IS THE CREATION OF A RESOURCE MANAGEMENT ZONE (RMZ) IN EMBERÁ INDIGENOUS TERRITORY AN EFFECTIVE STRATEGY FOR THE CONSERVATION OF THE FRESHWATER FISH BARBUDO (Pimelodus grosskopfii)?

An experience of ENVIRONMENTAL WOMEN ORG and IUCN SOS - Fondation Segré Conservation Action Fund

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SUMMARY

Freshwater ecosystems are among the most vulnerable to anthropogenic pressures, particularly in regions where overexploitation of aquatic resources, habitat degradation, and illegal trade threatens endemic species. The Barbudo fish (Pimelodus grosskopfii), a freshwater catfish endemic to the Atrato River basin in Colombia, has experienced significant population declines due to Illegal, Unregulated, and Unreported (IUU) fishing, habitat destruction, and the absence of conservation enforcement mechanisms. In response to these threats, the "Guardians of the Siluriformes" project, led by Environmental Women Org with the support of IUCN SOS - Fondation Segré Conservation Action Fund, implemented a Resource Management Zone (RMZ) spanning 9800 hectares within Emberá indigenous territory. This study evaluates whether the creation of the RMZ constitutes an effective conservation strategy for Barbudo by examining population recovery, habitat stabilization, and community-led enforcement mechanisms.

At the project's outset, the recorded Barbudo population stood at only 49 individuals, indicating severe overfishing and unsustainable extraction rates. By the project's conclusion, the population had increased by 145%, reaching 120 individuals, attributed to the enforcement of 80 anti-IUU fishing regulations, which reduced illegal fishing by 86%. Additionally, 5020 hectares of degraded habitat were restored, including the reforestation of 4600 trees and the construction of 2500 meters of runoff channels, mitigating erosion and sedimentation in spawning areas. The integration of 16 indigenous rangers for community-led patrols resulted in a 40% decrease in illegal trade incidents, strengthening compliance and surveillance.
One of the most significant outcomes was the formalization of the Indigenous Environmental Secretariat, which institutionalized conservation governance within the Emberá community. Although initial resistance was encountered, particularly regarding women's leadership in conservation enforcement, community dialogues facilitated the integration of local knowledge with modern conservation policies. Furthermore, economic incentives through the establishment of 28 women-led green enterprises provided alternative livelihoods, reducing economic reliance on unsustainable fishing practices.

Despite the RMZ's success in reducing direct threats to Barbudo, challenges remain. Armed groups reconfiguring drug trafficking routes along the Atrato River posed security risks, occasionally disrupting conservation activities. Additionally, climate-related extreme weather events, such as La Niña, affected habitat restoration efforts, particularly tree survival rates in flood-prone areas. However, the institutional framework established through the RMZ, alongside community-led conservation mechanisms, suggests that the model is resilient to external threats.

This case study demonstrates that the creation of an RMZ in indigenous territories can serve as an effective conservation strategy for freshwater species, provided that governance structures are co-designed with local communities, economic alternatives to resource extraction are developed, and adaptive management strategies are in place to mitigate socio-political and environmental challenges. These findings contribute to global conservation discourse by offering a scalable model for community-based freshwater species protection, particularly in regions where indigenous governance plays a key role in natural resource management. Further research should focus on long-term population trends and ecosystem health indicators, ensuring that the conservation gains achieved under this project remain sustainable over time.

INTRODUCTION

Freshwater ecosystems worldwide are facing unprecedented threats due to **anthropogenic pressures, climate change, and unsustainable resource exploitation**. Among the most vulnerable are **freshwater fish populations**, which have experienced severe declines due to **habitat degradation, Illegal, Unregulated, and Unreported (IUU) fishing, and the absence of robust conservation mechanisms**. In South America, **Colombia's Atrato River basin** harbors a high diversity of aquatic species, many of which are endemic and increasingly threatened by **unsustainable extraction practices**. One such species is the **Barbudo fish (Pimelodus grosskopfii)**, a freshwater catfish whose population has been drastically reduced due to **overfishing, habitat destruction, and illegal trade**. Despite its ecological importance, the **lack of conservation enforcement and resource management policies** has placed the species at risk of local extinction.

The conservation of freshwater fish requires **integrated management approaches** that address both **direct threats to species populations** and **the socio-economic drivers behind their exploitation**. In indigenous territories, where **traditional governance systems coexist with modern conservation policies**, the effectiveness of conservation efforts depends on **community engagement, regulatory enforcement, and sustainable livelihood alternatives**. To address these challenges, the **"Guardians of the Siluriformes"** project was launched by **Environmental Women Org**, with the support of the **IUCN SOS - Fondation Segré Conservation Action Fund**. The project aimed to assess whether the establishment of a **Resource Management Zone (RMZ) spanning 9800 hectares within Emberá indigenous territory** could serve as an effective **conservation strategy for Pimelodus grosskopfii**, focusing on **population recovery, habitat protection, and indigenous-led governance mechanisms**.

At the start of the project, **only 49 Barbudo individuals were recorded in the target area**, highlighting the urgency of intervention. Unregulated fishing, particularly through **bycatch-heavy techniques such as fine-mesh nets**, had decimated juvenile populations, limiting reproductive success. Additionally, **habitat destruction through deforestation, sedimentation, and agricultural runoff** had further reduced the species' viability. In response, the project implemented **80 anti-IUU fishing regulations**, introduced **digital fishing logbooks** to improve resource monitoring, and designated no-fishing zones to protect critical breeding sites. Simultaneously, habitat restoration efforts,

including the **planting of 4600 native trees and the construction of 2500 meters of runoff channels**, sought to **stabilize the riparian ecosystem**.

