Ana Sibelonia Saldanha Veras

A Sustentabilidade do Geoturismo na Amazônia Setentrional: Estudo de Caso do Município de Mucajaí, Estado de Roraima, Brasil.

Universidade Fernando Pessoa
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Tese apresentada à Universidade Fernando Pessoa como parte dos requisitos para a obtenção do grau de Doutora em Ecologia e Saúde Ambiental, sob a orientação da Professora Doutora Maria Alzira Pimenta Dinis e coorientação do Professor Doutor Nelson Azevedo Barros.

RESUMO

Ana Sibelonia Saldanha Veras: ***A Sustentabilidade do Geoturismo na Amazônia Setentrional: Estudo de Caso do Município de Mucajaí, Estado de Roraima, Brasil.***

(Sob a orientação da Professora Doutora Maria Alzira Pimenta Dinis e coorientação do Professor Doutor Nelson Azevedo Barros

A região de Mucajaí, Roraima, Brasil, objeto desta tese, oferece paisagens naturais associadas a fascinantes morfologias, como afloramentos de rochas, minerais e cursos hídricos, relevantes no âmbito do conhecimento das geociências. Importa, ainda, salientar as consideráveis populações indígenas locais, como principais atores e beneficiários do geoturismo, e seu papel na preservação e desenvolvimento sustentável da região em estudo.

Nesse sentido, a presente tese de doutoramento tem como objetivo contribuir para o estudo e sistematização em ambiente local, com foco nas condicionantes ambientais e interação entre o cidadão e comunidade acadêmica, para o uso de um geoturismo sustentável. O fulcro deste estudo insere-se na herança paisagística da região central de Mucajaí com destaque para os aspectos geológico-geomorfológicos que promovem a potencialidade latente dessa região para o geoturismo.

No delineamento metodológico, aplicou-se pesquisa de caráter descritivo e exploratório, com estudo de caso fundamentado em revisão bibliográfica e trabalhos de campo, visando à compreensão e interpretação ambiental da região alvo desta tese. Isto por meio da base conceitual da geodiversidade e a sua aplicabilidade ao geoturismo como atividade sustentável.

Para alcançar o núcleo deste trabalho, esta tese compõe-se de sete capítulos resultantes de publicações internacionais indexadas, pretendendo realçar a identidade interpretativa e a integridade dos recursos ambientais para a atividade do geoturismo em uma região distante, como é o caso dessa porção territorial da Amazônia setentrional no Brasil. As pesquisas publicadas reiteram contribuições significativas para a área estudada.

O primeiro capítulo, ***Sustentabilidade da paisagem: contribuição da região de Mucajaí-Roraima, Brasil***, refere-se à paisagem como importante contribuição para medir e interpretar o bem-estar humano no consumo sustentável ambiental, constituindo um enorme desafio para os gestores públicos no desenvolvimento de um bom planejamento e ao despertar o compromisso dos cidadãos da região em análise. Insere-se ainda na ótica do Desenvolvimento Sustentável, especificamente nos Objetivos de Desenvolvimento Sustentável (ODS) 12 e 15, i.e., além de preservar a natureza, apoiar iniciativas de interpretação no meio rural como alternativa sustentável para a vida dos munícipes.

O segundo capítulo, ***Praia da Rufina e Desenvolvimento Sustentável: o papel da mulher em Mucajaí, Roraima, Brasil***, traz a descrição das ações vivenciadas por mulheres na atividade turística sob o viés da Agenda 2030 e ODS 1 a 5, 8 e 11, identificando a cultura da sustentabilidade ambiental e empoderamento da mulher, em busca da prosperidade frente ao pacto global. Apresenta-se uma experiência única, de relevância ecológica sobre o ecossistema fluvial, liderada por mulheres que utilizam o patrimônio geológico para conduzir geoturistas ao lazer, banhos e práticas sustentáveis em águas perenes e rios de água doce. Os visitantes são conduzidos em barcos aos melhores lugares de apreciação da flora e fauna, destacando-se a importância da preservação do patrimônio geológico e geomorfológico.

Quanto ao terceiro capítulo, ***A Trilha Davi em Mucajaí, Roraima, Brasil: uma experiência para (re)conectar e proteger a natureza***, reveste-se de uma ferramenta valiosa para a conservação do ambiente e apresenta o geoturismo. Neste trabalho, discute-se em escala local a natureza, vinculada à Agenda 2030 e aos ODS 1, 3, 4, 5, 8 e 10, que repercutem na prosperidade dos cidadãos em harmonia com o ODS 15, vida na Terra sustentável, com descrição da trilha como fenômeno geocientífico conservado e de atração geoturística que permite o contato com o ecossistema. Aplicou-se o conceito de

capacidade de carga como ferramenta útil de planejamento ancorado no princípio da caminhada, ação recreativa e lazer, motivando o comprometimento do geoturista com o ecossistema, bem como contribui com práticas de educação ambiental no universo amazônico.

O quarto capítulo, ***Percepção de sustentabilidade de ecossistemas lóticos e lênticos na bacia amazônica pela lente de uma comunidade local***, identifica a percepção e atitudes de uma comunidade local da Bacia Amazônica sobre os ecossistemas lótico e lêntico, como parte da Agenda 2030 composta pelos ODS a serem alcançados: um conjunto de metas desafiadoras na salvaguarda do ecossistema hídrico. É assim importante enfatizar que esta pesquisa consubstancia o ser humano como principal responsável no sucesso da proteção dos recursos hídricos, sinônimo de vida do planeta. Assim, diante das inúmeras vantagens, o desafio é receber a devida atenção das autoridades, com investimento do setor público e privado e a capacitação para gestores, incluindo o geoturismo, destacando o potencial hídrico.

O capítulo quinto, ***Rodovia BR-174, geoturismo e conflitos socioambientais nas regiões remotas do Norte da Amazônia***, dedica-se à socioanálise do modal terrestre que liga o estado brasileiro de Roraima, o mais setentrional que integra a tríplice fronteira com a Venezuela e Guiana, às demais regiões do Brasil. Inaugurada em 1977, a Rodovia BR-174 trouxe melhorias significativas às populações e promoveu estratégia geopolítica. Aborda ainda a adoção das recomendações da Agenda 2030 e metas dos ODS 12, 13, 15 ao 17, i.e., dimensão ambiental para apoiar e estimular cidadãos a uma boa gestão, ancorada no planejamento para utilizar o modal como um relevante corredor de movimento contínuo e distribuição de pessoas aos municípios. Logo, a interpretação dos recursos abióticos contribui para o uso do Geoturismo como atividade econômica sustentável.

Quanto ao capítulo sexto, apoia-se na publicação ***Construindo pontes entre povos indígenas e a atividade geoturística: o caso da etnorregião da Raposa em Roraima, Brasil***, que aborda as etnias indígenas Macuxi e Yanomami em etnoregiões de Roraima. Os Yanomami vivem em áreas remotas protegidas e defendem a floresta com base na cosmovisão dos elementos naturais para garantir a conservação da geodiversidade, do

ambiente ecológico e de sua cultura. Já o turismo praticado é respaldado pelas técnicas de artesanatos e agricultura dominadas pelos Macuxi, que conhecem os melhores lugares para visitação geoturística. Dessa forma, comprova-se em plano de visitação que a atividade turística é sustentável. Os indígenas, orientados nos ODS 1, 15 e 17, e com apoio de parcerias, promovem a inclusão e vida na terra, assim como o uso da geodiversidade.

O capítulo sétimo está sustentado pela publicação ***Constrangimentos sociais do geoturismo e instrumentos de proteção numa perspectiva de sustentabilidade***, a pesquisa discute os constrangimentos sociais do geoturismo e os instrumentos de proteção em regiões dominadas por formações rochosas classificadas como patrimônio natural, assumidas como veículos importantes na salvaguarda dos sítios geológicos. Trata-se de pesquisa sobre regulamentos ambientais e administrativos, i.e., instrumentos coletados de sítios oficiais do governo disponíveis na *Internet*, empresas, condutores locais e substrato geológico, e.g., geoformas para identificar condicionantes alicerçadas e duráveis para o ambiente. Consideram-se os critérios de sustentabilidade não apenas como a melhor maneira das empresas atuarem, especialmente as pequenas e médias, mas também como o fortalecimento da instituição de turismo do município de Mucajaí, Roraima, Brasil.

Todos os capítulos são descritos e interligados, conforme as morfologias mais representativas na porção central de Mucajaí. Nesse sentido, geossítios notáveis são úteis ao cidadão e didáticos do ponto de vista científico para o geoturismo. Desse modo, a descrição que a geodiversidade oferece não é apenas um diferencial, mas também oportunidade para a formatar geoprodutos para uso e proteção sob o manto da Agenda 2030. Ademais, os ODS são metas de aplicação no contexto global, destacando-se uma região remota como a Amazônia setentrional, com uma atividade de geoturismo que protege e amplia as oportunidades de preservação do patrimônio.

No desenvolvimento do conjunto metodológico, i.e., relativo aos trabalhos de campo como observação e descrição de atrativo para gerar o conhecimento científico, contou-se com o apoio de técnicos (as), acadêmicos (as), empresários (as) e proprietários(as) de áreas rurais para a coleta dos elementos essenciais da pesquisa, sendo notória a importância dada pelos munícipes ao estudo.

É imperioso sublinhar a comunicação indispensável da contribuição desta tese para o conhecimento acerca da geodiversidade nesta região remota do Brasil, e esta precisa ser avaliada, gerenciada, valorizada e interpretada pelo geoturismo. O público dessa atividade é composto de acadêmicos (as), empresas turísticas, associações e sociedade em geral, ao despertarem para um maior domínio e enobrecendo-se os atrativos da natureza com conhecimento científico em prol do geoturismo, baseando-se nas condicionantes e recursos geológicos e geomorfológicos.

Portanto, a compreensão para a elaboração de argumentos convincentes é um fio condutor de um processo mais aprofundado sobre a atividade do geoturismo e um progresso para essa região longínqua do Brasil, nos princípios sustentáveis a serem conduzidos por seus residentes e populações autóctones no delineamento de novas alternativas. Dessa forma, os resultados podem contribuir para que os líderes regionais melhor identifiquem as necessidades da região e implementem atividade de geoturismo com práticas sustentáveis para salvaguardar a região da pressão antrópica.

ABSTRACT

Ana Sibelonia Saldanha Veras: ***The Sustainability of Geotourism in the Septentrional Amazon: A Case Study in the Municipality of Mucajaí, State of Roraima, Brazil***.

(Supervised by Professor Maria Alzira Pimenta Dinis and Professor Nelson Azevedo Barros)

The region of Mucajaí, Roraima, Brazil, object of this doctoral dissertation, offers natural landscapes associated with fascinating morphologies, such as outcrops of rocks, minerals, and watercourses, relevant in the scope of knowledge of geosciences. It is also important to emphasize the pertinence of local indigenous populations as the main actors and beneficiaries of geotourism, and their role in the preservation and sustainable development of the region under study.

In this sense, this research aims at contributing to the study and systematization at a local environmental level, focusing on environmental conditions and the interaction between citizens and the academic community for the use of geotourism sustainably. The focus of this study is the landscape heritage of the central region of Mucajaí, with emphasis on the geological-geomorphological aspects that promote the potential of this region for geotourism.

For the methodological outline, a descriptive and exploratory approach was applied, a case study based on a bibliographical review and field work, aiming at the understanding and interpretation of the environment in the target region of this thesis. That was discussed through the conceptual basis of geodiversity and its applicability to geotourism as a sustainable activity.

To achieve the goal of this work, this thesis is composed of seven chapters resulting from publications in indexed international journals, intending to enhance the interpretative identity and the integrity of environmental resources for the geotourism activity in a remote region, as is the case of this territorial portion of the northern Amazon in Brazil. The published research reaffirms significant contributions to the studied area.

The first chapter, ***Landscape sustainability: contribution of Mucajaí-Roraima, Brazil, region***, refers to the landscape as an important contribution to measuring and interpreting human well-being in a sustainable environmental consumption. It constitutes an enormous challenge for public managers in the development of good planning and to awaken the commitment of the citizens of the region under analysis. It is also part of the perspective of Sustainable Development, specifically in the Sustainable Development Goals (SDGs) 12 and 15, *i.e.*, in addition to preserving nature and supporting initiatives of interpretation in rural areas as a sustainable alternative for the lives of residents.

As for the second chapter, ***Rufina Beach and Sustainable Development: the role of women in Mucajaí, Roraima, Brazil,*** it presents the description of the actions experienced by women in tourist activities under the bias of Agenda 2030 and SDGs 1 to 5, 8, and 11, identifying the culture of environmental sustainability and women's empowerment, in search of prosperity in the face of the global pact. It presents a unique experience of ecological relevance on the fluvial ecosystem, led by women who use the geological heritage to lead geotourists to leisure, bathing, and sustainable activities in perennial waters and freshwater rivers. Visitors are taken in boats to the best places to appreciate flora and fauna, highlighting the importance of preserving the geological-geomorphological heritage.

The third chapter, ***The Davi Trail in Mucajaí, Roraima, Brazil: an experience to (re)connect and protect nature***, is a valuable tool for environmental conservation and the presentation of geotourism. In this work, nature is discussed on a local scale, linked to the 2030 Agenda and SDGs 1, 3, 4, 5, 8, and 10, which have an impact on the prosperity of citizens in harmony with SDG 15, sustainable life on Earth. It describes the trail as a conserved geoscientific phenomenon and a geotouristic attraction that allows contact with the ecosystem. The concept of carrying capacity is applied as a useful planning tool

anchored in the principle of strolling, recreational activities, and leisure, motivating the geotourist's commitment to the ecosystem, as well as contributing to environmental education practices in the Amazonian universe.

The fourth chapter, ***Sustainability perception of lotic and lentic ecosystems in the Amazon Basin through the lens of a local community,*** identifies the perception and attitudes of a local community in the Amazon Basin on lotic and lentic ecosystems, as part of the 2030 Agenda composed by the SDGs to be achieved: a set of challenging goals in safeguarding the water ecosystem. Therefore, it is important to emphasize that the research substantiates the human being as the main responsible for the successful protection of water resources, synonymous with life on the planet. Thus, given the numerous advantages, the challenge is to receive due attention from the authorities, and the investment from both public and private initiatives, as well as the training of managers, including for geotourism, which highlights the water potential.

The fifth chapter, ***BR-174 highway, geotourism and socio-environmental conflicts in the northern remote regions of the Amazon***, is dedicated to the socio-analysis of the land modal that connects the Brazilian state of Roraima, the northernmost that integrates the triple border with Venezuela and Guyana, to the other regions of Brazil. Inaugurated in 1977, the BR-174 Highway brought significant improvements to the population and promoted a geopolitical strategy. It also addresses the adoption of the 2030 Agenda recommendations and the goals of SDGs 12, 13, 15 to 17, *i.e.*, environmental dimension to support and encourage citizens to good management, anchored on the planning to use the modal as a relevant corridor of continuous movement and distribution of people to municipalities. Therefore, the interpretation of abiotic resources contributes to the use of Geotourism as a sustainable economic activity.

