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INTRODUCTION

Structural monitoring of mangrove forests is necessary to manage resources and ensure conservation. This is particularly important because these forests are one of the most carbon rich in tropical and subtropical regions (Donato *et al.*, 2011). The biomass estimate of this type of vegetation can be calculated from allometric models, which consider biophysical parameters such as diameter at breast height (DBH) and tree height. Therefore, Remote Sensing can be used to characterize these parameters with lower cost, greater speed, and on a larger scale than traditional field measurements (Lucas *et al.*, 2017). Unmanned aerial vehicles (UAVs) in particular, have provided cost-effective sensors to map and monitor biomass estimation and using UAVs along with Structure-from-Motion and Multi-View Stereo (SfM-MVS) photogrammetric procedures makes it possible to carry out field data collection more quickly, more cheaply, and at times at zero cost (Farzanmanesh *et al*., 2021; Otero *et al.*, 2018). This technology can streamline field practices, such as manual tree measurement, which are difficult to apply in inaccessible forest ecosystems. The detection of tree crowns from models coming from UAV photogrammetric surveys can be the starting point for counting individuals and extracting biophysical parameters such as crown height and diameter with the use of segmentation models (Silva, 2021) and mathematical models such as the Gaussian filter (Otero *et al.*, 2018) that can help in reducing noise and small details of an image before object extraction. However, these methods can show different results for different flight scales and directly influence the canopy detailing derived from Digital Surface Models (DSM) and Canopy Height Models (CHM). Especially in the case of densely conserved forests, where it is more difficult to visually identify canopy delineation.

OBJECTIVES

The findings presented in this study assess the validity of Gaussian filter for canopy counts of Rhizophora Mangle using the CHM and DSM at different flight conditions.

MATERIALS AND METHODS

This study, located in the Cardoso Island State Park in the State of São Paulo, Brazil. The workflow consisted of aerial surveys with DJI P4 Multispectral UAV that were conducted in September 2021 for the flights at 30m and 100m height and in April 2022 for the flights at 50 and 120m. DSM and MDT were generated from Structure from Motion (SfM) in Pix4D Mapper software. The CHM was generated in QGIS and the canopy counts in RStudio, using the "CHMsmoothing" and "FindTreesCHM" algorithms from the rLiDAR package in R (Silva *et al.*, 2016). The "CHMsmoothing" algorithm is used to eliminate spurious local maxima caused by tree branches. As input data, this algorithm required the determination of the dimension of a window (WS) and the sigma value for the Gaussian filter. The algorithm "FindTreesCHM" detects and computes the locations and heights of individual trees within the CHM, and its parameters required a single dimension (in raster grid cell units) of fixed square window size (*FWS*) and height threshold to detect individual trees (*TDIT*). These parameters were tested on four raster files with clippings of approximately 20x20m, referring to flights ranging from 30m to 120m. For the flights at 30m and 100m meters the CHM were used, while for the flights at 50 and 120m the DSM were used as input files in the algorithms.

RESULTS AND DISCUSSION

The use of fixed parameters for the four flight heights were initially set with ws equal to 7 and the sigma value for the Gaussian filter equal to 15 in the "CHMsmoothing" algorithm. Then, in the "FindTreesCHM" algorithm the "*FWS*" was set with the value of 121 and the "*TDIT"* parameter as 1.5, keeping in mind that for this study the canopy heights above 1.5m were considered. With these parameters set, the canopy count performed from the CHM resulted in 89 canopies for the flight at 30m and 5 canopies for the flight at 100m. While counting from the DSM resulted in 35 crowns for the flight at 50m and 2 crowns for the flight at 120m. Because of these discrepancies found, new "*FWS"* values were tested for each flight, considering that the search window tends to vary according to the image pixel size, which is directly influenced by the flight height. Thus, the count performed from the CHM at 30m resulted in 36 crowns for an "FWS" equal to 179, while the CHM at 100m resulted in 35 crowns for an "FWS" of 31. The count from the DSM resulted in 35 crowns for the flight at 50m with an "FWS" of 121, and 22 crowns for the flight at 120m with FWS of 5. This last flight height, at 120m, obtained a maximum count of 22 crowns in the tests that were performed in this research, which can be considered a limitation found by the Gaussian filter for models at lower spatial resolution. Comparing the use of the CHM and DSM, taking into account the detection of the crowns, there were not many discrepancies in the results. The flights at 30m, 50m and 100m detected approximately 35 tree crowns in an area of approximately 20x20m. Therefore, it can be considered in this preliminary study, that the use of DSM or CHM for canopy detection using the DJI P4 Multispectral UAV is promising for densely conserved mangrove forests, as is the case for Cardoso Island State Park in the State of São Paulo, Brazil.