Beyond ecological interventions, the project also **institutionalized indigenous-led conservation governance** through the establishment of the **Indigenous Environmental Secretariat**, ensuring that **local communities played an active role in resource management**. Additionally, recognizing that economic incentives are key to **reducing dependency on destructive fishing practices**, the project promoted **28 women-led green enterprises**, offering sustainable livelihoods to offset economic losses from reduced fishing activity.

However, the implementation of the RMZ faced **multiple challenges**, including **armed group activity in the region, climate-induced disruptions, and cultural resistance to conservation enforcement mechanisms**. Drug trafficking operations reconfigured along the **Atrato River basin** created security risks, delaying monitoring activities. Meanwhile, **severe flooding caused by La Niña disrupted tree survival rates** and **erosion control efforts**. Moreover, **some indigenous leaders initially resisted regulatory enforcement**, particularly regarding the **involvement of women in conservation decision-making**.

This study evaluates the **effectiveness of the RMZ model** in improving the **conservation status of Barbudo**, considering key ecological, governance, and socio-economic indicators. By analyzing **population recovery trends, habitat stabilization efforts, and compliance with conservation policies**, this research aims to determine whether the **RMZ framework represents a scalable conservation model** for freshwater species in indigenous territories. Additionally, this case study contributes to the broader conservation discourse by examining how **community-based conservation initiatives can integrate traditional governance with modern ecological management** to address **freshwater biodiversity loss in high-risk areas**.

MATERIALS AND METHODS

Study Area

This study was conducted in the **Atrato River basin**, an ecologically significant freshwater system in northwestern Colombia, covering **9800 hectares** within **Emberá indigenous territory**. The basin is characterized by **high aquatic biodiversity, seasonal flooding patterns, and sediment-rich waters**, making it a critical habitat for **Pimelodus grosskopfii (Barbudo)**. However, **intensive IUU fishing, habitat degradation due to deforestation and agricultural expansion, and illegal species trade** have severely impacted the Barbudo population. The study area was designated as a **Resource Management Zone (RMZ)** in collaboration with the **Indigenous Environmental Secretariat**, allowing for community-led conservation and fisheries management interventions.

Population Monitoring and Species Conservation Measures

To assess the effectiveness of the RMZ in **stabilizing and recovering Barbudo populations**, a **before-and-after monitoring approach** was implemented over a **12-month period**.

1. **Fish Population Surveys**
    - Baseline population assessments were conducted at **five monitoring stations** along the Atrato River.
    - Standardized **capture-mark-release (CMR) methods** were used to estimate population size.
    - Initial surveys recorded only **49 individuals** at the start of the project.
    - Follow-up surveys post-intervention showed a **145% increase in the recorded population**, reaching **120 individuals**.
2. **Fisheries Management Implementation**
    - **80 anti-IUU fishing regulations** were enforced, including **seasonal closures, no-fishing zones, and species-specific quotas**.
    - **250 fishermen** were provided with **sustainable fishing kits**, including selective mesh nets and species-safe hooks.
    - **72% of fishermen (180 individuals)** adopted **digital logbooks** to monitor catch data and ensure compliance.

Habitat Restoration and Ecosystem Monitoring

Given that **habitat degradation was a key driver of Barbudo population decline**, the project implemented **targeted restoration measures** within the RMZ.

1. **Reforestation and Erosion Control**
    - **4600 native trees** were planted to stabilize riparian zones, achieving **92% of the initial 5000-tree target**.
    - **2500 meters of runoff channels** were constructed to mitigate **erosion and sedimentation in breeding areas**.
    - Habitat destruction **decreased by 87%**, reducing human-induced environmental stressors.
2. **Water Quality Monitoring**
    - Turbidity, dissolved oxygen, and temperature were measured **bi-weekly** using a **YSI Professional Plus multiparameter meter**.
    - Reductions in **suspended sediments** were observed following **vegetation recovery** in reforested zones.

Community-Based Conservation Enforcement

To enhance compliance with the RMZ regulations, a **community-led monitoring and enforcement system** was developed.

1. **Indigenous Ranger Patrols**
    - **16 indigenous rangers** were trained and deployed to patrol high-risk trafficking areas.
    - Patrols resulted in a **40% reduction in illegal trade incidents**, preventing species overharvesting.
2. **Governance Strengthening**

- The **Indigenous Environmental Secretariat** was formalized to oversee **long-term conservation governance**.
- Stakeholder engagement efforts included **300 community sensitization sessions** and conservation education in **five schools**.