As for the sixth chapter, it is based on the publication ***Building bridges between indigenous peoples and geotourism activity: the case of the Raposa ethnoregion in Roraima, Brazil***, which addresses the *Macuxi* and *Yanomami* indigenous ethnic groups in ethnoregions of Roraima. The *Yanomami* live in remote protected areas and defend the forest based on a cosmovision of natural elements to guarantee the conservation of geodiversity, the ecological environment, and their culture. The practiced tourism is

supported by handicraft and agriculture techniques mastered by the *Macuxi*, who know the best places for geotouristic visitation. This way, the visitation plan proves that the tourist activity is sustainable. The indigenous people, guided by SDGs 1, 15, and 17, and with the support of partnerships, promote inclusion and life on earth, as well as the use of geodiversity.

The seventh chapter is supported by the publication ***Geotourism social constraints and protection instruments from a sustainability perspective.*** The research discussed the social constraints of geotourism and the instruments of protection in regions dominated by rock formations classified as natural heritage, assumed as important vehicles in the safeguarding of geological sites. This is research on environmental and administrative regulations, *i.e.*, instruments collected from official government websites available on the internet, companies, local conductors, and geological substrate, *e.g.*, geoforms to identify solid and durable constraints for the environment. Sustainability criteria are considered not only as the best way for companies to act, especially small and medium-sized ones, but also as the strengthening of the tourism institution in the municipality of Mucajaí, Roraima, Brazil.

It is noticeable that all chapters are described and interconnected, according to the most representative morphologies in the central portion of Mucajaí. In this sense, notable geosites are useful to citizens and didactic from a scientific point of view for geotourism. In this way, the description that geodiversity offers is not only a differential, but also an opportunity to form geoproducts for use and protection under the guide of the 2030 Agenda. In addition, the SDGs are goals for application in the global context, highlighting a remote region such as the northern Amazon, with a geotourism activity that protects and expands preservation opportunities.

In the development of the methodological set, *i.e.*, related to field work as observation and description of attraction to generate scientific knowledge, we had the support of technicians, academics, entrepreneurs and owners of rural areas to collect the essential elements of the research, being notorious the importance given by citizens to this study.

It is important to emphasize the indispensable contribution of this dissertation to the knowledge about geodiversity in this remote region of Brazil, an activity which needs to be evaluated, managed, valued and interpreted by geotourism. The audience for this activity is composed of academics, tourist companies, associations and society in general, as they awaken to a greater mastery and ennoble the attractions of nature with scientific knowledge in favor of geotourism, based on the geological-geomorphological constraints and resources.

Therefore, the understanding for the elaboration of convincing arguments is a guiding thread for a more in-depth process on the geotourism activity and the progress for this remote region of Brazil, in the sustainable principles to be conducted by its residents and indigenous populations in the design of new alternatives. In this way, the results can help regional leaders better identify the needs of the region and implement geotourism activities with sustainable practices to safeguard the region from anthropic pressure.

RÉSUMÉ

Ana Sibelonia Saldanha Veras: ***La durabilité du Geotourisme en Amazonie Septentrionale : Une Étude de Cas de la Municipalité de Mucajaí, État de Roraima, Brésil***.

(Supervisé par le professeur Maria Alzira Pimenta Dinis et le professeur Nelson Azevedo Barros)

La région de Mucajaí, Roraima, Brésil, objet de cette thèse, offre des paysages naturels associés à des morphologies fascinantes, telles que des affleurements rocheux, des minéraux et des cours d'eau, pertinents dans le cadre des connaissances en géosciences. Il est également important de souligner l'importance des populations indigènes locales, en tant que principaux acteurs et bénéficiaires du géotourisme, et leur rôle dans la préservation et le développement durable de la région étudiée.

En ce sens, cette thèse de doctorat vise à contribuer à l'étude et à la systématisation de l'environnement local, en tenant compte des contraintes environnementales et de l'interaction entre les citoyens et la communauté universitaire, pour l'utilisation du géotourisme durable. Cette étude se concentre sur le patrimoine paysager de la région centrale de Mucajaí, en mettant l'accent sur les aspects géologiques et géomorphologiques qui favorisent la potentialité latente de cette région pour le géotourisme.

Dans la conception méthodologique, il s'agit d'une recherche appliquée de nature descriptive et exploratoire, avec une étude de cas basée sur une revue bibliographique et un travail de terrain, visant à la compréhension et à l'interprétation environnementale de la région cible de cette thèse, à travers la base conceptuelle de la géodiversité et son applicabilité au Géotourisme comme activité durable.

Pour atteindre l'objectif principal de ce travail, cette thèse est composée de sept chapitres résultant de publications internationales indexées, visant à mettre en évidence l'identité interprétative et l'intégrité des ressources environnementales pour l'activité de géotourisme dans une région éloignée, comme c'est le cas de cette portion territoriale de l'Amazonie septentrionale au Brésil. La recherche publiée réitère des contributions significatives à la zone étudiée.

Le premier chapitre, ***Durabilité du paysage: contribution de la région de Mucajaí-Roraima, Brésil***, se réfère au paysage comme une contribution importante pour mesurer et interpréter le bien-être humain dans la consommation durable de l'environnement, constituant un énorme défi pour les gestionnaires publics dans le développement d'une bonne planification et dans l'éveil de l'engagement des citoyens de la région analysée. Il s'inscrit également dans la perspective du développement durable, en particulier dans les Objectifs de Développement Durable (ODD) 12 et 15, c'est-à-dire, en plus de la préservation de la nature, le soutien des initiatives d'interprétation dans les zones rurales comme alternative durable pour la vie des habitants.

Le deuxième chapitre, ***Praia da Rufina et le développement durable : le rôle des femmes à Mucajaí, Roraima, Brésil,*** apporte la description des actions vécues par les femmes dans les activités touristiques sous le biais de l'Agenda 2030 et des ODD 1 à 5, 8 et 11, en identifiant la culture de la durabilité environnementale et l'autonomisation des femmes, à la recherche de la prospérité face au pacte mondial. Il présente une expérience unique, d'importance écologique sur l'écosystème fluvial, menée par des femmes qui utilisent le patrimoine géologique pour conduire les géotouristes aux loisirs, à la baignade et aux pratiques durables dans les eaux pérennes et les rivières d'eau douce. Les visiteurs sont emmenés en bateaux vers les meilleurs endroits pour apprécier la flore et la faune, soulignant l'importance de la préservation du patrimoine géologique-géomorphologique.

Quant au troisième chapitre, ***Le Sentier David à Mucajaí, Roraima, Brésil: une expérience pour (re)connecter et protéger la nature***, il constitue un outil précieux pour la conservation de l'environnement et présente le géotourisme. Dans ce travail, la nature

est abordée à l'échelle locale, en lien avec l'Agenda 2030 et les ODD 1, 3, 4, 5, 8 et 10, qui ont des répercussions sur la prospérité des citoyens en harmonie avec l'ODD 15, la vie durable sur Terre, avec une description du sentier en tant que phénomène géoscientifique préservé et attraction géotouristique qui permet un contact avec l'écosystème. Le concept de capacité de charge a été appliqué comme un outil de planification utile ancré dans le principe de la marche, de l'action récréative et du loisir, motivant l'engagement du géotouriste avec l'écosystème, et contribuant aux pratiques d'éducation environnementale dans l'univers amazonien.

Le quatrième chapitre, ***Perception de la durabilité des écosystèmes lotiques et lentiques du bassin amazonien à travers le prisme d'une communauté locale***, identifie la perception et les attitudes d'une communauté locale du bassin amazonien sur les écosystèmes lotiques et lentiques, dans le cadre de l'Agenda 2030 composé des ODD à atteindre: un ensemble d'objectifs ambitieux pour la sauvegarde de l'écosystème hydrique. Par conséquent, il est important de souligner que la recherche justifie l'être humain comme le principal responsable de la protection réussie des ressources en eau, synonyme de vie sur la planète. Ainsi, face aux nombreux avantages, le défi consiste à recevoir l'attention nécessaire des autorités, telles que les investissements des secteurs public et privé et la formation des gestionnaires, y compris le géotourisme, qui met en évidence le potentiel de l'élément hydrique.

Le cinquième chapitre, ***Autoroute BR-174, géotourisme et conflits socio-environnementaux dans les régions reculées de l'Amazonie du Nord***, est consacré à la socio-analyse du mode terrestre qui relie l'état brésilien de Roraima, le plus septentrional, qui intègre la triple frontière avec le Venezuela et la Guyane, aux autres régions du Brésil. Inaugurée en 1977, l'autoroute BR-174 a apporté des améliorations significatives à la population et a favorisé la stratégie géopolitique. Il aborde également l'adoption des recommandations de l'Agenda 2030 et des cibles des ODD 12, 13, 15 à 17, c'est-à-dire la dimension environnementale pour soutenir et encourager les citoyens à une bonne gestion, ancrée dans la planification de l'utilisation du modal comme un corridor pertinent de mouvement continu et de distribution des personnes aux municipalités. Par conséquent, l'interprétation des ressources abiotiques contribue à l'utilisation du géotourisme en tant qu'activité économique durable.

Quant au sixième chapitre, il s'appuie sur la publication ***Construire des ponts entre les peuples autochtones et le géotourisme: le cas de l'ethnorégion Raposa à Roraima, Brésil***, qui traite des groupes ethniques indigènes Macuxi et Yanomami dans les ethnorégions de Roraima. Les Yanomami vivent dans des aires protégées reculées et défendent la forêt en se basant sur une cosmovision des éléments naturels pour garantir la conservation de la géodiversité, de l'environnement écologique et de leur culture. Le tourisme, quant à lui, est soutenu par les techniques artisanales et agricoles maîtrisées par les Macuxi, qui connaissent les meilleurs endroits pour les visites géotouristiques. De cette façon, le plan de visite prouve que l'activité touristique est durable, les peuples indigènes, guidés par les ODD 1, 15 et 17, et avec le soutien de partenariats, favorisent l'inclusion et la vie sur terre, ainsi que l'utilisation de la géodiversité.

Le septième chapitre est soutenu par la publication ***Contraintes sociales du géotourisme et instruments de protection dans une perspective de durabilité***, la recherche aborde les contraintes sociales du géotourisme et les instruments de protection dans des régions dominées par des formations rocheuses classées patrimoine naturel, assumées comme d'importants vecteurs de sauvegarde des sites géologiques. Il s'agit de recherches sur les réglementations environnementales et administratives, c'est-à-dire les instruments collectés sur les sites officiels du gouvernement disponibles sur Internet, les entreprises, les conducteurs locaux et le substrat géologique (géoformes pour identifier les conditions solides et durables pour l'environnement). Les critères de durabilité sont considérés non seulement comme la meilleure façon d'agir pour les entreprises, en particulier les petites et moyennes, mais aussi comme le renforcement de l'institution touristique de la municipalité de Mucajaí, Roraima, Brésil.

On remarque que tous les chapitres sont décrits et interconnectés, selon les morphologies les plus représentatives de la partie centrale de Mucajaí. En ce sens, les géosites remarquables sont utiles au citoyen et didactiques du point de vue scientifique pour le géotourisme. Ainsi, la description qu'offre la géodiversité n'est pas seulement un différentiel, mais aussi une opportunité de la formater, ce qui donne lieu à des géoproduits pour l'utilisation et la protection sous le manteau de l'Agenda 2030. En outre, les ODD sont des objectifs d'application dans le contexte mondial, mettant en évidence une région

éloignée comme l'Amazonie du Nord, avec une activité de géotourisme qui protège et élargit les possibilités de préservation.

Dans le développement de l'ensemble méthodologique lié au travail de terrain, comme l'observation et la description des attractions, nous avons eu le soutien de techniciens, d'universitaires, d'hommes d'affaires et de propriétaires de zones rurales pour la collecte des éléments essentiels de la recherche, avec l'importance donné par les citoyens à l'étude étant notoire.

Il est impératif de souligner la communication indispensable de la contribution de cette thèse à la connaissance de la géodiversité dans cette région éloignée du Brésil, et cela doit être évaluée, gérée, valorisée et interprétée par le géotourisme. Le public de cette activité est composé d'universitaires, d'entreprises touristiques, d'associations et de la société en général, qui s'éveillent à une plus grande maîtrise et ennoblissent les attraits de la nature avec des connaissances scientifiques en faveur du géotourisme, basées sur les conditions et les ressources géologiques et géomorphologiques.

Par conséquent, la compréhension de l'élaboration d'arguments convaincants est un fil conducteur d'un processus plus profond concernant l'activité de géotourisme et un progrès pour cette région isolée du Brésil, dans les principes durables à appliquer par ses résidents et les populations autochtones dans la délimitation de nouvelles alternatives. De cette manière, les résultats peuvent contribuer à ce que les dirigeants régionaux identifient mieux les besoins de la région et mettent en œuvre des activités de géotourisme avec des pratiques durables pour sauvegarder la région de la pression anthropique.

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A Deus, força maior que inspira os seres vivos em suas várias esferas de *habitat*, a saúde recebida, proteção e oportunidade de estudar na conceituada Universidade Fernando Pessoa.

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ÍNDICE

LISTA DE FIGURAS

LISTA DE ABREVIATURAS E SÍMBOLOS

A

ANVISA – Agência Nacional de Vigilância Sanitária

APP – Área de Proteção Permanente

ArcGIS – *Software* para Sistema de Informações Geográficas

ASPEMM – Associação de Pescadores do Município de Mucajaí

B

BR-174 – Rodovia longitudinal que liga o Estado de Roraima ao resto do Brasil

BASA – Banco da Amazônia

C

CADASTUR – Cadastro de Turismo

CNPJ – Cadastro Nacional de Pessoa Jurídica

CNAE – Classificação Nacional de Atividades Econômicas

CPRM – Companhia de Pesquisa e Recursos Minerais

D

DETUR – Departamento do Turismo

F

FLONA – Floresta Nacional

FEMAR – Fundação Estadual do Meio Ambiente e Recursos Hídricos

FETUR – Fórum Estadual do Turismo

FUNGETUR – Fundo Geral de Turismo

G

GG – Global Geoparque

GSE – *Geotourism Social Engagement*

GPS – *Global Positioning System*

I

IBGE – Instituto Brasileiro de Geografia e Estatística

IES – Instituição de Ensino Superior

INCRA – Instituto Nacional de Colonização e Reforma Agrária

INPA – Instituto Nacional de Pesquisa da Amazônia

ISBN – *International Standard Book Number*

IUCN – União Internacional para Conservação da Natureza

K

km^2 – Quilômetro quadrado

M

MTur – Ministério do Turismo

MUC – Mucajaí-estradas vicinais

N

N – Latitude Norte, ponto cardeal

O

ODS – Objetivo do Desenvolvimento Sustentável

ONG – Organização não governamental

P

PAT – Plano Anual de Trabalho

PMM – Prefeitura Municipal de Mucajaí

PNGATI – Política Nacional de Gestão Territorial e Ambiental de Terras Indígenas

Q

QR-CODE – Código barramétrico que pode ser facilmente digitalizado por celulares equipados com câmera

R

RR – Estado de Roraima

S

SAC – Sistema de Amortização Constante

SEADI – Secretaria de Agricultura, Desenvolvimento e Inovação

SEXTO (6.º) BEC – Batalhão de Engenharia e Construção

SEBRAE – Serviço Brasileiro de Apoio às Micro e Pequenas Empresas

SECULT – Secretaria de Cultura e Turismo

SENAC – Serviço Nacional de Aprendizagem Comercial

SENAT – Serviço Nacional de Aprendizagem do Transporte

SESC – Serviço Social do Comércio

SESI – Serviço Social da Indústria

SIGEP – Comissão Brasileira de Sítios Geológicos e Paleobiológicos

SRTM – *Shuttle Radar Topography Mission*

SELIC – Sistema Especial de Liquidação e Custódia

SNUC – Sistema Nacional de Unidades de Conservação

T

TIRSS – Terra Indígena Raposa Serra do Sol

U

UNESCO – *United Nations Educational, Scientific and Cultural Organization*/ Organização das Nações Unidas para Educação, Ciência e Cultura

UFP – Universidade Fernando Pessoa (Porto, Portugal)

UFRR – Universidade Federal de Roraima

W

W – Longitude Oeste, ponto cardeal

INTRODUÇÃO

Esta tese enquadra-se no programa de Doutoramento em Ecologia e Saúde Ambiental promovido pela Universidade Fernando Pessoa UFP. Constitui a questão central desta tese um estudo da sustentabilidade e processos geológicos e geomorfológicos que dão origem às paisagens, rochas, minerais, águas, solos, clima e outras caraterísticas terrestres para a atividade do geoturismo em Mucajaí, Roraima, Brasil. Importa ainda, salientar a importância das populações indígenas locais, como principais atores e beneficiários do geoturismo, bem como do seu papel na preservação e desenvolvimento sustentável da região em estudo. Desse modo, a existência da paisagem natural reveste-se de relevante interesse para entender o processo de esculturação e gênese das formas destacadas e continuamente modificadas pela ação humana. A sustentabilidade é o alicerce na manutenção desse processo local de alto potencial geoturístico e de interesse na atualidade (Raeisi et al., 2022, Newsome e Dowling, 2022). A partir dos cuidados para com o meio físico, a sustentabilidade torna-se muito importante, nomeadamente em regiões extremas, onde a atividade do geoturismo pode oferecer papel expressivo para a comunidade, contribuindo para alcançar os Objetivos de Desenvolvimento Sustentável (ODS) em Mucajaí, Roraima.