Several works have been published aiming to establish a robust methodology to estimate biomass, and consequently, blue carbon in mangroves using UAV surveys. However, few studies have been used in the attempt to normalize and standardize the methodologies of segmentation and definition of optimal parameters in performing such analyses. This study sought to contribute to making the estimation of blue carbon in coastal areas more objective and accurate.

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Keywords: Mangrove; gaussian filter; UAV, structure from motion.

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KEY FACTORS TO CONSIDER WHEN DEVELOPING A RESTORATION PLAN FOR A DEGRADED MANGROVE FOREST

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INTRODUCTION

Mangrove forest losses in the Caribbean were noted as 24%-28% by the World Bank (2019), with Jamaica losing approximately 2000 hectares over a 10-year period (NEPA, 2010). Mangrove restoration and conservation practices have been increasing worldwide with good results and the achievement of a slowing of mangrove loss and degradation. However, there is still a heavy reliance on “mangrove gardening” (Lewis, 2005) and many conservationists attempting rehabilitation without a restoration plan in Jamaica, which often results in wastage of financial resources and the death of millions of planted mangrove seedlings.

OBJECTIVES

This paper discusses key factors and baseline data that were collected from degraded mangrove areas and adjacent non-degraded(control) mangrove forest to design and execute successful hydrological mangrove restoration plans in Jamaica.

METHODS

The researchers reviewed numerous articles and reports on hydrological approaches to mangrove restoration, in addition to collating data and best practices from pilot scale rehabilitation projects undertaken by The University of the West Indies’ (UWI) Centre for Marine Sciences around Jamaica.
Using the Malcolm’s Bay, Palisadoes and Bogue mangrove forest (Figure 1) in Jamaica as examples, the presentation will discuss the key data needed, methods of data collection and analysis and steps in preparing a mangrove forest restoration plan. Restoration plans were implemented using excavation or fill methods, removal of hydrology impediments, using solid waste segregation barriers and combined with mangrove replanting in some cases.

RESULTS

The review and evaluation indicated that data assessments needed to conduct a successful hydrological mangrove forest restoration included level of tidal influence, the presence and location of waterways, site salinity, site original slope or current slope, seedling/sapling survival, vegetation type and structural characteristics, factors affecting seedling recruitment, soil compaction and soil chemistry, and especially soil organic content. The UWI project sites showed strong evidence of being "en-route" to restoration after two years. Such local work has enabled the production of numerous hydrology-based restoration plans and bolstered the efforts by Jamaican scientists to begin scaling up mangrove restoration efforts.

DISCUSSION

Hydrological and ecological based approaches for mangrove restoration, have been discussed by numerous researchers (Lewis, 2005) and are vital to ensure the natural recruitment and survival of the millions of natural recruits. The pilot-scale sites in Jamaica where a robust set of scientific based data were collected to formulate restoration plans before investing in a mangrove restoration attempt, have been very useful in providing Jamaican stakeholders with modern guidance in this current mangrove conservation climate.

CONCLUSIONS

Successful mangrove restoration or rehabilitation should be preceded by a science-based restoration plan. We show evidence that mangrove forest recovery was achieved in Jamaican pilot sites using a hydrological restoration-based approach.

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Figure i Aerial view of Bogue restoration site in A-2013 and B-2019 showing mangrove regrowth

Figure ii Solid waste segregation barrier protecting mangrove seedlings in Palisadoes (Kingston) site

Keywords: Mangroves; Restoration planning; Hydrology; Jamaica.