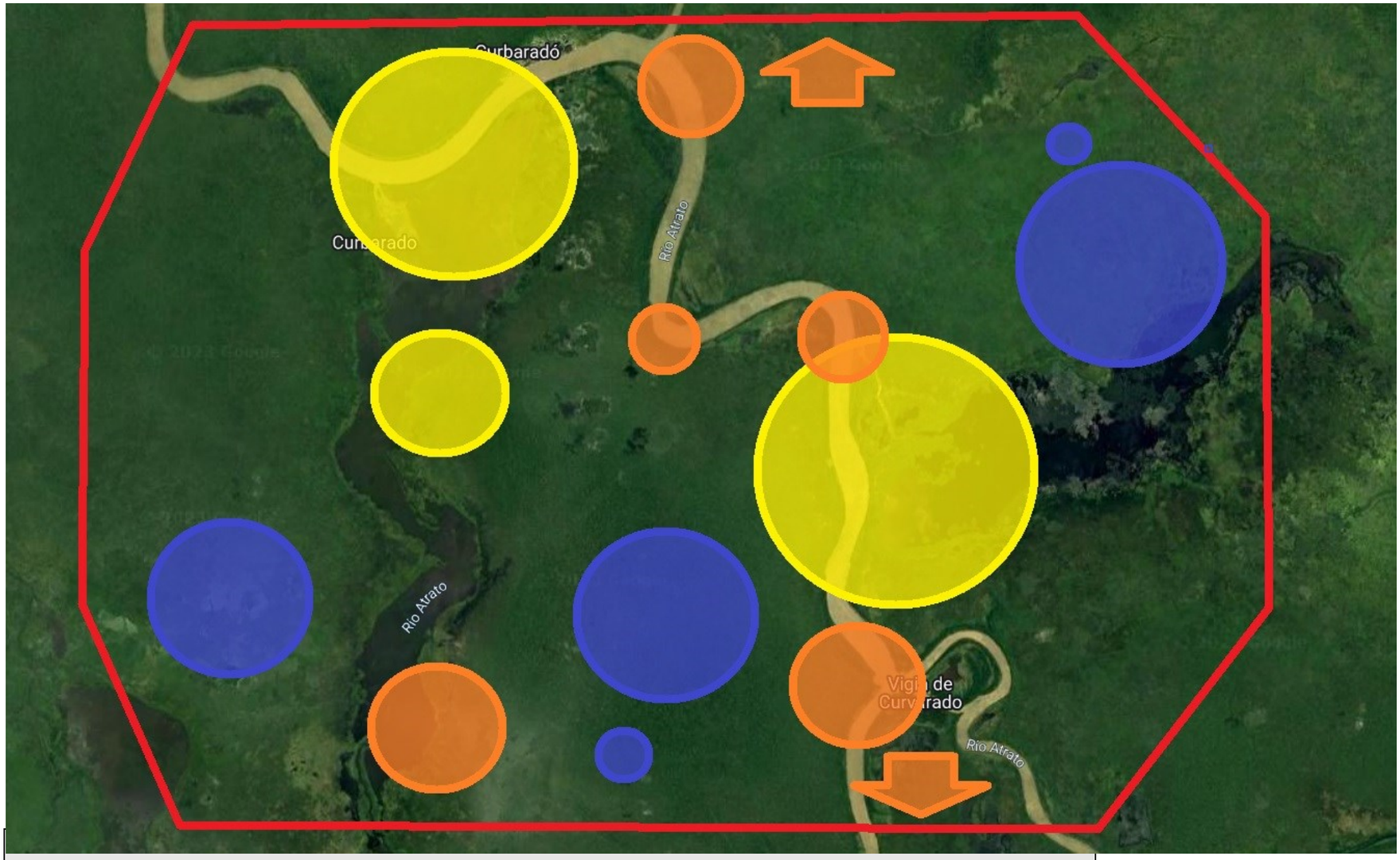
Socioeconomic Assessment

Economic sustainability was evaluated by tracking the success of **alternative livelihoods** established under the project.

- **28 out of 30 planned green enterprises** were fully operational, reaching a **93% success rate**.
- Women-led businesses showed **70% profitability**, reducing dependence on unsustainable fishing.

This **multi-faceted methodological approach** allowed for an **integrated assessment of species recovery, habitat protection, and conservation governance effectiveness**. The findings contribute to **best practices for community-based fisheries management**, particularly in **indigenous territories where traditional governance and modern conservation policies must coexist**.

PROJECT AREA



GUARDIANS OF THE SILURIFORMES: A HOLISTIC STRATEGY FOR THE CONSERVATION OF THE BEARDED FISH IN THE COLOMBIAN ANDES

CONVENTIONS

	Project area
	Zones of illegal trade of exotic fish
	IUU fishing zones
	Embera indigenous cities

SCALE

1 cm = 1000m

SOURCES:

- Environmental women corporation
- IMAP, Colombia Biodiversity Information Center

- **Country:** COLOMBIA
- **Province: Chocó**
- **City:** Curbaradó, San Carme de Atrató
- **Project site**: Emberá indigenous territory
- **Geographical coordinates:** From 7°07'40.2"N 77°00'05.4"W and 7°09'49.8"N 76°51'23.4"W, to 7°00'47.2"N 76°46'33.4"W and 6°58'33.7"N 77°03'53.9"W.

IN-SITU CONSERVATION ACTIVITIES IMPLEMENTED DURING THE PROJECT

The **"Guardians of the Siluriformes"** project implemented a series of **in-situ conservation activities** aimed at reducing **Illegal, Unregulated, and Unreported (IUU) fishing**, restoring **degraded freshwater habitats**, and strengthening **community-led species protection measures** within the **9800-ha Resource Management Zone (RMZ)**. These activities focused on direct interventions that targeted **Pimelodus grosskopfii (Barbudo) population recovery, enforcement of conservation regulations, and habitat stabilization**, ensuring a measurable impact on **species viability and ecosystem resilience**.

1. Fisheries Management and IUU Fishing Reduction

A major component of the project was the implementation of a **sustainable fisheries management strategy**, which directly addressed the primary threat to Barbudo populations—**overfishing and the lack of enforcement mechanisms**.