A sustentabilidade, um tema emergente e necessário na atualidade, reveste-se do marco histórico da Agenda 2030 e respetivos ODS. O geoturismo, como uma atividade recente e transformadora, sustenta a identidade de um território, sendo cada vez mais reconhecido por países com abundância em recursos naturais como alternativa econômica para muitas comunidades desfrutem de harmonia e prosperidade, tendo o cidadão como protagonista do lugar e carregado de cultura (Lamba et al. 2023).

A despeito dos estudos da Organização das Nações Unidas (ONU), os ODS emergem dos estudos, apresentados em vários eventos como os de Estocolmo, em 1972, Rio de Janeiro, em 1992, Johannesburgo, em 2002, e Rio + 20, em 2012, e estabelecem a ótica transformadora sobre os pilares indissociáveis: social, cultural, econômica e ambiental aprovados pela Assembleia Geral das Nações Unidas e do relatório Nosso Futuro Comum (Salamanca, 2022). É legítimo o conceito de sustentabilidade: "aquele que atende às necessidades presentes, sem comprometer as gerações futuras". Sua repercussão ganhou notoriedade ampla, segundo Leal Filho et al. (2022), com o lançamento da Agenda 2030 cada vez mais realçada, com ênfase no comportamento de cidadãos no mundo inteiro tornando-se um compromisso de todos, i.e., Instituições de Ensino Superior, Gestores públicos e Setor privado a fim de diminuir a pobreza, reduzir a violência em diversas dimensões e na proteção dos recursos naturais, portanto, os ODS devem garantir a todos paz e prosperidade (Serafine et al., 2022).

Mucajaí é um município do estado de Roraima, Brasil, um destino emergente em plena Amazônia setentrional, onde estão insertas pequenas cidades, portanto, uma região onde a natureza é essencial por subsidiar a existência humana e por ser fonte de informações para realçar os aspectos geológicos, estéticos e culturais como ferramentas para desenvolver o geoturismo de forma duradoura pelos cidadãos. Nesse contexto, a geodiversidade é abordada pelo viés das condicionantes ambientais e suas implicações, como regra básica que atende às necessidades do presente, sem comprometer a capacidade de futuras gerações (Cifuentes, 1992, Medway et al., 2022, Rogers, 2022). A sustentabilidade da geodiversidade na área da pesquisa tem grande importância especialmente para o ambiente quanto às áreas longínquas alicerçadas em recursos exuberantes que tendem ao uso por sua atratividade geoturística, educacional e recreativa (**Veras**, 2020). Esses ambientes, entretanto, necessitam ser apresentados como alternativa complementar de renda das populações locais, os quais possuem papel fundamental na gestão dos recursos ambientais, pelos seguintes motivos:

(i) pela necessidade de apresentar a sustentabilidade como equilíbrio, formas e regras básica de operar o geoturismo para gerações jovens,

(ii) pela inevitabilidade de caracterizar recursos geológico e geomorfológicos potenciais na região da denominada Amazônia setentrional,

(iii) pela imperiosa necessidade de promover o uso consciente e seguro do visitante em ambientes naturais quanto pela comunidade do entorno em prol do convívio harmônico e sustentável,

(iv) pela emergência de demonstrar o caráter inovador de uma nova atividade,

(v) pela indispensabilidade de preservar locais didáticos, extraordinários aos olhos do cidadão, de subsidiar a geoeducação e, especialmente, a atividade geoturística.

O geoturismo conta com crescimento significativo na esfera global, tendo sua gênese vinculada à Europa, Estados Unidos da América e Austrália, e surge do interesse do geólogo italiano Michele Gortani em 1956, ao afirmar que formações rochosas contam sua história. Este fato foi também assegurado por Gray (2019) e Newsome e Ladd (2022) que o corroboram, quando afirmam que os denominados ecossistemas são importantes serviços para a melhoria da qualidade ambiental, saúde pública e manutenção do bem-estar humano em contextos locais, regionais e internacionais. Somam-se às raízes dessa atividade, posteriormente, pesquisas acadêmicas focadas no desenvolvimento rural sustentável (Newsome et al., 2022). Embora as atividades pioneiras datem do século XVII, cientistas europeus direcionaram as redes de geoparques muito difundidos na atualidade (Gentilini, 2009, Ngwira, 2015, Al-Halbounni et al., 2022, Hawkins et al., 2022).

Assim, o geoturismo, não apenas valoriza a estética local, i.e., os recursos abióticos dentro dos princípios sustentáveis compreendem: (i) o bem-estar de seus residentes da área investigada e (ii) benefícios da interpretação do patrimônio natural, segundo Hose (1999), mas também (iii) a geologia da região em análise, uma das menos conhecidas e estudadas. São áreas de terrenos do Pré-Cambriano, pelo acesso por áreas de florestas de copas densas (Cordani, 2017). Estas formações com cobertura vegetal constituem a geomorfologia dos processos endógenos, tectônicos e fósseis, em tempos pretéritos assegurados (Woo e Worboys, 2019). Um conceito mais geocientífico e atual que encontra respaldo na Global Geoparque (GG), Organização das Nações Unidas para

Educação, Ciência e Cultura (UNESCO) e da União Internacional para a Conservação da Natureza IUCN (Girault, 2019, Matshusa et al., 2021), tratando-se de (iv) áreas geográficas de relevância internacional que reúnem conexões com os aspectos naturais, realçando paisagens geológicas (Dollma, 2019, Singh et al., 2021). Destacados dentro do que preconiza a sustentabilidade na experiência de uma viagem marcante, num conceito holístico de proteção que congrega elementos abióticos (Valente et al., 2021).

Salienta-se ainda que territórios com destacada estética contribuem para o fortalecimento da economia, para a prosperidade dos locais longínquos, valorizam e integram a sustentabilidade de um destino. Assim, uma parte vital da agenda do geoturismo concentra-se na inovação do patrimônio ambiental nos moldes sustentáveis, em experimentar e aprender sobre a paisagem, valorizando as características que realçam o território, como os recursos hídricos, serras, cachoeiras, devidamente classificados cientificamente como geossítios (Pasquaré Marriot et al. 2023). Esses são responsáveis por atrair geoturistas a apreciar e aprender a história de como o tempo, em milhões de anos, trabalhou a forma exposta (Dowling e Pforr, 2021). Numa visão holística, esse cenário gera benefícios de desenvolvimento sustentável (Pál e Albert, 2021), que podem ser significativos se estruturados com base na geologia e seus geossítios, muitas vezes desconhecidos pelo seu valor e importância para o cidadão local. Assim, o mundo abiótico, e.g., rochas, solos, rios, cachoeiras e trilhas, essenciais à vida e patrimônio da humanidade, deve ser preservado, utilizando-se para isso a geodiversidade (Mandal e Chakrabarty, 2021), geossítios fonte para a geoeducação comunicada por guias de turismo, condutores locais, um grande aliado da atividade sustentável e para maior visibilidade. Isso posto, é feita a interconexão dos componentes bióticos e abióticos (Ghasemi et al., 2021, Wulung et al., 2021) desse conjunto, consoante se apresenta na **Figura 1**.

Figura 1: Geodiversidade em perspectiva, vê-se a relação do geoturismo e os componentes bióticos e abióticos que ostentam sua magnitude à disposição da humanidade. Uma vez identificados, oferecem lazer a grupos de geoturistas, usufruto coletivo e solidário às gerações futuras como ferramentas de interpretação e educação para cidadãos, sendo parte integrante do cumprimento de metas dos ODS.

O desenvolvimento de projetos locais para a implantação de atividade turística consubstancia-se como uma das melhores metodologias para não só comunicar os valores da geociência mas valorizar os recursos abióticos (Robson, 2021). Portanto, objetivando a notabilidade do patrimônio, mas também para fazer crescer o nível de sensibilização do cidadão, do geoturista ou visitante. Essa interpretação é essencial para a divulgação e para a importância científica do patrimônio (Tormey, 2019). Para esse propósito, um dos maiores desafios é explicar como o tempo geológico formou a estética, pois nesses ambientes encontram-se fortes congruências de fósseis em rochas que ganham popularidade e estão mais criticamente afetados pelas mudanças climáticas (Boag et al., 2021).

A presente tese tem como objetivo geral contribuir para a utilização do geoturismo sustentável na região Central de Mucajaí, estado de Roraima, um município de pequeno porte segundo classificação brasileira (IBGE, 2001), por abranger população de até 20 mil pessoas.

Com base nesses pressupostos, desdobrou-se esta tese nos seguintes objetivos específicos, como princípios norteadores do trabalho desenvolvido:

(i) descrever a integração da paisagem quanto ao uso sustentável e condicionantes ambientais que afetam os desafios sociais em região remota,

(ii) analisar o recorte territorial no entorno dos principais geossítios quanto práticas antrópicas, assim como as favoráveis, em ambiente ecologicamente equilibrado, que possam garantir a sustentabilidade local,

(iii) examinar as ocorrências dos fatores ambientais, caracterizando os riscos em trilhas morfológicas,

(iv) analisar os usos e ameaças em ecossistema de água doce na Amazônia setentrional,

(v) descrever o modal terrestre e o importante papel de integração regional e internacional, demonstrando em mapa temático fenômenos geográficos distribuídos na área da pesquisa a partir das condicionantes ambientais,

(vi) reconhecer cidadãos e lideranças que mantém forte ligação com a atividades turísticas,

(vii) identificar os desafios a serem cumpridos, i.e., compromissos e responsabilidades como cidadãos, gestores e sociedade civil com o ambiente amazônico.

Esta tese estrutura-se em sete capítulos, nos quais cada parte é indicativa dos elementos ambientais descritos com potencial para o geoturismo, compondo-se dos aspectos geológicos e geomorfológicos atraentes e acessíveis na região. O componente sociocultural tem papel importante e conta-se povos originários, i.e., indígenas que se destacam na preservação da Amazônia setentrional brasileira. Todos os capítulos fazem referência aos compromissos dos cidadãos diante dos ODS. As descobertas científicas que integram esta tese transmitem informações de estéticas e consumo da paisagem, ecossistema fluvial liderada por mulheres, ambientes lóticos e lênticos para a interpretação, trilha geoturística, modal rodoviário, e fatores que favorecem e limitações na execução do geoturismo aos atores e respondem aos sete objetivos específicos. Portanto, os capítulos que integram esta tese e se encontram publicados são os seguintes: Capítulo I - ***Sustentabilidade da paisagem: contribuição da região de Mucajaí-Roraima, Brasil***. Abordou-se a paisagem como importante contribuição para medir e

interpretar o bem estar humano no consumo sustentável ambiental, sobre as características geológicas e geomorfológicas, refletindo sobre os recursos estratégicos em níveis locais. Sobre esse enfoque há um enorme desafio para os gestores públicos fortalecerem um bom planejamento e despertarem o compromisso dos cidadãos da região, buscando parcerias público privado para a região em análise. O capítulo insere-se nas metas da Agenda 2030 para preservar o ambiente com trabalho e renda no meio rural, utilizando-se do lazer e do contato com a natureza, por meio, de cachoeiras, praias e atividades que compõem o geoturismo. Sendo assim, o capítulo responde ao primeiro objetivo específico da tese: está vinculado ao desenvolvimento sustentável, a ação concreta ao consumo da paisagem, prioritária de políticas públicas, ou seja, o ambiente como palco, panorama de grandiosidade de contato e uso.

Capítulo II - ***Praia da Rufina e Desenvolvimento Sustentável: o papel da mulher em Mucajaí, Roraima, Brasil***. Descreve-se as interfaces do turismo com o lazer e as vivências científicas integrando o cidadão local, permitindo contato com o meio abiótico e compreendendo a importância da conservação dos geossítios no ambiente geológico e geomorfológico, princípios básicos em prol da manutenção desses ambientes para gerações futuras e em acordo com os ODS. A experiência enfatiza a relevância ecológica, liderada pelas habilidades das mulheres que utilizam o patrimônio geológico ao acompanhar turistas à lazer, banhos e práticas sustentáveis, i.e., águas perenes, rios de água doce. Logo, os visitantes são conduzidos em barcos aos melhores lugares de apreciação da flora e da fauna, destacando a importância da manutenção do bioma amazônico. O estudo identifica a mulher um ator-chave na sustentabilidade, portanto, responde-se com o capítulo II, ao objetivo apontado, distinguindo-se mulheres organizadas em associação na condução de atividades geoturísticas apesar das limitações respeitam o recurso fluvial, preservado onde reproduzem exemplos que compõe os requisitos integrantes dos ODS 1 a 5, 8, 11 e 12.

Capítulo III - ***A Trilha Davi em Mucajaí, Roraima, Brasil: uma experiência para (re)conectar e proteger a natureza***. Neste capítulo é evidenciado o atrativo da trilha Davi que se encontra no relevo local, digno de interpretação ao visualizar-se a grandiosidade das formações rochosas, sendo ideal realizar o percurso em pequenos grupos de

geoturistas, para sensibilizar cidadãos da caminhada em ambiente natural. Por oportuno, aplicou-se o conceito de capacidade de carga, como ferramenta útil de planejamento ancorada no princípio da classificação para os que têm limitações. A extensão é bastante considerada, incluindo ação recreativa e lazer, motivando o comprometimento às boas práticas do turismo sustentável, valorizando a identidade local, o ecossistema e contribuir com o ambiente no universo amazônico. Este capítulo responde ao terceiro objetivo específico da tese por alertar para a capacidade de carga ambiental da trilha utilizada.

