Waves of Change: Coastal Resilience with a Participatory-UAS Approach

Olas de Cambio: Resiliencia Costera con un Enfoque UAS Participativo

Vagues de Changement: Résilience Côtière avec une Approche UAS Participative

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EXTENDED ABSTRACT

The Participatory Uncrewed Aerial Systems (P-UAS) approach provides an innovative framework for enhancing the resilience of coastal communities in response to the pressing challenges of climate change. By combining drone technology with geospatial analysis tools and participatory methods, P-UAS fosters collaboration, improves governance structures, and empowers local communities through accessible and equitable environmental data.

By merging drone technology with geospatial analysis tools and integrating both ecosystem-based and participatory approaches, this method enhances collaboration, fosters good governance, and empowers stakeholders, making environmental data collection and monitoring both effective and engaging. The P-UAS approach integrates diverse knowledge systems—local insights, scientific data, and collaborative mapping techniques—into an ecosystem-based monitoring strategy that improves decision-making, promotes transparency, and empowers communities to play an active role in resource management. Utilizing high-resolution data to understand ecological interactions and determine appropriate geographic scales for management, this approach engages communities in data collection and analysis, facilitates real-time data dissemination and stakeholder collaboration, and improves decision-making frameworks through inclusive processes.

The flexible application of the P-UAS approach is demonstrated across various national and regional training projects, showcasing its wide-ranging use and impact across the Caribbean. These outcomes directly contribute to achieving key Sustainable Development Goals, including SDG 13 (Climate Action) by enhancing resilience to climate impacts, SDG 14 (Life Below Water) through improved marine resource management, and SDG 17 (Partnerships for the Goals) by fostering collaboration across diverse stakeholders and nations. Case studies illustrate how PUAS empowers communities, enhances environmental management, and supports informed governance at multiple scales. The participatory approaches applied not only ensure the collection of holistic and accurate data but also strengthens the role of widespread participation in marine governance. This increased understanding and ownership foster positive societal benefits beyond environmental management, aligning with all 17 of the Sustainable Development Goals (SDGs) 2030.

INTRODUCTION

Developed from the principles of Participatory-GIS (PGIS), the P-UAS approach integrates traditional ecological knowledge with state-of-the-art geospatial technologies. This evolution addresses critical gaps in coastal and marine management, enabling participatory decision-making processes at multiple governance levels. By equipping diverse stakeholders with the tools and knowledge to collect, analyze, and share environmental data, PUAS bridges technical expertise with grassroots empowerment.

METHODOLOGY

The PUAS approach is grounded in ecosystem-based principles, incorporating the following components:

- Mission Planning: Identification of survey parameters, safety protocols, and assessment of geographic and jurisdictional scales.
- Data Collection: High-resolution drone surveys, ground-truthing, and standardized field data workflows.
- Data Analysis and Dissemination: Web-based dashboards for processing, quality assurance, and sharing actionable insights through reports, maps, and interactive tools.

This user-centered and demand-driven framework is designed to be adaptable, fostering stakeholder ownership while enhancing the technical capacity of local communities.

RESULTS AND CASE STUDIES

Table 1. Participatory-UAS Impact Across the Caribbean. This table highlights the Participatory-UAS approach's geographic reach, training participants, and applications for coastal resilience and disaster management in the Caribbean (2022-24).

Category	Details
Total Participants	**2,130+ individuals trained**
Countries Involved	**17 Caribbean nations** including Bahamas, Barbados, St. Vincent & Grenadines, St. Lucia, Dominica, 9 OECS nations, and Overseas Territories.
Agencies Impacted	**65+ organizations** spanning government agencies, NGOs, researchers, and community groups.
Acres Mapped	**40,000+ acres** of terrestrial, coastal, and marine habitats mapped across participating nations.
Key Applications	- Coastal climate resilience (e.g., Pre- and Post-hurricane mapping). - Fisheries management (e.g., marine infrastructure, vessels, resource use). – Coastal vulnerability mapping and preparedness (e.g., real-time mapping). - Sargassum monitoring (e.g. abundance, management planning, validation).
Training Projects	- **FAO**: 92 trainees: Bahamas, Barbados, St. Vincent, St. Lucia & Dominica. - **BioSpace**: 50 stakeholders from 18 agencies across 9 OECS nations. - **CANARI**: 40 trainees in participatory coastal mapping across 4 nations.
Key Outputs	- High-resolution maps, 3D elevation models, maps and geospatial datasets. - Site level baseline ecosystem maps and monitoring strategies - Participatory UAS Monitoring Guidebook to aid ecosystem management.
Gender Inclusivity	**40%+ women** empowered to engage in environmental management.
Sustainability Focus	Aligns with all **Sustainable Development Goals (SDGs) 2030**, fostering collaborative approach to governance, equity and community resilience.

PUAS has demonstrated impactful results across various Caribbean nations, addressing coastal resilience, disaster preparedness, and marine conservation. Key examples include:

- **FAO Projects:** Training 92 professionals across the Bahamas, Barbados, St. Vincent and the Grenadines, St. Lucia, and Dominica, focusing on disaster resilience and coastal mapping.
- **BioSpace Initiative:** Engaging 50 stakeholders across nine OECS countries to establish regional baselines for sustainable coastal management.
- **CANARI Projects:** Empowering 40 trainees in sargassum monitoring and coastal community climate resilience planning across five Caribbean territories.

These projects collectively involved over 2,000 participants across 17 nations, representing more than 65 agencies. The P-UAS approach has been applied to map over 40,000 acres of terrestrial and coastal marine environment aiding more equitable and transparent marine management efforts.

DISCUSSION AND CONCLUSION

Over the past two decades, the P-UAS approach has evolved from foundational Participatory GIS methodologies into a robust framework now leveraging easy to use drone technology and accessible geospatial web-mapping analysis tools. This transformation has significantly enhanced data accessibility, equity and stakeholder engagement. By equipping local communities with practical tools, P-UAS fosters stakeholder ownership and empowerment, enabling sustainable stewardship of coastal and marine resources. Its success demonstrates the scalability of this model, bridging traditional knowledge with advanced technologies to align with the Sustainable Development Goals (SDGs) 2030. This approach offers a replicable and impactful solution for global environmental challenges, emphasizing the importance of inclusive governance and collaborative data collection.

KEYWORDS: Coastal Resilience, Ecosystem Approach, Participatory-UAS, Drone Mapping, Marine Governance