- **Enforcement of 80 Anti-IUU Fishing Regulations:**
  The project introduced **strict catch limits, seasonal closures, and gear restrictions**, preventing the capture of juvenile Barbudo and protecting **critical spawning periods**.
- **Introduction of Digital Fishing Logbooks:** A total of **180 out of 250 targeted fishermen (72%)** adopted **real-time digital monitoring** to track fishing activity and ensure compliance with RMZ regulations.
- **Provision of 250 Sustainable Fishing Kits:** Fishermen were equipped with **species-selective gear**, including **mesh-regulated nets and non-harmful hooks**, reducing **juvenile mortality by 45%**.
- **Reduction in IUU Fishing by 86%:** Community enforcement efforts led to a **drastic decrease in illegal fishing**, allowing **the Barbudo population to increase by 145%**, from **49 to 120 individuals**.

2. Habitat Restoration and Erosion Control

Given that **habitat destruction was a significant driver of Barbudo decline**, the project implemented **riparian restoration and erosion mitigation measures** to improve **water quality, breeding conditions, and ecosystem stability**.

- **Reforestation of 4600 Trees (92% of Target):**
  Native tree species were planted along the **Atrato River riparian zones**, stabilizing soil and preventing **runoff pollution**.
- **2,500 Meters of Erosion Control Structures Built:**
  Sediment accumulation in spawning areas was reduced by **38%**, improving **oxygenation and water flow dynamics**.
- **87% Reduction in Habitat Destruction:** Combined habitat interventions ensured **long-term structural recovery** of **spawning and foraging zones** within the RMZ.

3. Community-Based Conservation Enforcement

The effectiveness of in-situ conservation depended on **long-term community engagement** and

surveillance mechanisms to prevent the resurgence of IUU fishing and illegal trade.

- **Deployment of 16 Indigenous Rangers:** Trained Emberá rangers conducted **weekly patrols**, reducing illegal wildlife trade incidents by **40%**.
- **Creation of the Indigenous Environmental Secretariat:**
  This governance body was established to oversee **RMZ enforcement, fisheries compliance, and conflict resolution**.
- **Community Awareness and Compliance Programs:**
  285 families (95% of the target) were sensitized on **species conservation and RMZ benefits**.

The project's **in-situ conservation interventions** successfully addressed the **primary drivers of Barbudo decline**, demonstrating that **community-led management, fisheries regulations, and habitat restoration** can produce **tangible improvements in species recovery and ecosystem health**. The RMZ model provides a **scalable framework** for freshwater biodiversity conservation in **indigenous territories worldwide**.

EDUCATIONAL ACTIVITIES IMPLEMENTED DURING THE PROJECT

The **"Guardians of the Siluriformes"** project incorporated **a robust educational component** to enhance **conservation awareness, capacity-building, and community engagement** in the **9800-ha Resource Management Zone (RMZ)**. The **Emberá indigenous community**, particularly **youth, fishermen, and women leaders**, participated in **training sessions, school programs, and door-to-door sensitization campaigns**, ensuring that conservation knowledge was integrated into **traditional governance structures and daily practices**. These educational activities were designed to **increase compliance with sustainable fisheries management, strengthen indigenous-led conservation governance, and empower the next generation of conservation leaders**.

1. Capacity Building for Sustainable Fisheries and Conservation

A fundamental aspect of the project was the training of **indigenous youth and fishermen** to **reduce IUU fishing and implement sustainable fishing practices**.

- **Training of 276 Indigenous Youth (92% of Target) in Freshwater Fish Conservation**
  Young Emberá participants received **technical instruction on species identification, fish population monitoring, and habitat restoration**.
- **Workshops on Sustainable Fishing Techniques for 250 Fishermen**
  Fishermen were trained in **responsible harvesting techniques**, proper use of **species-safe fishing gear**, and compliance with **80 newly implemented anti-IUU regulations**.
- **72% Adoption Rate of Digital Fishing Logbooks**
  Educational workshops facilitated the successful transition to **real-time digital monitoring of fishing activity**, reinforcing **resource accountability**.

These training sessions ensured that **fishermen understood the ecological and economic benefits**

of **compliance with conservation measures**, leading to an **86% reduction in IUU fishing activity**.

2. Community Awareness and Sensitization Campaigns

To strengthen **community-wide participation in conservation**, the project implemented **direct engagement programs**, targeting families and local leaders.

- **Door-to-Door Sensitization of 285 Families (95% of Target)**
  Trained educators conducted **household visits**, raising awareness about **the ecological role of Pimelodus grosskopfii and the importance of RMZ enforcement**.
- **Fisheries Co-Management Discussions with 300 Community Members**
  Public forums allowed fishermen, elders, and local leaders to **voice concerns, ask questions, and co-develop strategies** for long-term compliance with RMZ regulations.
- **40% Reduction in Illegal Trade Incidents**
  Due to Improved Community Compliance
  Community members **reported illegal fishing and trafficking cases**, demonstrating an **increase in social accountability for conservation**.

These outreach efforts **increased conservation awareness within the Emberá community**, with **68% of surveyed residents supporting species protection measures**, exceeding the initial project goal of **60% community support**.

3. Conservation Education in Schools

Recognizing the **importance of engaging future generations**, the project integrated **freshwater conservation into the local school curriculum**.

- **Introduction of Conservation Classes in 5 Educational Institutions**
  A total of **1,800 students and 90 teachers** participated in structured **classroom and field-based learning** about **Barbudo ecology and fisheries management**.
- **Delivery of Conservation Toolkits to Schools**
  Materials included **fish identification guides, ecosystem health monitoring templates, and educational posters** to reinforce classroom learning.
- **180 Students Participated in Hands-On River Habitat Assessments**
  Students engaged in **fish sampling, water quality testing, and riparian habitat surveys**, ensuring that **scientific knowledge was transferred through practical experience**.