Capítulo IV - ***Percepção de sustentabilidade de ecossistemas lóticos e lênticos na Bacia Amazônica pela lente de uma comunidade local***. Destaca-se a sustentabilidade dos rios e lagos na planície amazônica. Estes resultaram da deposição de sedimentos e inundação de várzeas, como parte da mudança ambiental global, ciclo geoquímicos e ação humana, numa região de enorme valor e importância na interpretação do geoturismo. Componente da Agenda 2030 e dos ODS, todos geocientistas devem desenvolver atividades para todas as idades de forma aumentar a sensibilização sobre geologia e geomorfologia, explicar e preocupar-se na salvaguarda do recurso hídrico, com parcerias entre governo, comunidade local e iniciativa privada. Diante de muitas ameaças aos notáveis recursos hídricos, especialmente a região setentrional onde a abundância não é garantia de que o recurso seja infinito, responde-se ao quarto objetivo específico da tese.

Capítulo V - ***Rodovia BR-174, geoturismo e conflitos socioambientais nas regiões remotas do norte da Amazônia***. Empenha-se à análise do modal terrestre, i.e., único corredor de mobilidade, relevante infraestrutura com reflexos na qualidade de vida das populações locais, i.e., saída e entrada de pessoas e produtos. Logo, a rodovia compensa os cidadãos e estimula-os a prestação de serviços de conhecimentos sobre os espaços amazônicos a partir da interpretação dos recursos abióticos e os seus significados geocientíficos, representando variedades para o uso do geoturismo como atividade que promove a geodiversidade. Dessa forma, responde-se ao quinto objetivo específico desta tese, contribuindo para a melhor visualização e amplas possibilidades de integração com a região valorizada e estimular à abertura de empreendimentos, logo, um fluxo de geoturista materializa os veios pulsantes do desenvolvimento.

Capítulo VI - ***Construindo pontes entre povos indígenas e a atividade geoturística: caso da etnoregião da Raposa em Roraima, Brasil***. Refere-se as etnias Macuxi e Yanomami, povos em maior número no estado de Roraima. Portadores de direitos reconhecidos e destaques à preservação ambiental, os Macuxi usam de prerrogativas oferecidas por instituições públicas, inserindo-se em cursos, e.g., oficinas para empoderar mulheres nas práticas sustentáveis. O turismo praticado é respaldado pelas técnicas de artesanato e campos de flores, do domínio dos Macuxi que conhecem os melhores lugares para visitação geoturística. Há que salientar que os povos originários Yanomami desenvolvem o turismo em áreas naturais usando roteiros de visitas previamente aprovados em planos de visitação, promovendo a inclusão e com apoio de parcerias ao uso da geodiversidade. Diante da expressiva população indígena em Mucajaí área da pesquisa tornar-se então, imprescindível abordar essas etnias, e uma vez que as formações rochosas i.e., geologia e geomorfologia somam proteção para os povos tradicionais, assim sendo, responde-se ao sexto objetivo específico desta tese.

Capítulo VII - ***Constrangimentos Sociais do Geoturismo e Instrumentos de Proteção numa Perspectiva de Sustentabilidade***. Descreve-se os diferentes e necessários regulamentos para áreas naturais, e.g., ambientes dos geossítios, planícies e atrativos disponíveis e suas utilizações constituem-se uma tendência mundial para salvaguarda do patrimônio geológico. Como parte de ações de implementação e meio de promover a sustentabilidade para negócios geoturísticos, a contribuição é especialmente às pequenas e médias empresas, mas também com o fortalecimento da instituição de turismo da região geográfica de Mucajaí (**Veras**, 2014,**Veras**, 2020, **Veras**, 2021). Idealmente, é imperioso o conhecimento dos compromissos em nível local, estadual e federal, assim sendo, este capítulo responde ao objetivo específico sétimo, pois identifica as normas e procedimentos oficiais como condicionantes para a atividade do geoturismo no município de Mucajaí.

Nesta atualidade, a nova postura internacional de sensibilização sobre o meio ambiente estimulou a todos cidadãos às mudanças de comportamento em direção a uma sociedade mais consciente e mais comprometida ambientalmente (Silva e Braga, 2023). E a partir desse cenário foi desenvolvida uma rica e avançada legislação que atinge todos os tipos

de serviços. Nesse aspecto o geoturismo é inclusivo e contribui para prevenir danos ambientais decorrentes de ações antropogênicas, sendo, necessário o atendimento de normas, leis e demais obrigações constantes para áreas naturais de quem tanto o geoturismo depende (**Veras** et al. 2022). A componente geológica é um dos principais atrativos, não podendo ser negligenciada a utilização do geoturismo devidamente organizado e estruturado. Ao mesmo tempo, busca o conhecimento de fenômenos naturais e as responsabilidades estão compartilhadas com a comunidade e setor público municipal na adoção de práticas sustentáveis a fim de garantir a harmonia da geodiversidade.

Priorizar a preservação da geodiversidade está contemplado nas metas da Agenda 2030, os ODS fazem apelos à integração em todas as áreas contempladas e concatenadas e em prol da prosperidade do homem (Vu et al., 2022). Entretanto, há que ser feito um esforço intenso para o cumprimento dos objetivos, assim, para aumentar as chances de resultados positivos para proteção de áreas importantes não sejam reduzidos ambientes com expressiva geodiversidade (Shulla e Leal Filho, 2023). Nesse sentido, para ilustrar e melhor compreensão dos objetivos dos ODS propõe a sociedade alcançar as necessidades da geração atual, sem comprometer a capacidade de futura gerações, desse modo, os 17 objetivos visualizam-se na representação gráfica da **Figura 2**.

Figura 2: Esquema de aplicação dos Objetivos do Desenvolvimento Sustentável (ODS) com ilustração (a) Formação rochosa em Mucajaí, (b) Símbolos dos ODS, metas orientadoras para o planejamento de ações.

Quanto ao enquadramento metodológico adotado, constam da literatura que trata a geodiversidade em suas diferentes dimensões (García-Cortés e Urquí, 2018, Herrera-Franco et al., 2020), compondo-se também dos métodos exploratório, descritivo e qualitativo (Minayo, 2001). Essas abordagens possibilitam o entendimento da realidade de um universo de significados, aspirações e atitudes num processo permanente (Albach, 2015, Garcia et al., 2018), como também facilitam entender e descrever a dinâmica de relações sociais e suas atitudes com o ambiente, em específico a geodiversidade (CPRM, 2020). Para a interpretação entre o local e o global contou-se com os métodos à luz de Vosgerau e Romanowski (2014) e Kuleta (2018). O método aplicado na pesquisa de investigação no município de Mucajaí, Roraima, Brasil descreve pontos relevantes, cujos principais estão contextualizados a seguir:

(i) Para a composição da cartografia foi feita recolha de informação no Earth Explorer Shuttle Radar Topography Mission SRTM (NASA, 2013). Foram utilizadas coordenadas Sistema Universal Transverso de Mercator para se obterem dados altimétricos das formas de relevos (Winge et al., 2001).

Quanto aos limites do município e rodovias, foram acessados dados do Instituto Brasileiro de Geografia e Estatística (IBGE, 2019). Para compor e realçar as imagens ilustrativas, empregou-se a projeção cartográfica resultando em produtos de escala 1:50.000 e 1:100.000,

(ii) A pesquisa documental consistiu na seleção dos documentos e trabalhos integrantes de legislação, normas e critérios relativos à política de turismo (Bardin, 2016). Quanto ao uso do ambiente e regulamentos deste segmento, visando à percepção de práticas corretas e formais aceitáveis a serem conduzidas por gestores públicos e comunidades (Albach, 2015). A pesquisa exploratória, possibilitou estudar, na modalidade de estudo de caso, abordagens de entrevistas e revisão bibliográfica (Minayo, 2001),

(iii) Os dados de campo, os quais objetivaram dados particulares ou, ainda, análise e conhecimento do comprometimento do cidadão local (Almudi, 2019), sem expor a identidade dos respondentes, relativos aos recursos presentes no território (Pojo e Vilhena, 2014),

(iv) A descrição dos atrativos mais relevantes, observações em campo, dos geossítios, foi realizada sempre durante a estiagem na região, i.e., de setembro de 2020 a março de 2021, usando a técnica de observação *in situ* e a coleta de dados. Esta etapa foi registrada sempre acompanhada por membros da comunidade, i.e., com técnicos do setor do turismo, para garantir a autenticidade das observações, na transcrição nas imagens,

(v) A sistematização de dados foi feita de acordo com os capítulos a serem tratados, para favorecer a consulta, a redação do texto e apresentar os resultados obtidos, sobre os quais o estudo de caso se sustenta. A teoria é o instrumento da ciência baseada em conhecimento construído por outros pesquisadores, que consubstancia a gênese para o êxito da investigação,

(vi) Para a etapa da pesquisa denominada estudo de caso, i.e., setembro a novembro de 2021, realizou-se coleta de dados, como uso da terra, mapeamento, dados turísticos por meio de pesquisa documental, tendo como enfoque visitas em órgãos como: Prefeitura Municipal de Mucajaí, Instituto Brasileiro de Geografia e Estatísticas (IBGE), Secretaria de Estado do Planejamento e Desenvolvimento (SEPLAN), Fundação Estadual do Meio Ambiente e Recursos Hídricos (FEMARH), 6.º Batalhão de Engenharia e

Construção (BEC), Instituto Nacional de Colonização Reforma Agrária (INCRA), Instituto Nacional Pesquisa da Amazônia (INPA), Associação de Pescadores do Município de Mucajaí (ASPEMM), o contato com o Topógrafo Mário Severo Ávila, e, realizada pesquisa digital no Departamento do Turismo (DETUR). Nesta etapa, observou-se a pouca quantidade de informações sobre o tema geoturismo,

(vii) Abordagens teóricas qualitativa, quantitativa e exploratória (Minayo, 2011). Para tanto, este método utilizou como recursos pesquisas bibliográficas refletindo e correlacionando os resultados com os ODS foram descritas com base na conservação e popularização das geociências uma afirmação de Quesada-Valverde e Quesada-Román, (2023), e em conformidade com a Agenda 21 (UNWTO, 2020, ONU Brasil, 2022),

(viii) Utilizou-se os aplicativos ArcGIS *10.0*, na edição de modelagens, atributos, e simbologias das feições, para facilitar a automatização da produção de mapas temáticos.

Como atividade inovadora, o geoturismo interpreta e preserva o ambiente (Mao, 2021). Em território amazônico os diferentes ambientes ecológicos, feições geológicas e geomorfológicas, corporificado em reservas de recursos naturais exóticos definem a Amazônia setentrional (Da Silva Campos Filho, 2022). Conhecer o patrimônio natural é imprescindível para a elaboração de propostas de implantação da atividade com identidade amazônica e ao cidadão. A integração do conhecimento acadêmico especializado, empresas turísticas constituem-se grandes parcerias a tornar visíveis os geossítios (Rosa, 2020, Victor et al., 2021).

Com base no arcabouço teórico, assim, como analisado o contexto das principais características geográficas do município de Mucajaí, Roraima, Brasil, entende-se que o geoturismo identifica particularidades do objeto de estudo em suas variedades de ambientes, possibilitando que as comunidades longínquas contribuam com saberes sobre o local e se beneficiem com lucros dentro do paradigma da sustentabilidade.

Esta pesquisa está ancorada na sustentabilidade em sincronia com os pilares, i.e., econômico, social e ambiental (Van der Waal et al., 2021, Bhatt e Ghuman, 2022). A área de estudo, Mucajaí-RR, Brasil, situa-se na região central, dentro do quadrante N 02º 56' 59,78'' 02º 57'59'' e 02º 59' 79'' de latitude, e entre 63º 06' 31'' e 60º 50' 60" W longitude, numa altitude média de 70 m em relação ao nível do mar. A área compreende paisagens com topografia plana, apresentando relevo serrano e planícies entrecortadas com recursos hídricos expressivos que oferecem grandes oportunidades para o geoturismo. Mucajaí é um município brasileiro que se limita ao Norte com Alto Alegre, ao Sul e Oeste com Iracema, e a Leste com Boa Vista e Cantá e ocupa uma área de 12.461, 200 km^2. Na região de estudo, há terras ocupadas por populações indígenas como os Macuxi e os Yanomami, conhecidos como povos isolados organizados nas calhas dos rios e florestas (**Veras** et al., 2021).

A região é conhecida por ser uma área de desenvolvimento agropecuário e de grande potencialidade turística pela presença de cachoeiras e trilhas. O recorte da cidade compreende um aglomerado urbano cortado pela principal rodovia, BR-174, dotado de especificidades e particularidades, formado por populações de origens nordestina, indígena e, mais recente, por migrantes venezuelanos (Jarochinski-Silva e Baeninger, 2022) que entram por força dos pedidos de refúgio e estão presentes em todos os municípios de Roraima.

Em relação às características ambientais expressivas da área da pesquisa predominam formações que configuram favorecimento a visitas geocientíficas, recursos que apoiam atividades geoturísticas como as serras, praias de água doce. Esses atrativos não se restringem apenas a um público seleto estão disponíveis a sociedade, assim, algumas dimensões ambientais.

O mosaico geográfico refere-se ao conjunto de relevos, i.e., formas, cores, odores e dinâmicas de elementos naturais a ser interpretado, valorizado ao uso científico e de preservação paisagística (Pires, 2020, Saito, 2022). Nessa porção da pesquisa, é caracterizado por áreas bem preservadas, sendo forte sua ligação com o cidadão. O intercâmbio com os recursos hídricos faz da área de Mucajaí um ponto de alta

atratividade, considerando a distância de 51 km do município até a capital Boa Vista e entre 30 km e 40 km para a região das cachoeiras. Conforme descreve Holanda et al., (2014), a área abrange ainda a Floresta Nacional de Roraima - Flona, parte savana e/ou campo entrecortados por igarapés, denominados também córregos pertencentes à biota de água doce. São extensos e de grande importância econômica para a bacia amazônica, serras, formas residuais com feições variadas e bem distribuídas, essenciais na implantação de muitas atividades turísticas, em especial o geoturismo, por reunir um relevo diferenciado (Leal et al., 2018). A porção setentrional de grande importância ilustra-se no mapa de localização na **Figura 3**.