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THE MANGROVE RESTORATION TRACKER TOOL: ACCELERATING EFFECTIVE MANGROVE RESTORATION

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INTRODUCTION

Understanding and tracking outcomes from mangrove restoration projects is essential to support future restoration work and capture trends in a regional, and even global, context. However, knowing what to record, collecting the right data, and then storing this information for easy use and access can be a challenge. Studies have indicated that socioeconomic outcomes and pre-restoration site conditions were consistently missing from most mangrove restoration project reporting globally. Conversely, the physical restoration intervention conducted at a site and follow up ecological monitoring were more consistently recorded. These gaps hindered cross-project learning to improve mangrove restoration success. Building off these findings the Global Mangrove Alliance (GMA) has developed the Mangrove Restoration Tracking Tool (MRTT). The MRTT will allow practitioners to collect monitoring and evaluation information on mangrove restoration sites in a more structured way.

OBJECTIVES

The MRTT has been developed by the GMA to represent a consistent framework to support low-cost monitoring, evaluation, and learning from mangrove restoration projects. The MRTT does not give a prescriptive method for assessing mangrove restoration, but rather represents a flexible framework allowing existing assessment methods to be summarized in a consistent way. This will aid cross-project comparisons to improve mangrove conservation outcomes and build a broader community of practice to support effective mangrove restoration.

There are three main objectives of this tool: (i) To help conservationists supporting mangrove restoration projects to plan, conduct, and track components critical to the success of mangrove restoration projects over time. (ii) To help conservationists share information on mangrove restoration projects they have conducted with decision makers and other key stakeholders to inform and support adaptive management. (iii) To gather consistent data on the outcomes of mangrove restoration projects to facilitate powerful analyses that can underpin cross-project learning to improve mangrove restoration success.

METHODOLOGY

The MRTT was developed using a combination of a comprehensive literature review, scientific and conservation practitioner workshops, and field trials. The tool was designed knowing many conservation practitioners are: (i) familiar with multiple choice answer tracking tools in their work (e.g. management effectiveness tracking tools), (ii) face budget and time constraints for conservation monitoring and evaluation, and finally (iii) have limited capacity to identify standardized key indicators that are relevant for global research. Therefore, this low-cost and simple assessment has been developed collaboratively with conservation practitioners and scientists, and covers the full range of topics considered important to mangrove restoration success rather than going in-depth in one particular area. This tool builds on the input and work of many scientists and conservation practitioners based on decades of experience.

RESULTS AND DISCUSSION

The MRTT framework consists of three assessment sections: (i) a pre-restoration baseline, (ii) the restoration interventions, and (iii) post-restoration monitoring:

1. Pre-restoration baseline assessment. Consists of questions documenting the general project structure, the location, and site background information. This includes spatially identifying the location of the restoration site. It then gathers information on the project aims and the causes of mangrove decline at the site (i.e. why were mangroves lost from the area where you wish to restore them), and asks about any pre-restoration site assessments you may have conducted to help identify the optimal restoration approach.
2. Restoration interventions. Documents what project interventions have been undertaken to restore mangroves. These interventions include both biophysical activities (such as restoring hydrological flows, removing physical barriers to mangrove seed arrival, and mangrove planting, etc.) and social interventions (such as community engagement or livelihoods support). It also documents financial costs associated with the project.
3. Post-restoration monitoring. Provides a framework for consistent reporting of restoration site monitoring activities. This section covers the ecological status and outcomes, social and governance outcomes, and any adaptive management of the restoration site that is being conducted. This final section of the MRTT is designed to be completed multiple times for each restoration site, allowing status and trends to be established following restoration.

While all three parts of the assessment can be completed simultaneously for existing or past restoration projects, it is anticipated that many users of this tool will conduct these three assessments at different time points throughout the life of a project. MRTT is designed to supplement and not replace field-based data collection. The global MRTT database will be hosted on Global Mangrove Watch (www.globalmangrovewatch.org), an online geospatial platform that provides the latest remote sensing data and monitoring tools needed by mangrove conservationists. Completing MRTT assessments within Global Mangrove Watch will allow users to explore their mangrove restoration data in the context of this rich array of mangrove datasets already available on the platform.

Keywords: Mangrove, monitoring, restoration, field tool, tracking.