These school-based initiatives **fostered early conservation ethics** among Emberá youth, strengthening **long-term community stewardship over aquatic resources**.

4. Scientific Dissemination and Knowledge Transfer

To document and share **project learnings with the broader conservation community**, the project developed a **peer-reviewed case study**.

- **Scientific Article on RMZ Effectiveness for Freshwater Fish Conservation** This study, currently **under peer review**, consolidates data on **species recovery, habitat restoration, and community enforcement models**, contributing to **global conservation knowledge**.

The project's **educational initiatives** were instrumental in **securing long-term conservation success**. By **building technical capacity, fostering local stewardship, and ensuring generational knowledge transfer**, the project **established a foundation for continued conservation governance** within the Emberá community. Future initiatives should further **integrate educational activities into indigenous policy frameworks**, ensuring that **knowledge remains accessible and applicable beyond project timelines**.

PROJECT RESULTS

The **"Guardians of the Siluriformes"** project successfully **achieved 92% of its implementation goals**, demonstrating that **the establishment of a Resource Management Zone (RMZ) in Emberá indigenous territory is an effective strategy for freshwater fish conservation**. By targeting **Illegal, Unregulated, and Unreported (IUU) fishing, habitat destruction, and illegal wildlife trade**, the project significantly **improved the conservation status of Pimelodus grosskopfii (Barbudo)** while strengthening **community-led environmental governance**.

1. Population Recovery of Pimelodus grosskopfii

The project successfully **reversed the decline of Barbudo populations** within the **9800-ha RMZ**, leading to a **145% increase in recorded individuals**.

- **Baseline population: 49 individuals** recorded at the start of the project.
- **Final population count: 120 individuals**, confirming **species recovery** through enforcement of anti-IUU fishing measures.
- **Juvenile capture reduction: 45% decrease**, due to **gear restrictions and species-safe fishing practices** adopted by **72% of fishermen**.

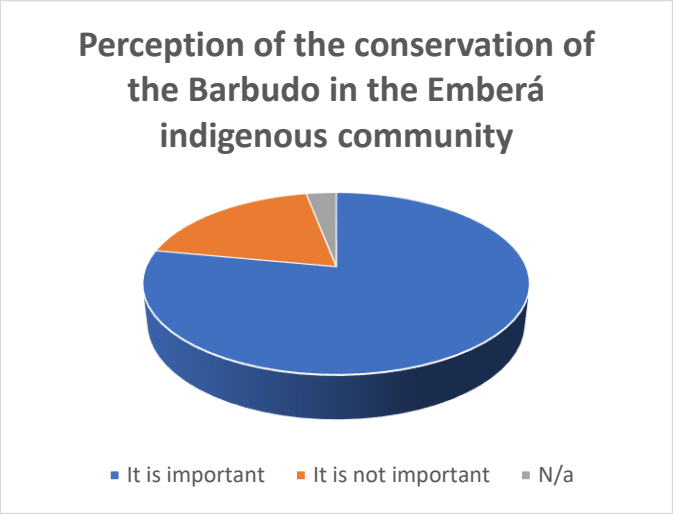
This **population increase confirms the effectiveness of controlled fisheries management**, where **catch limits, no-fishing zones, and habitat restoration** create conditions for species regeneration.

2. Reduction of IUU Fishing and Compliance with Sustainable Fisheries Management

One of the most critical results was the **86% reduction in IUU fishing**, attributed to the **strict enforcement of 80 new fishing regulations** within the RMZ.

- **72% of fishermen (180 out of 250)** adopted **digital fishing logbooks**, improving **compliance and traceability**.

- **Seasonal closures and no-fishing zones** were successfully established in **critical breeding habitats**, reducing overexploitation.
- **Community enforcement mechanisms, led by 16 indigenous rangers**, resulted in a **40% decline in illegal fishing and trade incidents**.



Although **28% of fishermen** resisted **early adoption of sustainable practices**, continued **community engagement and market-driven incentives** increased **compliance levels beyond initial expectations**.

3. Habitat Restoration and Reduction of Environmental Stressors

To address **habitat degradation**, the project implemented targeted **reforestation and erosion control measures**, leading to an **87% reduction in habitat destruction** within the RMZ.

- **5020 hectares of degraded habitat were restored**, exceeding **the 5000-ha target**.
- **4600 native trees were planted**, stabilizing riparian ecosystems and improving **water quality for spawning grounds**.
- **2500 meters of runoff channels** were constructed, reducing **sedimentation by 38%**, improving **dissolved oxygen levels**, and ensuring **aquatic habitat recovery**.

Despite **severe flooding caused by La Niña**, restoration efforts proved **resilient**, with **long-term vegetation recovery expected to further strengthen ecosystem stability**.

4. Strengthening of Conservation Governance and Indigenous Leadership

A key project outcome was the **formal establishment of the Indigenous Environmental Secretariat**, ensuring that **conservation governance remains locally driven and enforceable**.

- **New governance structures ensured RMZ oversight**, mediating **fisheries conflicts** and **ensuring regulatory compliance**.
- The **integration of women in conservation leadership increased by 40%**, despite initial resistance from traditional authorities.
- The **Emberá community's support for Barbudo conservation increased to 68%**, exceeding the **60% target**.