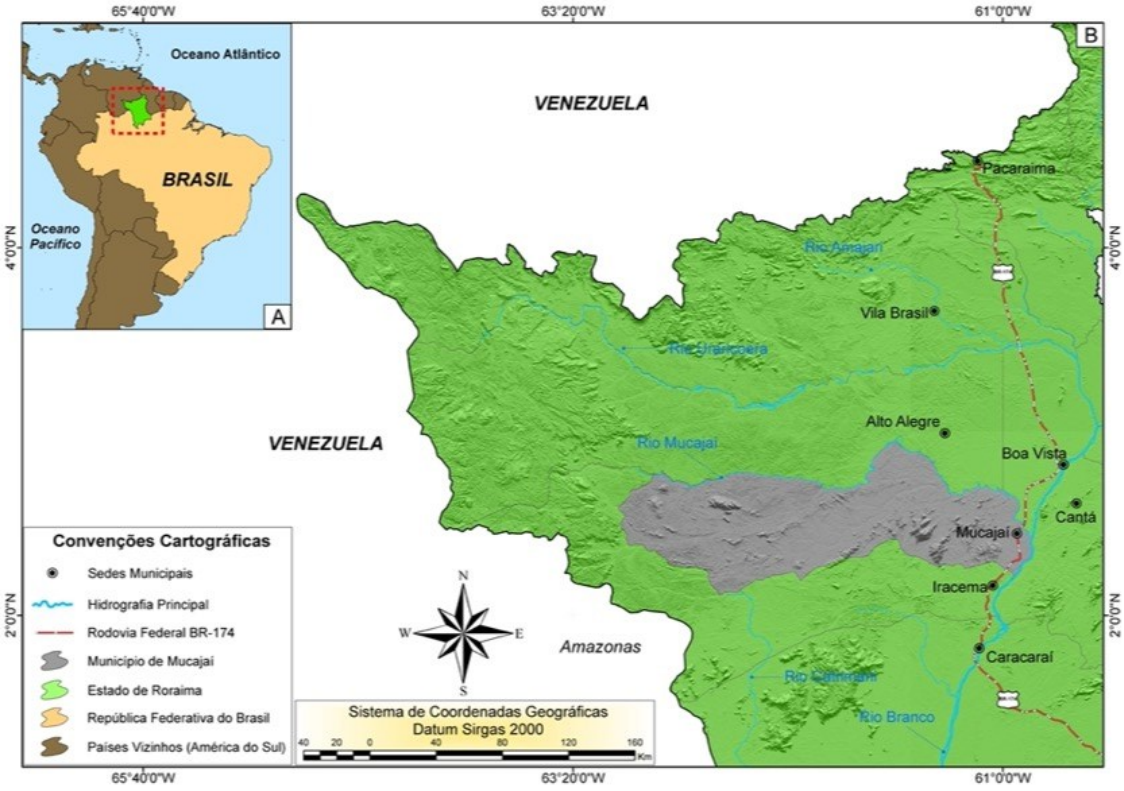

Figura 3: 🗺 Localização do Município de Mucajaí, Roraima, Brasil. Escala geocodificada de 1:100.000.

Como referido, esta tese estruturou-se em sete capítulos, em seguida apresentados, utilizando-se, essencialmente, metodologias descritivas. Contextualizou-se o geoturismo nas abordagens interpretativas para a natureza geológica e geomorfológica, conduzindo ao uso pelos visitantes e residentes de forma sustentável.

CAPÍTULO I – Sustentabilidade da paisagem: contribuição da região de Mucajaí-Roraima, Brasil. [1]

O capítulo refere-se a paisagem como importante contribuição para medir e interpretar o bem estar humano no consumo sustentável ambiental, constituindo um enorme desafio aos gestores públicos para desenvolver um bom planejamento e despertar o compromisso dos cidadãos da região em análise. Insere-se ainda na ótica do Desenvolvimento Sustentável, especificamente no ODS 15, i.e., preservar o ambiente com potencial para atividade de baixo carbono no meio rural como alternativa sustentável à vida dos munícipes. Aborda-se, também, a responsabilidade de cuidar e manter o ambiente, tanto para as atuais gerações quanto para as futuras possam usufruir de ambientes saudáveis e desenvolvimento humano. Hodiernamente, é nesse enfoque que a atividade do geoturismo interpreta e operacionaliza o uso do potencial materializado em ricos recursos, numa interface com as metas globais.

Sendo assim, os lugares de interpretações nesses usos aferem e conclamam ao zelo, ao cuidado e à postura do cidadão, sem agredir o extraordinário ecossistema e desenvolver consciência e gestão sustentável.

Nesta publicação, a primeira autora foi responsável pela recolha de dados em campo e contribuiu para a redação do capítulo.

[1] **Veras,** A. S. S., Vidal, D. G., Barros, N., Dinis, M. A. P. (2020). **Landscape Sustainability: Contribution of Mucajaí-RR (Brazil) Region**. In Leal Filho, W., Azul, A. M. Brandli , L., Özuyar, P. G., Wall, T. (Eds.), *Enciclopedia of the UN Sustainable Development Goals. Responsible Consumption and Production and Production* (pp.1-7). Switzerland: Springer International Publishing.
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Landscape Sustainability: Contribution of Mucajaí-RR (Brazil) Region

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Definition

Sustainable development should be at the core of countries' policies, and nature-based solutions are an efficient solution to promote healthy spaces to healthy people. Landscape sustainability consists in a complex and dynamic process of long-term ecosystem services provided by landscape. These services are important to environmental and public health quality improvement, and to maintaining human well-being at local, regional, and international contexts. Due to the contemporary socioenvironmental challenges, landscape sustainability science assumes an important contribution to mediate and interpret the relationship between ecosystem services and human well-being. Alongside, landscape sustainability allows developing sustainable awareness and responsible consumption behavior. The recognition of the landscape potential, and its contribution to environmental regeneration and provision, is a path to safeguard and preserve the available resources, aligned with the vision of sustainable development.

Introduction

Sustainable Development is a subject present in academic, media, social, economic, and political discussions, being repeatedly criticized when the questions around the subject happen to support its relevance and permanence in contemporaneity. In many studies, ambiguity is pointed out (Raynaut et al. 2018) when it is applied to a physical-natural environment *versus* a socioeconomic environment considered globally. An example is when global warming is applied to conservation of protected areas with some authors (Feil and Schreiber 2017) defending that this ambiguity is associated with the idea of growth, progress, maturity, evolution, or heritage and wealth. Therefore, arose the genesis of sustainability parts from the thought that a society should provide better life conditions to the human being, so it needs healthy ecological, economic, and social stability, and be able to deal with all those concerns. This trajectory starts in 1713 with the discussion of the pillars of ecology in Europe because of the scarcity of wood in forests in Germany. More recently, heated up

W. Leal Filho et al. (eds.), *Responsible Consumption and Production*, Encyclopedia of the UN Sustainable Development Goals, https://doi.org/10.1007/978-3-319-71062-4_82-1

debates emerged in the Conference of United Nations on Sustainable Development (CNUDS) (Raynaut et al. 2018), in Rio de Janeiro, Brazil.

Nature is still conserved in the Amazonian scenery, known globally as a large tropical rainforest (Fearnside 2018) and important and valuable environmental services, including standing forests such as water vapor (i.e., tree evapotranspiration) that irrigate regions which would otherwise tend to dryness (Attard 2019; Nogueira et al. 2017; Porto-Gonçalves 2015; Ballesteros-Camaro, Ríos-Guerrero 2019). Complex biome comprises an area of eight million km^2 that covers parts of the territorial margins of countries such as Suriname, Guyana, Venezuela, Colombia, Peru, Ecuador, Bolivia, and Brazil. Roraima is one of the states integrating the northern regions, in the central area of the Guiana Shield, bordering the Bolivarian Republic of Venezuela, the Cooperative Republic of Guyana, and Pará, Brazil. It houses unique aspects of some of the oldest geological units and geomorphological variety throughout the Brazilian Amazon (Holanda et al. 2014).

Mucajaí, still barely discovered, presents extraordinary natural and human characteristics, as well as geological elements originated from magma processes like granite and biotite (Holanda et al. 2014). Those compound heritages, both biotic and abiotic, possess varied formations, whereas, at the same time, those environments are open-air laboratories that explain the origins and decay that shaped the models, now understood as landscapes (Ladeira and Dantas 2014).

The geological substrate is the basis for the development of life on Earth, but which received less attention (Holanda et al. 2014). It is important for geotourism activity to take advantage of environments to explain the formation, age, and color of the hills – a responsible conservation means that reflects on the comfort and quality of life of humans. Although remote, the Brazilian Northern region is included in the 2030 Agenda Sustainable Development Goals (SDG) (Brazil 2018) in the SDG 12 – Ensure sustainable consumption and production patterns – and SDG 15 – Life on land, protecting, restoring, and promoting sustainable use of terrestrial ecosystems (Costanza et al. 2017). This entry intends to reflect about environmental safeguard, in order to contribute to the understanding of sustainable development through the perspective of geotourism activity using the Mucajaí-RR region as an example of landscape sustainability.

Context and Sustainable Development

Since the mid-twentieth century, specifically in the 1980s when the United Nations (UN) established the World Commission on Environment and Development, Sustainable Development became a global concern. Citizens started speaking about sustainability (Kibert 2018; Purvis et al. 2018), sustainable development, and how other societies should organize and evolve without damaging one another, considering that future generations have the right to survivability and environmental justice, incorporated in almost everything in a citizen's life on planet Earth (Macedo and Torres 2019; Panta 2019; Turine et al. 2017). Such concerns derive from the results of crises in the planet, extinction of continental species, global warming, or environmental degradation. These thoughts in favor of saving the planet were developed by the well-known Brundtland Commission, directed by a Norwegian woman called Gro Harlem Brundtland (UNBR 2018; WCED 1987). Some events have resulted from this conference, including movements around the world that led to the formation of Agenda 21, Agenda Brazil, and a meeting of the World Summit on Sustainable Development, in Johannesburg, South Africa (Krohling and Silva 2019; Fragas and Correa 2019).

Originated from the United Nations Conference held in Rio de Janeiro in June 1992, Local Agenda 21 is a key document (Vidal 2019). Among the SDGs, five of them concern strategic natural resources, water, biodiversity and forests, and the sustainable use of such resources and the implementation of the National System of Conservation Units (SNUC). An important initiative took place in Brazil: the creation of the Public Forest Management Law, Law 11.284/2006 (Brazil 2006), considered an advance in the protection

of Brazilian vegetation cove. The state is responsible for organizing its use and conservation and requiring management actions that include development opportunities.

Geotourism is a sustainable development strategy (Gordon et al. 2018; Hacer and Yusuf 2019) focused on strengthening the identity of the territory that hosts transcendental geological heritage, used and conserved for future generations (Sánchez-Cortez and Simbaña-Tasiguano 2018). Moreover, this type of tourism supports and promotes rural areas (Brzeziñska-Wójcik and Skowronek 2018; Figueiró 2019), and it is a way of obtaining a balance between the growth potential of tourism and the conservation.

Thus, this activity considers the characteristics of using landscape potential, such as hills and mountains that preserve geological history (Piacentini et al. 2019) in favorable and preserved areas in which nature causes a good impression, with rocks, not polluted, being a part of a pleasant and disease-free environment. Bordering the highway RR 325, which cuts through the entire municipality area of Mucajaí, there is a floristic homogeneity formed by a *Ombrophylous* Forest, housing endemic plants of rare species favorable to scientific research, among other environments, such as rocky surfaces and walls with rock inscriptions that can be archaeologically researched, and escarpments that can be used as viewpoints favorable to contemplation (Arco and Menezes Júnior 2018).

In Brazil, geotourism acts as a large consumer of landscapes and has citizen participation (Rangel et al. 2019; Carvalho 2018; Dowling and Newsome 2017). Today, the environments and the elements associated with it can lead to call large numbers of people, or tourists, generating curiosity, comfort, and leisure in places of singular beauty. Recently, the known "selfies," to be shared with social groups, friends, and family, stood out in social media with greater evidence, promoting the place (Brito and Freitas 2019).

All environmental scenarios must achieve protection, and a treaty was signed by the member 197 states of the Convention on Biological Diversity CBD, such as the Multilateral International Treaty ratified by Brazil in Federal Decree no. 2.519 (1998), to protect from 10% to 17% of terrestrial environments, i.e., freshwater and sea, as well as close monitoring and conservation measures (Baylis et al. 2016; Schleicher et al. 2019).

Mucajaí-RR Landscape Contribution to the Sustainable Development Reflection and Responsible Consumption

The Global 2030 Agenda of the United Nations, addressing the Sustainable Development Goals, highlights the SDG 15, about life on land, which redirects the initiatives of environmental interpretation to landscape appreciation and promotion. In this sense, the characteristics of the outstanding attractions present environments with strong possibilities for the feasibility of geotourism in the farthest north of Brazil. Thus, the geological-geomorphological potentialities based on the uniqueness of rural areas, freshwater scenarios, and the naturalness of the Mucajaí-RR are chosen to open the debate on this topic (Carvalho 1999; Kaygili et al. 2018; Moura-Fé 2015; Pires 2001).

The Northern region lies in the extension of the city, inside the quadrant N 02° 55′ 59,78″ 02° 55′ 59″ and 02° 59′ 78″ 60″ N Latitude and 63° 06′ 31″ and 60° 53′ 60″ W Longitude, and the places are specifically in the road known as Vicinal Tamandaré 459, Mucajaí-RR, Brazil. Landscapes of nonrenewable nature, i.e., mountains or lakes, were prioritized in the field in order to present conditions still well preserved, although with minimal road infrastructure, which favors the practice of geotourism in the region. Understood as a form of nature tourism that focuses on landscape and geology, geotourism approach obeys to abiotic, biotic, and local culture (ABC) and supports and enhances the identity of the territory (The 2011 Arouca Declaration and Dowling 2013), emphasizing environmental conservation and its local benefits. This economic activity generates extra income for citizens and investors (UN 2012; Bhaduri and Pandey 2019).

The existent body of literature suggests the identification of the landscape environmental dimension: a favorable scenario among the environmental elements that houses a large amount of

Landscape Sustainability: Contribution of Mucajaí-RR (Brazil) Region, Fig. 1 (**a**) Complex of hills and *Inselbergs*; (**b**) Apiaú mountain, riverbed; (**c**) main watercourse, Mucajaí river; and (**d**) main road of the municipality, the BR174 federal road. (Photos Courtesy of Authors)

springs, such as the geological substrate that produces and supplies the soil, and water, supporting biodiversity and climate stability. Available for hiking, leisure, or scientific studies, *Inselberg* is an isolated rock hill, knob, ridge, or small mountain that rises abruptly from a gently sloping or virtually level surrounding plain, providing the essential services for environmental harmony.

Aligned Hills and *Inselbergs*

Unprotected morphologies stand out with isolated distribution. The order is divided, forming waterfalls and water niches. In these areas, tourists come into contact with lithology, where they can contemplate hills: savannah, park, and grassy *phytophysiognomy*, as well as paths of buriti (*mauritia fleuxuosa*). These resources present numerous possibilities for the local community to operate tourist circuits and routes.

Mucajaí River Panorama

The potential for leisure activities is undeniable on the Mucajaí River, making it much sought by citizens with free time. Water travels a winding course, and its morphology stimulates all life cycles. The most popular leisure activity is the beach soccer summer championship. The population around this area is comprised by fishermen and small traders who, if sensitized, can develop geotourism, thus favoring sustainable development. Mountainous areas and lakes favorable to professional and scientific practice are illustrated in Fig. 1.

Landscape and Consumption: Raising Sustainable Awareness

As part of the 2030 Agenda, responsible and sustainable consumption integrates the SDG 12. According to this goal, it is an urgent need to reduce the ecological footprint by changing the way citizens produce and consume goods and resources (United Nations General Assembly 2015). Changing global and local behavior must be based on an efficient management of shared natural resources, namely in the case of developing countries, where the mission to adopt sustainable patterns of consumption faces numerous cultural, political, and social barriers.

Urban spaces, in general, do not produce resources to meet local communities' basic needs. Cities are increasingly resource dependent of distant places, namely rural ones, and that is an unsustainable process. Due to this current reality, the political institutions and stakeholders must develop sustainable strategies to reduce the ecological footprint, and increase in ecosystem

services of each region could strongly contribute to that aim. The displacement of many cultures has contributed to kill the identity or distinctiveness of many regions around the world, undermining the efforts to achieve a sustainable future. Therefore, landscape sustainability acts as an environmental safeguard, helping to reduce the ecological footprint, providing knowledge for making landscapes more sustainable in the face of urbanization, globalization, and climate change (Wu 2013). Accordingly, geotourism should be recognized as an important tool to share sustainable values and practices, supporting local communities and tourism itself.

Landscape sustainability science is an important contribution to enhance the journey to pursue sustainable and responsible practices in a world that struggles to achieve a major goal: well-being.

Final Remarks

Considering that geotourism is based on interpretative activities of natural and cultural landscapes, it can be stated that this integration guides sustainable landscape use. The cited literature allows a better understanding of the scientific studies of research dedicated to Sustainable Development and SDG 15 in particular. Preserving environment with potential for low carbon activity in the rural areas is a sustainable alternative to the life of the citizens of Mucajaí-RR. There is an enormous challenge for public managers in developing good planning, conducting environmental policies and arouse citizens' commitment to tourism attraction, and seeking partnerships to strengthen and better educate citizens and society in general.

Another aspect concerns the foundations of the SDGs, constituting key partnerships in choosing leaders to meet the Local Agenda 21, as priorities for joint work and income opportunities in rural areas, taking advantage of leisure and contact with nature, whether through waterfalls, beaches, local culture or even hiking, and activities integrating geotourism.

Cross-References

- Agriculture Production and Consumption
- Efficient Use of Natural Resources
- Promote Local Culture and Products

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CAPÍTULO II – Praia da Rufina e Desenvolvimento Sustentável: o papel da mulher em Mucajaí, Roraima, Brasil.[2]

Neste capítulo procedeu-se a um aprofundamento, igualmente sob o viés dos ODS 1 a 5, 8, 11 e 12, todos em busca da prosperidade e identificando-se a cultura da sustentabilidade ambiental e o empoderamento da mulher, merecendo destaque frente ao pacto global. Nessa abordagem, apresenta-se uma experiência única de relevância ecológica sobre o ecossistema fluvial, conduzido por mulheres que utilizam o patrimônio geológico para conduzir turistas à lazer, banhos e práticas sustentáveis, i.e., águas perenes, rios de água doce, os visitantes são guiados em barcos aos melhores lugares de apreciação da flora, fauna destacando a preservação, unindo ação pontual, relevante no cenário de regiões distantes como é a Amazônia setentrional e seus povos carregados de cultura. O capítulo contribui para a tese na óptica socioeconômica local, em igualdade de oportunidades na valorização da mulher, seja ela em que territorialidade esteja inserta, a conduzir atividade inovadora com responsabilidade, tratando o ambiente dentro dos princípios sustentáveis em áreas distantes, respondendo ao segundo objetivo específico da tese.

Nesta publicação, a primeira autora contribuiu para a redação e a recolha de dados em campo. Acrescenta-se que este trabalho ganhou vulto quando apresentado no *2nd Word Symposium on Social Responsality and Sustainability,* na modalidade *on-line,* em decorrência do período da pandemia da COVID-19, resultando num capítulo.

[2] **Veras,** A. S. S.**,**Vidal, D. G., Barros, N. A. (2021). **Rufina Beach and Sustainable Development: The Role of Women in Mucajaí, RR, Brazil.** In Leal Filho, W., Tortato, U., Frrankenberger, F. (Eds.). Integrating Social Responsibility and Sustainable Development (pp.365-376). Switzerland: Springer International Publishing. https://doi.org/10.1007/978-3-030-59975-1-24

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Rufina Beach and Sustainable Development: The Role of Women in Mucajaí, RR, Brazil

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1 Introduction

Due to its immense forest, geomorphology, landscape, drainage of rivers and their tributaries, the volume of freshwater and the relevance of all in the life of the populations, the Amazon region has a significant importance for the environmental balance of the world (Divino and Mc Alleer 2009; Fechine 2008). In addition to environmental wealth, there is a cultural diversity such as rubber tappers, chestnut trees, farmers, ranchers, rural workers, who, living in a remote area, far from contemporary living standards and dominated by technology, seek to live a life within a specific reality (Rodrigues et al. 2015; Zanetti et al. 2018), arousing the interest of many to know this region. In this territory, Legal Amazon represents 60% of the land, which includes heterogeneous environments and various forms of land use of citizens who inhabit the states of Acre, Amazonas, Amapá, northern Mato Grosso, Pará, Tocantins, Rondonia, Roraima part of Maranhão.

Located in the Amazon, the state of Roraima has a territorial extension of 224,273.831 km^2 with 605.761 inhabitants (IBGE 2019), corresponding to a low population density of 2.7 inhabitants/km^2. This portion represents only 0.0026%

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of the Brazil total area, concentrating 0.29% of the national population. Due to its distance from the country's main economic and political centres, to the lack of public investments and the difficulties imposed by environmental conditions, much of this territory lacks basic infrastructures and internet connection, which undermine the possibility to develop professional tourism and to take advantage of abundant water resources (Souza et al. 2019).

The municipality of Mucajaí was created by Federal Law no. 7,009 on July 1, 1982. In its genesis are families of north-eastern emigrants that moved to region in 1951, initially called the Fernando Costa agricultural colony, and currently corresponding to a population of 14,792 people, that lives close to Mucajaí River (IBGE 2019). Among the natural resources of the region, water is widely used in tourism in the Northern Amazon, specifically in Mucajaí, RR, Brazil. There is a symbiotic relationship between the human being and the fluvial ecosystem, comprised by the streams, lakes and rivers. Being used for the sustenance and leisure of local populations, the commitment to environmental safeguarding lies not only in public managers, but also in citizens and visitors.

Recently widespread in Brazil, geotourism is therefore considered the cornerstone for the practice of sustainability (Beretić et al. 2019) through geological heritage giving rise to many springs of perennial waters, rivers and lakes. In addition, it values the local culture, integrating it into the tourist practices of the region and making local populations active in this process. The freshwater resource is good for the worthy citizen and promoter of sustainable local development.

With the establishment of the Sustainable Development Goals (SDGs) as global targets adopted during the 2015 United Nations Conference on Sustainable Development (United Nations General Assembly 2015; Vidal 2019), poverty eradication, SDG 1, and hunger, SDG 2, are aligned, aiming to improve health, SDG 3, and education, SDG 4, achieve gender equality, SDG 5, promoting inclusive and promote sustainable economic growth, SDG 8, making cities more sustainable, SDG 11, and combating and protecting oceans and forests, SDG 14. SDGs are key elements for a fairer, more equitable and sustainable society, more specifically for a more dignified and integrating secure environment, also addressing social responsibility.

SDGs are challenges for all citizens of the planet in their search for sustainable and resilient solutions in everyday life and institutions, playing a key role in the environmental sphere, given the growing ecological interdependence and strengthening the role of citizens facing inequalities. The environmental debate is indispensable in the Agenda 21, with the objective to promote collective actions in favour of the socioeconomic, political and environmental areas. It is extremely important for the Brazilian reality to adopt SDGs as references for the implementation of a development model with a strong focus on ecosystem conservation, so as to ensure the sustainable and legal use of finite resources (ONUBR 2018), creating oportunities of social responsibility and sustainability.

The World Tourism Organization (WTO) highlights sustainable tourism as a form of resource management in which the economic, social needs and physical characteristics of attractions can be met, while maintaining cultural integrity, essential

ecological processes, biological diversity and sustainable systems life support as climate (Butler 1999; Hall 2019; Higgins-Desbiolles 2017; UNWTO 2007).

The objective of this research is to describe the actions experienced by women in geotourism and the possibilities of geotourism practices, anchored in SDGs, in the region with low population density in Mucajaí, RR, Brazil.

2 Sustainable Geotourism Activity and Its Interfaces

Throughout history, tourism is not just an object of leisure exercise, but of scientific and social experience, and of citizens integration. Thus, it is possible to emphasize that geotourism allows a greater contact with the local ecosystem where it is possible to understand the importance of the environment and its conservation, as well as its dynamics. This connection is made by residents who create and recreate the local culture.

With emphasis on geological and geomorphological aspects, geotourism has emerged with significant emphasis since the 1990s due to the need to value geodiversity and consider indigenous populations as holders of local knowledge and contributing to the discovery of places. However, geotourism is not yet recognized as a segment in Brazil (Brandão 2019). This activity, defined as tourism practiced in natural areas, explores geology for understanding the Earth Sciences, using the landscape from the discerning of geosites, and must fundamentally include the citizens (Hose 1995).

In line with the SDGs, tourism must be able to meet the needs of the present without compromising the future generations. In this sense, sustainability is represented by the modern concept consisting of three pillars or dimensions: economic, environmental and social (Šušić and Dordević 2019). Given these basic principles, the socioeconomic benefits of tourism represent an important source of income, in addition of generating jobs (Dogra 2019; Halisçelik and Soytas 2019). Therefore, tourism is seen as ecologically sustainable and economically viable activity in the long run, as well as providing an equitable social ethics for local communities. The social dimension, as example, includes the women who, mastering specific activities, apply skills and reiterate the important status towards liberation and visibility of this gender. At this regard, it is important to refer to the skills of women in rural Amazon (Bühler and Souza 2011; Furtado 2019; Dogra 2019) who felt the need to take advantage of the abundant and finite resources that are available in the scope of tourism, increasing their participation to complement family income, assimilating tourism activities, and playing a relevant role in terms of social responsibility and overall environmental sustainability.

3 Women's Sorority and River Wisdom

The Amazon biome has gained attention and greater relevance due to its high cultural and biological richness, materialized in finite water resources, representing the largest and most preserved region of tropical vegetation (BNDES 2010). Many citizens survive on agriculture and complement their activities with tourism, with rivers being used as indispensable resources, limited by natural cycles. This region is characterized by a very peculiar climatic variability, with natural watercourses presenting a regular annual cycle of high-water levels, known as floods, and, very low-water levels in the dry season, also known as weather drought or hydrological drought (Almudi 2019).

In the context of touristic activities, a number of citizens' initiatives are driven by water cycles, also including the beaches for leisure, and this environmental dimension is in favour of experienced residents. In these Amazonian waters of great importance, surrounded by forests of various shades of green colours, biodiversity is vigorous and gigantic, interspersed with streams where curiosities and stories of fishermen are expressed with such realism that are believed to be true (Pojo et al. 2014). These initiatives of unity for the benefit and conservation of nature are triggered by women of north-eastern origin, demonstrating, through the preparation of regional fish-based dishes, handling and confection of fibre and seed crafts from the region, their skills and close connections with the natural water cycle (Simonetti 2015).

4 Materials and Methods

The adopted methodology sought to describe and value the interpretation of natural environments and the different social practices of the local Amazon community in Mucajaí, RR, Brazil, being the object of study the geotourism and the role of women in the conduction of tourist activities (Lohmann and Panosso Netto 2012), an opportunity to contribute to local sustainability in this region.

5 Study Area

Mucajaí is in the middle of the Northern Amazon, in the state of Roraima, Brazil. It is located at a distance of 51 km from Boa Vista (capital), having an altitude of 70 m above the sea level. Its access is made by highway BR-174 towards the south. The geographical dimension is about 12,351.341 km^2, housing non-Indian and indigenous populations in the Yanomami Indigenous Land in the portion of the immense Roraima-Flona National Forest; Arboreal savanna or thick field of thin physiognomy and Savannah graminosa. The climate of the region is, according to Köppen's classification (Geiger 1954), as rainy tropical, from "Ami" type (Barbosa

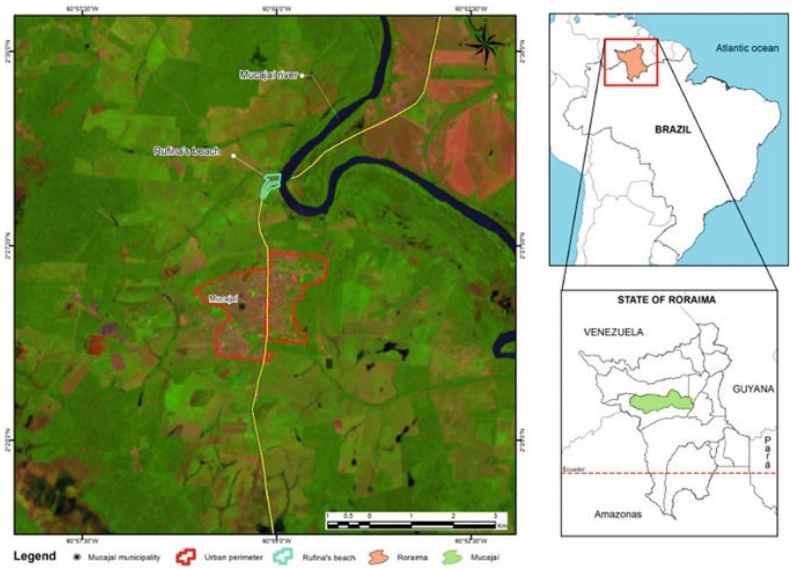

Fig. 1 Location of Mucajaí, RR, Brazil. Mucajaí, RR, is highlighted in red. In blue, the beach of Rufina on Rio Mucajaí. Author: Victor Viriato Maia. Cartographic base of the state of Roraima of a scale of 1:100,000 provided by the Brazilian Institute of Geography and Statistics (IBGE)

1997), with temperature varying between 28 and 38 °C. The Centre/East region has water deficits around 3–5 months with reduced rainfall. As for the drainage of the municipality, the river basin is composed of the Rio Branco tributaries, with the Couto de Magalhães, Catrimani, Apiaú and Mucajaí rivers to the north (IBGE 2019). The geographical location of the survey area is shown in Fig. 1.

6 Fieldwork

Fieldwork, an essential component of geography, was chosen as the research methodology. Accordingly, the applied methods were based in informal interviews, direct observation, participation in the life of the group, collective discussions and self-analysis, as suggested by Groh (2018). Anchored in a qualitative approach, the visits to the region were accompanied by a historian and members of the Association of Rural Women Workers of the Municipality of Mucajaí, RR. The main objective was to know the reality of the activities developed by the women in this region of Mucajaí, RR, Brazil. The contact with the region occurred in part by land walk and in part by canoe, following the most used routes and tours. With the oral support of local women and capturing images of freshwater environments, the visits allowed

describing the reality and social and cultural practices of the region. In addition to this approach, this research has a strong ethnographic component, justified by the integration of the researcher in the community. Due to this methodological option, four types of field notes were taken in four different domains: job notes, namely some keywords or expressions written during the visit to the field area; field notes, which are complete and descriptive notes about the physical context and people involved, namely relating behaviour and types of communication; methodological notes, consisting in new ideas that have emerged during the visit and that will be applied in future visits; and, finally, journals and diaries, where the researcher records all the events, such as rituals, socialization and oral histories.