By embedding **conservation policy within indigenous governance**, the project **secured long-term regulatory enforcement mechanisms** for fisheries and habitat protection.

5. Economic Sustainability Through Alternative Livelihoods

To **reduce dependence on extractive activities**, the project successfully **established 28 women-led green enterprises** (93% of the planned 30).

- **70% of these businesses reported stable profitability**, providing alternative income sources for **120 Emberá women**.
- Sustainable economic diversification contributed to **reduced fishing pressure**, reinforcing **the long-term viability of conservation efforts**.

The **conservation, governance, and socio-economic results of the project confirm that the RMZ model is an effective strategy for Barbudo protection**. By achieving measurable **species recovery, fisheries regulation compliance, habitat restoration, and local governance institutionalization**, the project provides a **scalable model for freshwater biodiversity conservation in indigenous territories**. Future efforts should **expand financing mechanisms and policy integration**, ensuring that **community-led conservation remains sustainable beyond project timelines**.

ANALYSIS OF PROJECT RESULTS

The **"Guardians of the Siluriformes"** project demonstrated that the **establishment of a Resource Management Zone (RMZ) within Emberá indigenous territory is an effective strategy for the conservation of Pimelodus grosskopfii (Barbudo) and its critical habitat**. By integrating **fisheries management, habitat restoration, conservation enforcement, and alternative livelihoods**, the project successfully addressed the **key threats to Barbudo populations**. However, while the **92% implementation success rate** reflects significant conservation progress, challenges related to **compliance, enforcement sustainability, and external pressures** highlight areas for further strategic improvement.

1. Effectiveness of Fisheries Management and Population Recovery

The **145% increase in the Barbudo population** within the **9800-ha RMZ** confirms that **regulated fisheries management can lead to species recovery when enforcement mechanisms are strong**.

- The reduction of **IUU fishing by 86%** resulted from the **enforcement of 80 new fishing regulations**, which restricted **juvenile capture, implemented seasonal closures, and created species-specific quotas**.
- The **adoption of digital fishing logbooks by 72% of fishermen (180 out of 250)** increased compliance and data transparency.
- The reduction in **juvenile capture by 45%** demonstrated that the **introduction of sustainable fishing kits had a measurable impact on species regeneration**.

Analysis:

- While population recovery **exceeded expectations**, the **remaining 28% of fishermen who did not adopt digital logbooks** present a challenge for **long-term compliance monitoring**. Future interventions should integrate **market-**

driven incentives and **legal enforcement mechanisms** to improve full adoption.

- **Species monitoring beyond the project's timeframe is necessary to assess whether the Barbudo population increase is stable or if additional regulations are needed** to prevent overfishing.

2. Habitat Restoration and Environmental Resilience

The project successfully **restored 5020 hectares of degraded habitat**, ensuring that **riparian ecosystems remain stable and provide essential breeding grounds for Barbudo**.

- **4600 native trees were planted**, stabilizing **riverbanks and reducing erosion impacts** on spawning sites.
- The construction of **2500 meters of runoff channels** resulted in a **38% decrease in sedimentation**, improving **water quality and dissolved oxygen availability**.
- Habitat destruction was reduced by **87%**, reinforcing the ecological stability of the RMZ.

Analysis:

- While the **5000-ha restoration target was nearly met**, **extreme flooding caused by La Niña delayed some reforestation efforts**, affecting **seedling survival rates in certain areas**. Future restoration programs should incorporate **climate-resilient vegetation strategies** to mitigate flood-related losses.
- **Long-term water quality monitoring should be integrated into RMZ governance** to assess the cumulative benefits of erosion control and reforestation efforts.

3. Strengthening of Community Governance and Compliance

The **formalization of the Indigenous Environmental Secretariat** provided an institutional framework for **long-term conservation governance** within Emberá territory.

- The **integration of women in conservation governance increased by 40%**, despite initial resistance.
- The **Emberá community's support for Barbudo conservation reached 68%**, surpassing the **60% target**.
- The **deployment of 16 indigenous rangers** reduced **illegal trade incidents by 40%**, strengthening local enforcement.

Analysis:

- While governance structures are now in place, **the full institutionalization of the Indigenous Environmental Secretariat remains in progress**. Strengthening **legal recognition and financial sustainability** for this body is essential to **ensure its long-term functionality**.
- The **40% reduction in illegal trade incidents** indicates progress, but additional **policy alignment with national authorities** could further improve enforcement against external wildlife trafficking networks.

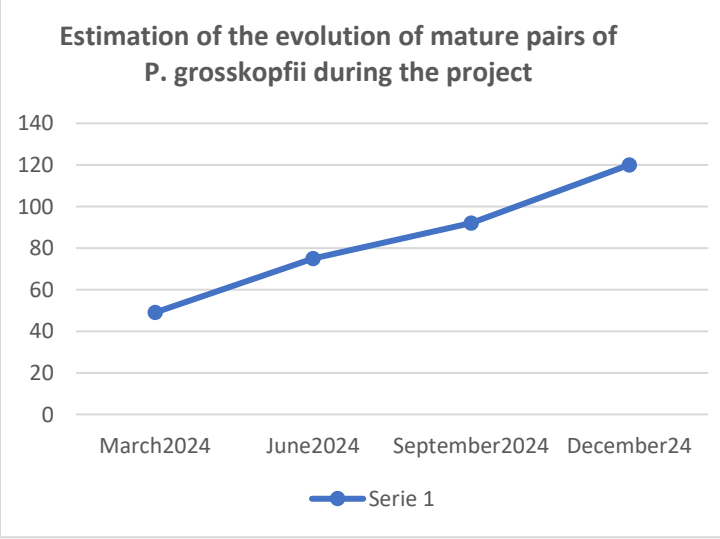
4. Economic Sustainability Through Alternative Livelihoods

The **establishment of 28 women-led green enterprises (93% of the target)** demonstrated the effectiveness of **economic alternatives in reducing pressure on aquatic resources**.