7 Results and Discussion

7.1 Rural Women Workers of Mucajaí, RR

From the need to strengthen environmental causes, ecological preservation, support for educational services, movements for the protection of religious minorities, feminists, advocates of ethnic, cultural, academic causes, neighbourhood associations and community organizations, the Association of Rural Women Workers of the Municipality of Mucajaí, RR was created. Its main beneficiary is the local population, thus having a fundamental role in terms of social responsibility and sustainability. It is important to note that this Association makes use of the possibilities offered by law to guarantee the exercise of citizenship, consequently, contributing to the sustainable use of environmental resources and overall sustainability. In line with what the SDGs advocate, based on the principles of internalizing, disseminating and giving transparency to local agendas, the same Association provides opportunities for social groups interested in leisure activities, folkloric and carnival events, and artistic segments, aiming to broaden experiences at the local level, both in terms of professional activities and income. Currently in Mucajaí, RR, Brazil, there are three associations that together can carry out various activities to bring people from nearby municipalities. This is also due to women's advancements in strengthening positive experiences, spreading the importance of local agendas towards poverty eradication, a very important subject in this region, since there is a reduced dependence on aid from the municipality. It is about repositioning the place of women in this region, in areas where men were at the centre as the main element for exercising the activity of tourism.

8 The Contribution of Fish Gastronomy

Women work in food preparation using natural ingredients free of pesticides, mastering the typical regional cuisine, and this is an important point, especially in the preparation of native fish dishes marketed to visitors such as stew, marinade, fish fried fish, fish bait and roast fish *tambaqui* (*colossoma macropomum*), *matrinxã* (*brycon cephalus*), *piau* (*leporinis obtusidens cantares*). Therefore, fish enters the diet which is mostly served to visitors, followed by poultry, such as regional chicken.

9 The Importance of Boating

The boat rides or canoes last for one hour and are a time for contemplation of flora and fauna. In some points of the river, there are stops for the visitor to interact with locals and local culture, and the information passed to the visitors derive from the reading of nature developed by women, presenting the enigmatic and the exuberance of the scenarios. The care with the environment is highlighted, and it is also related with the accumulation of waste by visitors, or even by the residents, who are advised to transport generated waste, after the visit, for proper disposal. These tours are considered one of the greatest experiences in nature, where care occurs in favour of the preservation of water resources.

Freshwater beaches provide spaces for recreation, such as bathing, water sports and sustainable activities. The canoes made of wood do not impact the waters, an example of the care with nature.

All these activities contribute to instigate social responsibility in citizens, and that the same time, contribute to overall sustainability in this specific region.

10 Rufina Beach and Its History

The name Rufina originates from the story of a legend that occurred in the region with the disappearance of a woman that used to go to the river to fish:

> This beautiful woman, whose name was Maria Rufina decided on a beautiful sunny day, to go fishing with her two sons and her husband, but suddenly the family split to go looking for bigger fish and Maria Rufina was feeling tired and decided to take a nap in the sand, trying not to lose the fishing tied by the line of the hook in one of her legs and slept. Maria Rufina's idea was good, but it failed in one detail: she did not wake up and a very large fish dragged her into the depths of the river. When her children and husband returned, they did not find her, only finding a Lord of the World who owned a straw house near the river, who soon said: I do not know what happened, but I heard some shouts to that side and when I watched there was no one. And no one ever heard from Maria Rufina again despite the extense search.

To this day, the region is known as Rufina Beach and Rufina Lake. The legend says that the woman Maria Rufina, did not allow her family, children and husband,

to fish small fish, still very young. Instead, it directed them to return small fish to the water and to remove the hook to catch big fish (Silva 2007), a sustainable attitude related to the protection of the natural space, aiming at minimal impact in nature, and water biodiversity, in particular. The story of Maria Rufina feeds the imagination of visitors who are encouraged by residents to go to the beach in order to stay in touch with the story. It is a region rich in fish and typical white sands of moon gazing around bonfires and many stories of fishermen and legends, much appreciated in the Amazon, Mucajaí, RR, Brazil. It contributes to involve families in providing tourist services, as well as in the distribution of benefits to the residents in dealing with the visitors and having sustainable attitudes for the preservation of freshwater environments, and consequently a sustainable geotourism, contributing to reach the SDG goals (Fig. 2).

Fig. 2 **a** The Mucajaí river in its largest bed and anchoring a sightseeing boat. **b** Mucajaí River panorama in its flood period providing Rufina Beach leisure environment and object of the Legend of Rufina. **c** Side of the ravine stopping boat for sightseeing

11 Sustainable Experiences Adopted in the Fresh Waters of Rufina Beach

Positive initiatives ensure environmental conservation, allowing a harmonious coexistence with the citizens. It is possible to highlight the use of rowing canoes, equipment made of wood from the region, the use of water and the beach used by small groups of people held on the night moon and the stars, during full moon nights with jokes and chants, thus reducing the impact on the environment, thus contributing to environmental sustainability. The waste produced by groups of people during the tours are brought by each visitor. Sensitivity attitudes occur with the handling of the flora, with no vegetable being cut down or burnt and not allowing to take anything from nature. The integration of deforestation and burn prevention actions are important. The absence of children and/or adolescents in tourist activities contribute to this care with the environment. The emphasis given to the use of the rest of the wood when falling naturally, as is the case of seeds and woods, and used in the construction of handicraft pieces, are all important aspects of these geotourism activities, and important social responsibility actions.

12 Final Considerations and Future Directions

Reflecting on the SDGs, with regard to specific SDGs 1, 2, 3, 4, 5, 8, 11 and 14, small actions and attitudes of citizens, aiming to preserve the environment can be observed in the Mucajaí, RR, Brazil region studied, although not yet fully implemented. Environmental issues, responsibility and commitment to the preservation of geotourism, are presented in this text as an alternative in favour of nature and environmental promotion.

This municipality has historically registered a high number of important activities made by females, symbolizing that women are supported and well accepted in executive work and, more recently, also in the tourism sector. These characteristics demonstrate the projection of women as full citizens in comparison with men in conducting tourist activities and dealing with nature in environmental conservation. Thus, with regard to the tourism services in Mucajaí, women also act in this sector with dedication and great responsibility in the face of nature and in terms of a relevant social role, intending to provide income to families.

Despite the obvious limitations regarding the women's role in society, the actions developed need to be improved to ensure the progress of all women living in the Amazon. Government is still the largest investor in capacity building and dissemination, exploiting the high potentials available in forests and wetlands that need to be preserved for humanity, and women may actively contribute to assist local authorities in a more equal society, playing an essential role in terms of social responsibility and sustainable development. A financial stimulus, with proper planning and technical

guidance for small businesses, will boost the entire geotourism production chain, thus contributing to the overall sustainable development.

In terms of future research, it is important to have in consideration that this activity is conducted by women that have a powerful connection with the environment, thus a more in deep research on the women's role in the leadership of entrepreneurship activities should be carried out. These activities are related with the destination of non-biodegradable waste, such as plastics generated by the activities and by the community's own residents, that currently happens in a fragmented and isolated way. Future research should also integrate major issues, addressing the environmental impacts of such activities, in order to develop sustainable strategies based in social responsibility, along with a sociographic study of these women and their understanding about sustainability in living environment. Being this the last decade to achieve the sustainable development goals, geotourism must be seen as a socially responsible way to balance wanderlust and preservation of fragile areas such as in Mucajaí, RR, Brazil.

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CAPÍTULO III – **A Trilha Davi em Mucajaí, Roraima, Brasil: uma experiência para (re)conectar e proteger a natureza.** [3]

No Capítulo III, tratou-se de um pilar muito forte do geoturismo que impacta diretamente na geoconservação revelado pela caminhada e ainda, conhecer o ambiente geológico e geomorfológico singular da região de Mucajaí, é ainda oportunidade para o geoturista conhecer e praticar saúde física e bem-estar. Associam-se a contemplação da paisagem do lugar e os geossítios, a cultura e demais belezas cênicas distribuídas ao longo do percurso. Um aspecto a ser destacado são as atitudes desfavoráveis praticadas no meio ambiente em decorrência da ausência de sensibilidade ao ecossistema e seus constituintes. Os desafios em direção a sustentabilidade e para manutenção do ambiente dizem respeito às alterações do solo e supressão da vegetação. A mudança de atitude pode ser cumprida a partir de hábitos, respeitar o local onde vive ou visitar de modo a influenciar outros cidadãos. Esses hábitos são assertivos e contribuem com a Agenda 2030 e ODS 12 e 15. É conveniente ressaltar a contribuição da primeira autora na redação, i.e., desenvolvimento, metodologia, trabalho de campo e na interação com a comunidade na pesquisa de campo.

[3] **Veras,** A. S. S., Vidal, D. G., Barros, N. A., Dinis, M. A. P. (2021). **The davi trail in Mucajaí, Roraima, Brazil: an experience to (re)connect and protect nature.** In Leal Filho, W., Vidal, D. G., Dinis, M. A. P., Dias, R. C. (Eds.) *Sustainable Policies and Pratices in Energy, Environment and Health Research* (pp. 3-20). Switzerland: Springer International Publishing. https://doi.org/10.1007/978-3-030-86304-3_1

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The davi trail in Mucajaí, Roraima, Brazil: an experience to (re)connect and protect nature

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Abstract Considering the massive growth of tourism on a global scale and the threats involved, the trails must be understood as a geoscience phenomenon of tourist attraction offering a unique experience. The trail allows contact with the geoecosystem to understand the natural dynamics around the wear and tear of use and anthropic action, developing awareness about how to support it. Thus, the objective of this work is to apply the concept of carrying capacity as a useful tool for the planning of the local trail, anchored in the principles of hiking, recreational and leisure activities, as a way to stimulate the commitment to the geoecosystem, following the current official safety standards. Part of a private farm, the Davi Trail is located in the central region of Mucajaí, in the state of Roraima, Brazil, and it is the object of this research. The methodology followed a literature review and field visits carried out from March 10 to 12, 2021, intending to describe the trail, its altimetric profile and carrying capacity. As a result, the trail and its potential for the activity of geotourism are presented. The trail is located 51 km away from the state capital, in Boa Vista, with a well-maintained natural structure. It is an alternative to complement the income of local citizens, as well as contributing to environmental educational practices. The municipality's public policies should integrate the voice of citizens who have deep knowledge of the reality in Mucajaí, boosting the social entrepreneurship of the region and safeguarding the natural geoecosystem.

Keywords Tourist paths · Hiking · Carrying capacity · Geotourism · Geodiversity · Geoecosystem

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Introduction

Population growth in an urban context involves complex challenges not only to global sustainability but also to the sustainable maintenance of the natural geoecosystem that is part of it and to the well-being of the population. Considering the tendency of increasing concrete at the expense of nature, with an increasingly reduced space in the urban area, it is essential to have

alternatives that allow people to contact with nature (Vidal et al., 2020).

Among the existing alternatives, geotourist trails, important infrastructures for the development of geoturism activity, can be assumed as guided tourist paths, identified with informative signs, connecting places and objects that are attractive in terms of sight, nature or culture, with a strong presence of geodiversity (Zawadka & Pietrzak-Zawadka, 2018). Trails also contribute to the citizens well-being in the face of an environment where anthropic action is still residual and, where the natural environment prevails and the principles that must be respected, as advocated by Helgadóttir and Sigurðardóttir (2018). Geotourism, an activity growing at a global scale, is a segment of tourism based on information on geological and geomorphological attractions (i.e., rock outcrops, waterfalls, caves, landscapes), the geosites, which values the integration of the citizens' knowledge to promote the sustainable development of the region (Dowling, 2014; Dowling & Newsome, 2005; Hose, 2006). In the international debate, the contribution of geoethics reflects the ethical aspects of human behaviour towards the geosciences in environmental emergency context, highlighting the geoscientist's responsibility to alert and to raise awareness about the practice of exploring geo-resources (Frey, 2021; Peppoloni & Di Capua, 2017). Despite being a concept widely used, it must be noted that the first definition of geotourism dates back to 1995 as "The provision of interpretive and service facilities to enable tourists to acquire knowledge and understanding of the geology and geomorphology of a site (including its contribution to the development of the Earth sciences) beyond the level of mere aesthetic appreciation" (Hose, 1995, p. 17). However, no consensus has been observed yet since even among geologists since this study area is not accepted by all, focusing more on production than on geoconservation.

As an innovative activity that promotes geodiversity, refering to the variety of earth materials, forms and processes that constitute and shape the Earth (Zwolinski, 2004), geotourism can be considered as a sustainable alternative for socio-economic development (Veras et al., 2020a). This activity allows contact with the geoecosystem, to understand its dynamics so that it becomes possible to conserve, value and interpret the geosites, locations that have a particular geological or geomorphological significance, present in the area, and also acting as a didactic tool (Telbisz et al., 2020). However, the economic benefits from the available environmental resources have resulted in pressure on them, leading to cultural and environmental degradation and destabilization (Halder & Sarda, 2021; Veras et al., 2021). These natural environments, endowed with services from various geoecosystems, are highly pursued since they provide visitors with a feeling of contentment and restorative effect, as well as the pure air offered by nature when practising walks on natural trails (Christian, 2021; Guimarães et al., 2021; Veras et al., 2020b). With a focus on geological awareness for the awakening of the heritage to be conserved, geotourism has been growing worldwide (Matshusa et al., 2021).

According to Newsome and Dowling (2010), geotourist trails plays an important role in geotourism exploration since it allows to connect the visitors with the attractions, minimizing the physical barriers to access geosites, by also contributing to positively impact in the regional socio-economic development. Some studies have contributed to demonstrate how geotourist trails may be a tool to intensify geotourism and to make it functional (Ginting et al., 2017; Norrish et al., 2014). Newsome et al. (2012) and Norrish et al. (2014) identified some elements that may be useful to interpret geosites and to develop a geotourist trail, such as panels, viewpoints, tours, gardens, visitor centres, and museums, timelines, brochures, academic visits, supported by available apps highlighting geosites value. According to Cifuentes (1992), for environmental control to ensure the sustainability of resources, it is recommended to establish a monitoring plan, expand special rules and maintain a profitable tourist activity for balancing the impacts on water, soil, vegetation, fauna and social. Monitoring can be applied to tourist trails, and it is necessary to use samples of quantitative or qualitative indicators for trails up to five kilometres (Table 1).

In a broader dimension, the National Climate Change Plan (NCCP), which aims to implement instruments of the Adaptation to Climate Change policy, consists of a set of strategies to deal with the unpredictability of climate phenomena thats affect societies in the face of catastrophes such as floods, intense heat waves, forest fires, droughts, landslides, CO_2 emissions, recording levels that are increasing in many regions of the world, embodied in existential threats for humanity (Pandy & Rogerson, 2021; Scott,

Table 1 Procedures for management of tourist trails. Source: Adapted by Oppliger et al. (2020)

Field approach indicators	Data collection method	Assessment	Frequency	General materials monitoring
Trampling	Sampling (points)	Qualify	Semester	Field sheet
Track width (every 100 m)		Quantify	Annual	
Damage to natural resources (fire, water pollution)		Quantiqualify	Annual	Satellite images
Presence of waste			During visits	Field sheet
Drainage problems (water puddles, apparent erosion)			Annual	Field sheet (holidays and special date-peak periods)
Damage to infrastructure—graffiti on trees, rocks, broken branches (guardrail, sign, observatory, bridge)		Qualify	Semester	Photograph
Visitor experience	Questionnaire interview (via email and/or suggestion box)	Quantiqualify	During visits	Report

The results of the monitoring process must be tabulated through Excel or other software that allows automatic calculation to know their occurrence and if it has reached the established standard for the space and the appropriate actions for verified problems, with priority for those where the intervention requires emergency

2021). The NCCP is of utmost importance in the tourism activity since it recognizes the climate change impacts on this activity, namely in the job reduction and the threats to natural and built infrastructures. Therefore, there is an absolute need to strengthen and establish partnerships towards the protection of the ecosphere (Pathak et al., 2021).