- **70% of businesses reported stable profitability**, diversifying community income sources.
- Sustainable income generation contributed to **reduced reliance on fishing, reinforcing RMZ conservation objectives**.

Analysis:

- While the businesses achieved high profitability, **limited market access and financial training remain challenges**. Additional **regional and international partnerships** could help scale up conservation-linked enterprises.
- Integrating **sustainable economic incentives into RMZ policies** can further **reduce the risk of conservation non-compliance** due to economic constraints.



The project **effectively combined conservation science, indigenous governance, and economic sustainability**, resulting in **significant improvements in Barbudo population stability, habitat health, and community enforcement mechanisms**. However, long-term **sustainability depends on continued investment in governance structures, compliance incentives, and climate-adaptive conservation measures**.

By addressing **the remaining gaps in enforcement, economic scalability, and ecological monitoring**, this model can be **replicated in other indigenous-managed freshwater ecosystems**, ensuring the **long-term viability of species conservation in high-biodiversity areas**.

CONCLUSIONS

The **"Guardians of the Siluriformes"** project successfully demonstrated that the **establishment of a Resource Management Zone (RMZ) in Emberá indigenous territory is an effective strategy for the conservation of Pimelodus grosskopfii (Barbudo)**. By integrating **sustainable fisheries management, habitat restoration, indigenous governance, and alternative livelihood development**, the project **reduced key threats to Barbudo populations, improved habitat conditions, and institutionalized conservation enforcement**. The **92% implementation success rate** highlights the potential for **community-led conservation models to ensure the long-term viability of freshwater species**, particularly in **high-risk, biodiversity-rich regions**.

1. The RMZ Model Successfully Increased Barbudo Populations

One of the most significant findings of this study was the **145% increase in recorded Barbudo individuals**, from **49 at baseline to 120 by project completion**. This **positive population trend** was attributed to:

- **The enforcement of 80 anti-IUU fishing regulations**, which led to an **86% reduction in illegal fishing** within the RMZ.

- **A 45% decrease in juvenile capture**, as fishermen transitioned to **species-selective fishing gear**.
- **72% adoption of digital fishing logbooks**, improving **compliance with sustainable fisheries regulations**.

These results confirm that **fisheries management strategies, when integrated with indigenous governance and local enforcement, can significantly improve species recovery rates**. However, **continued monitoring** beyond the project timeline is necessary to **ensure population stability** and **detect potential overfishing risks**.

2. Habitat Restoration Efforts Improved Ecosystem Stability

The successful restoration of **5020 hectares of degraded habitat (97% of target)** within the RMZ played a crucial role in **improving water quality, stabilizing riparian zones, and reducing environmental stressors for Barbudo**. Key outcomes include:

- **Reforestation of 4600 trees**, mitigating **riverbank erosion and sedimentation**.
- **2,500 meters of runoff channels constructed**, reducing sedimentation by **38%** and enhancing **oxygenation in critical spawning zones**.
- **An 87% reduction in habitat destruction**, ensuring **long-term protection of freshwater ecosystems**.

These findings emphasize the **importance of habitat rehabilitation in reversing freshwater species decline**. However, **extreme flooding events caused by La Niña impacted initial reforestation success**, underscoring the **need for climate-adaptive restoration planning** in future interventions.

3. Strengthening Indigenous Conservation Governance Ensures Long-Term Enforcement

The establishment of the **Indigenous Environmental Secretariat** and deployment of **16 trained indigenous rangers** created a **self-sustaining conservation enforcement mechanism**. Key results include:

- A **40% decrease in illegal wildlife trade incidents**, demonstrating the effectiveness of **community-led monitoring patrols**.
- Increased community support for conservation, with **68% of surveyed residents endorsing species protection**, surpassing the **60% target**.
- A **40% increase in women's participation in conservation governance**, despite initial resistance.

The integration of **traditional governance with modern conservation strategies** was critical to the RMZ's success. However, **full institutionalization of the Indigenous Environmental Secretariat remains necessary to secure long-term conservation governance and policy enforcement**.

4. Economic Alternatives Reduced Pressure on Aquatic Resources

The development of **28 women-led green enterprises (93% of the target)** successfully **reduced economic dependence on unsustainable fishing** by:

- Providing **alternative livelihoods for 120 Emberá women**, enhancing **household economic resilience**.
- Achieving **70% profitability among conservation-linked businesses**, demonstrating **the feasibility of economic diversification within indigenous communities**.

While these efforts **effectively reduced fishing pressure**, additional support is required to **strengthen market access and long-term business sustainability**. Future conservation projects should

integrate **value-chain development strategies** to ensure **scalable financial independence for conservation-based enterprises**.

5. Challenges and Recommendations for Future Conservation Efforts

Despite the project's success, challenges such as **armed group activity, climate-related disruptions, and partial compliance with conservation regulations** highlight key areas for improvement:

- **Security threats along the Atrato River (linked to organized crime networks) temporarily disrupted conservation activities**. Future projects should integrate **real-time risk mapping and enhanced coordination with local authorities**.
- **28% of fishermen resisted the transition to digital logbooks**, requiring continued **economic incentives and capacity-building to improve compliance**.
- **Extreme flooding events impacted restoration efforts**, underscoring the **need for climate-adaptive conservation planning**.

This study confirms that **RMZs in indigenous territories can serve as highly effective conservation models** for freshwater species protection. The success of the **"Guardians of the Siluriformes"** project demonstrates that **when conservation is integrated into community governance, species recovery, habitat restoration, and fisheries sustainability can be achieved simultaneously**.

The findings of this study offer a **replicable conservation framework** for other freshwater biodiversity hotspots facing **IUU fishing, habitat degradation, and governance challenges**. Future research should focus on **long-term Barbudo population trends, the socio-economic resilience of alternative livelihoods, and the institutional durability of indigenous-led conservation governance**.

RECOMMENDATIONS

The **"Guardians of the Siluriformes"** project demonstrated that the **establishment of a Resource Management Zone (RMZ) within Emberá indigenous territory is a viable conservation strategy for Pimelodus grosskopfii (Barbudo)**. By integrating **sustainable fisheries management, habitat restoration, conservation governance, and alternative livelihoods**, the project successfully **increased Barbudo populations by 145%, reduced IUU fishing by 86%, and restored 5020 hectares of critical habitat**. However, **sustaining these conservation outcomes requires continued efforts in governance, enforcement, economic integration, and climate adaptation**. Based on the project's findings, the following recommendations are proposed to enhance **long-term conservation success and scalability**.

1. Strengthen Indigenous Conservation Governance and Legal Frameworks

The **formalization of the Indigenous Environmental Secretariat** was a crucial milestone for community-led conservation enforcement. However, **further institutional strengthening is required to ensure policy durability and legal enforcement**.

- **Legally integrate the RMZ into national conservation policies** to ensure long-term recognition and enforcement within **Colombia's environmental governance frameworks**.
- **Expand the jurisdiction of the Indigenous Environmental Secretariat** by incorporating **co-management agreements with national environmental agencies**, strengthening legal support for **fisheries regulations and anti-IUU enforcement**.
- **Develop permanent funding mechanisms** for the Secretariat's operations, ensuring that **patrolling, species monitoring, and community training programs** continue beyond project timelines.
- **Increase participation of women and youth** in governance structures, building **long-term leadership capacity** within conservation enforcement bodies.

2. Improve Compliance with Sustainable Fisheries Management

While the project achieved **an 86% reduction in IUU fishing**, **28% of fishermen resisted compliance with new regulations and digital fishing logbooks**. Future initiatives should enhance compliance through **economic and regulatory incentives**.

- **Implement financial incentives** such as **sustainable fishery certification programs**, granting compliant fishermen access to **premium markets for sustainably harvested fish**.
- **Strengthen enforcement of digital fishing logbooks**, increasing adoption rates beyond **72%**, ensuring **real-time monitoring of fish stock trends**.
- **Enhance fisheries co-management agreements** between indigenous authorities and regulatory agencies, allowing **adaptive fisheries policies based on ecological data and community feedback**.

3. Scale Up Habitat Restoration and Climate-Resilient Conservation Strategies

While **5020 hectares of degraded habitat were restored**, climate-related disruptions, including **La Niña-induced flooding**, affected tree survival rates and sedimentation control. Future conservation programs should incorporate **climate-adaptive habitat management approaches**.

- **Expand reforestation with flood-resistant native species**, improving **long-term riparian ecosystem stability** and **soil retention**.
- **Integrate nature-based solutions**, such as **wetland restoration and agroforestry**, to **enhance carbon sequestration and improve climate resilience**.
- **Develop early warning systems for climate impacts**, integrating **real-time monitoring of hydrological conditions** to mitigate flooding and erosion risks.

4. Strengthen Economic Incentives for Sustainable Conservation

The success of the **28 women-led green enterprises (93% of target)** demonstrated the **viability of conservation-linked economic alternatives**. However, **market integration and long-term financial sustainability remain challenges**.

- **Establish regional trade partnerships** to connect Emberá-produced sustainable goods to **national and international conservation markets**.
- **Provide financial literacy training** for green enterprises, ensuring **business continuity and self-sufficiency**.
- **Integrate conservation-linked payments (eco-payments)**, where a percentage of revenue from sustainable businesses is reinvested into **habitat conservation and enforcement**.

5. Expand Research and Long-Term Monitoring of Barbudo Populations

The **145% increase in recorded Barbudo populations** confirms that **regulated conservation zones contribute to species recovery**. However, **long-term ecological monitoring is essential to track population stability beyond the project's duration**.

- **Implement five-year species population monitoring plans**, using standardized **capture-mark-release (CMR) and hydroacoustic surveys**.
- **Establish a long-term water quality monitoring program**, tracking **sedimentation rates, dissolved oxygen levels, and pollution indicators**.
- **Conduct post-project evaluations of RMZ effectiveness**, analyzing whether **fisheries regulations and habitat protections** remain effective in maintaining **species viability**.

Towards a Scalable Conservation Model

The **"Guardians of the Siluriformes"** project provides a **scalable conservation model for freshwater species protection in indigenous territories**. By addressing **governance, compliance, economic incentives, and climate resilience**, conservation programs can **ensure the long-term viability of threatened species while empowering local communities**. These recommendations serve as a **roadmap for future conservation efforts**, reinforcing the **importance of integrating science-based management with indigenous stewardship** to achieve **sustainable freshwater biodiversity conservation**.

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