In this context, the municipality of Mucajaí, in the state of Roraima, North Brazil, has a privileged natural area, endowed with a scenic beauty that leads to the search for exotic and preserved places. Accordingly, the search for trails in remote areas has untapped potential for the activity of geotourism. Considering the above, the objective of this research is to explore the carrying capacity in David Trail, through the analysis of the definition of geotourism trail and the structuring of this environment to achieve a planned tourism development.

Literature review

Emergency and consolidation of the trail

The planning and feasibility of public access visits to natural and urban areas, with the objective to obtain recreational, educational and interpretation moments are one of the strongest components of geotourism, strongly impacting geoconservation. The literature reveals that walking promotes well-being, increasing the physical health of people suffering from health problems such as obesity, stress, depression and diseases that are aggravated with the current daily sedentary lifestyle (Song et al., 2015). In addition, Hartig et al. (2011) considered the contemplation of scenic beauties, which are known to be historical and culturally significant, to be beneficial to the society, as perpetrators of collective memory.

Trails have been indispensable for travel and tourism for millennia, helping to form the basis of past and present mobility patterns (Timothy & Boyd, 2014). Trails include water routes, but the most used are land-based trails, called linear trails, which have infrastructure elements for the geoturism activity depending on the level of specialization, i.e., if they are in mountains or hills (Reis & Jellum, 2012). Trails growth has been consolidating around the world in the last thirty years, with emphasis given by the insertion of technologies such as the Global Positioning System (GPS), interpretive pens and specific apps, available resources that reach different types of either expert and inexperienced users (Beeco & Hallo, 2014).

The trails provide complementary experiences on education, recreation, the identity of an unknown place, exploration of environmental conservation themes suggested by the trail guide, with knowledge and respect for nature (Folmann et al., 2010). This happens through didactic attitudes, playing an ecological role in the conservation of natural paths in different ways (Eisenlohr et al., 2013). The trails can be classified into levels of difficulty and defined as the path that leads to a geosite. As a result, they are important pieces of planning, since they greatly contribute to the appreciation of heritage and thus also generating opportunities of development for the surrounding community (Fortenberry, 2021; Marion & Wimpey, 2017; Upadhayaya, 2018). A new approach has recently emerged to interpret geodiversity, requiring technicians in the area to prepare geotourist educational, scientific and touristic routes (Brilha, 2016), anchored in what the normative postulates for the identification of geosites and the National System of Protected Areas (in Portuguese *Sistema Nacional de Unidades de Conservação da Natureza – SNUC*), Law n. 9.985/2000, art. 11 (Brazil 2000), which deals with recreation in contact with nature.

The trail classification occurs according to the shape, which can be circular, in eight or linear; according to the function of outdoor educational activities, which can be of a recreational and environmental interpretation type and according to the level of difficulty associated with the trail itself, which depends on landforms on the Earth's surface (Silva, 2016). Even so, it is important to incorporate in the planning of the trail the so-called carrying capacity, a relevant element for calculating the maximum given time and space for people allowed to explore the walk aiming at sustainability (Rezagama et al., 2021).

Carrying capacity concept

Considering the expansion of the tourist activity in the world, particularly in countries with advanced industrialization levels, the studies on natural environment, of a descriptive and analytical nature, appear to contribute to explain and to debate the essence of natural resources. Social, economic and cultural dimensions must be considered in the destination's carrying capacity, aligned with sustainable development goals to support the surrounding environment, guaranteeing a synergistic integration to the long-term well-being of the local citizens (Álvarez-Herranz & Macedo-Ruíz, 2021; Boullón, 2006). Accordingly, the tourism activity needs to balance the carrying capacity of a particular destination, aiming to avoid mass or excessive tourism, resulting in negative effects on the geoecosystem and human health, widely recognized either by the citizens as by the scientific community. The carrying capacity concept may be used to define the maximum use of biota and physical processes in protected areas, with a focus on the visitor's management of impacts, developed by both the national park service and conservation associations. Environmental interpretation activities not compromising the harmony of life in the region may be organized to assist the carrying capacity concept (Aliyeva et al., 2020; Koshim et al., 2019).

The theoretical genesis of carrying capacity was recommended in the field of mechanics in 1760 and later incorporated in the area of geoecosystem and forest resources, evolving into the field of tourism in 1890, and becoming an important indicator for planning and use in environmental management (Miao et al., 2021). During its conception and emergence, the carrying capacity concept has been renamed as ecological capacity or environmental stress (Liu & Borthwick, 2011). Thus, consumption and the sustainable use of natural resources results in society leisure, satisfaction and relaxation. The concept of tourism carrying capacity is the of support or tolerance of an area to receive a certain number of visitors without changing its natural state, which implies a restriction of tourism growth in an area without altering its surroundings. It reflects the tolerance of an area to accommodate visitors without affecting the natural balance of the geoecosystem, which implies a limit on tourist growth. Thus, geotourism is an alternative to unbridled tourism, as it encourages the creation of geoparks, unified areas that advance the protection and use of geological heritage sustainably, by promoting the economic well-being of the local communities (Mc Keever & Zouros, 2005). Also through geosite inventories, i.e., site location areas or territories in which it is possible to identify a geological or geomorphological interest for conservation (Cleal et al., 1999), while simultaneously contributing to the preservation of the environment. However, the methodology has been the target of some criticism, namely being considered an

inappropriate and reductionistic approach that maintains the illusion of control (Mc Cool & Lime, 2001).

The carrying capacity methodology, developed by Cifuentes (1992), results from calculations that incorporate the concern with the satisfaction of the visit and/or walk of the tourist with an environmental focus (Pires 2005). The concept ascends with the repercussion of the Sustainable Development paradigm, concerns and advances involving the carrying capacity, which incorporated the socio-cultural issues, e.g., local communities of tourist destinations. Thus, the concept anchors in environmental factors and impose limits on the maximum use of biota or physical processes in an area before the pressure becomes unacceptable (Singtuen & Won-In, 2018). Thus, the carrying capacity is assumed as a strategy to establish limits for the development of territories without causing additional pressure on the balance of the geoecosystem, being useful in the management of places with adverse tourism activities generated by human action and with negative impacts on the community and quality of ecosystems. It is thus considered an important essential tool for planning, to be promoted among decision-makers and in the assessment of visitors who experience tourism activities (Rogowski, 2020).

Worldwide, several studies have been demonstrated the application of this method in different contexts. In the field of geoparks, the methodology has been applied to assess if these spaces are aligned with the main principles of sustainable tourism. Examples are the study of Gui and Chung (2019) in Hong Kong, which applied the tourism carrying capacity in a geopark to prove its validity and to confirm if the park strategy is aligned with sustainable tourism practices; the study of Vujko et al. (2017), in Serbia, which allowed to develop a method for determining the carrying capacity based on the zoning of environmental resources and zoning in Fruška Gora (Mountain) National Park in Northern Serbia or the study of He et al. (2013) in China, establishing an appraisal indicator system of tourism environmental carrying capacity of geoparks, using as a case-study the Xinwen Karst World Geopark in Sichuan province. This methodology has been also been applied to touristic trails, specifically in South America, to assess their carrying capacity. In Brazil, many studies have chosen specific trails to assess its carrying capacity, such as the study of Folmann et al. (2010) which have chosen the Trail of Salto São Jorge; the study of Oliveira et al. (2018), which applied the methodology to the Mata do Limoeiro trail and the study of Teixeira et al. (2015), assessing the carrying capacity of the Serrinha Trail.

Trail classification

Geotourist trails are an opportunity to understand the origin of several materials (soil, sediment, rock and others and also to prevent the erosion, and to relief. According to Silva et al. (2016) and to the Brazilian Association of Technical Standards (2008), the trails classification consists of levels of difficulty that the beginner, professional and/or person with physical disability and/or with reduced mobility may have to participate in successful experiences in terrains that allow the practice of tourism or physical activities without the risk of accidents in the geotourist universe. Considering these principles, the classification levels are presented according to the level of difficulty in Table 2.

Trails' environmental threats

In the context of the Anthropocene era, characterized by the unfavourable human action on the environment (Crutzen & Stoermer, 2000), there is an absence of sensitivity for a full coexistence with the environment, increasingly driving consumption, without concern for the fundamental principles of respect for future generations (Araújo and Lima 2020). Part of these impacts are visible in the course of the trails, namely in the soil texture through erosion and loss of the soil constituent, sometimes considered irreversible (Marion, 2006), depending on the type of geoecosystem and its constituents, i.e., soil, rocks, biodiversity, water, and others. Once damaged, the recovery of this soil is slow and the consequence of the loss affects the exposure of roots and rocks, since the pluviometric conditions, erosivity and the topography of the land are interconnected, impacts that are also mentioned in other trail methodologies such as the Limits of Acceptable Changes (McCoy et al., 1995) and the Recreation Ecology (Marion et al., 2012). All of these factors may cause accidents during the geotourists walk, thus reflecting on the aesthetics, quality of the trail and the safety of the tourist, leaving the tourist more exposed in the recreational experience (Marion & Wimpey, 2017). On the other hand, lands close to a

Table 2 Classification of trails according to the degree of difficulty and profile of the visitor who intends to practice this type of hiking, adapted from Silva (2016) and ABNT - Brazilian Association of Technical Standards (2008)

Difficulty level	Description The level of difficulty varies from person to person depending on physical condition and eventual baggage. The risks occur according to the characteristics of the natural environment: temperature, rainfall, risk of falls and rescue. The use of geotechnologies, such as Global Position System, is essential to assist and optimize the route
 Level 1 (easy)	Suitable for trail user with some physical limitation with little physical preparation and that requires assistance during the walk (e.g., route) with a distance of up to 2000 m
 Level 2 (light)	Suitable for citizens with low physical preparation to face this type of trail, lasting up to 4 h on a distance of up to 6000 m with obstacles of 200 m
 Level 3 (moderate)	Indicated for trail user who has some experience in mid-degree hiking, this is one of the most sought. In this mode, the distance can reach up to 12,000 m in 8 h
 Level 4 (difficult)	For experienced citizens with a good physical condition
 Level 5 (severe)	To professional with expertise in large altitudes above 3 thousand meters and distance up to 20,000 m and duration of up to 14 h

large number of water resources contribute to an increased negative environmental impact, such as the felling of trees, the loss and damage of vegetation (Araújo and Lima 2020; Arredondo et al., 2021).

Material and methods

Characterization of the study area

The area integrating the Davi trail is currently used for ecotourism tours (Bednarczuk, 2019), being visited by local citizens and tourists. It has a geological framework linked to the Craton Amazonian event, which gave rise to the structuring of crustal blocks consisting of gneissic and granitoid complexes aligned to NE-SW in the state of Roraima, Brazil (Holanda et al., 2014). According to Veras et al. (2020a), these rock complexes shaped by geomorphology gave way to a differentiated landscape in the central-west part, supported by a geodiversity that gives rise to water resources, fulfilling the social function of providing recreation, in addition to playing a fundamental role for all living things (Holanda et al., 2014).

The population density of Mucajaí, Roraima, is of 1.19 inhabitants per km^2, in a territory extending over 12,461.21 km^2 (IBGE—Instituto Brasileiro de Geografia e Estatística 2017). The origin of the municipality dates back to 1951, starting as the Fernando Costa Agricultural Colony, on the banks of the Mucajaí River, in settlements made official by the National Institute of Colonization and Agrarian

Reform (in Portuguese *Instituto Nacional de Colonização e da Reforma Agrária—INCRA*), at the time executed in the Vila Nova and Samaúma Settlement Project. Nowadays, it comprises agricultural activities, mostly family, together with fish farming in the semi-intensive system. There are large farms in the region that exploit large-scale cattle ranching (Xaud & Xaud, 2017).

The predominant soils in the region follow the following taxonomic units: Red-Yellow Latosol, Neossolos, Plintosolos, Gleisolos, Argisolos and Nitossolos, predominating the Red-Yellow Latosol (Gama, 1983). The genesis of these soils belongs to the wavy reliefs constituted by residual masses distributed in abundance in the region. They complement phyto-physiognomy (e.g., landscape) with vegetation characterized by the low and medium altitude savanna-forest transition (Barros et al., 2010).

To carry out this research, the Davi Trail was used. It covers a distance of 2 km in an approximate time of 8 h on the land walk. The 8-h walk includes time to explore the space surrounding the trail, to observe and experience the space, enjoying the natural environment and taking advantage of a pleasant walk (Fig. 1).

Methodological procedures

The research methodology is an exploratory one. It aims to characterize and expand the knowledge of the region and its potential for the geotourism activity (Liamputtong, 2013). The qualiquantitative method was used. Its interpretation enables rich narratives when describing, understanding and working with attitudes that correspond to space and explain a certain phenomenon (Huaroc Ponce et al., 2021). The research was supported by a bibliographic research and a descriptive design about the concept of geotourism, geodiversity, of the carrying capacity concerning visitors, as well as the legislation related with organizing trails.

Data were collected through direct observation, embodying exploratory research, as it uses techniques such as literature review with a qualitative approach (Gil, 2008). To describe the Davi trail. The setting of this field investigation in the description of natural phenomena was carried out in the municipality of Mucajaí, Roraima, Brazil, more precisely in the neighbourhood named MUC 151, from March 10 to 12, 2021. The trail is located at coordinates N 02° 19‘47″ e W 61° 23′ 43″ on private property and not yet categorized as a protected area or any other particular category, as determined by the National System of Conservation Units-SNUC (Brasil, 2000). The Davi name is a tribute to the trail owner. By offering a waterfall bath to the neighbours around his property, it resulted in an attraction to be publicized locally, according to oral testimony from the local driver conducting the trail path, frequented for groups of up to 10 people. However, by prior agreement without a formal contract, the use of the trail as an attraction has been occuring since 2013.

Along with the fieldwork, it was possible to carry out the photographic records which allowed to identify the variability of the preserved environment along the 2 km route. As for safety aspects, the trail has a steel cable, some plates of preservation that provides support and accessibility in stretches of difficulty. To obtain more precise information about the trail, a local guide and two people from the family that owns the land where the trail is located assisted in this study.

Carrying capacity methodology

According to the Cifuentes (1992), the criteria of Physical Load Capacity (*PLC*), Real Load Capacity (*RLC*) (weighted by some correction factors [*CF*] obtained from the fieldwork), Effective Load Capacity (*ELC*,) and the relationship established between the *PLC* is always greater than or equal to the *RLC*, which in turn will always be greater or equal to the ELC, is translated through the following relationship:

$$PLC > RLC \geq ELC.$$

where *PLC* is the calculation of physical capacity, in which the standard of 1 m^2 per visitor is used to cover the trail, divided by the time available for visiting the area; *RLC* is a calculation of the real carrying capacity, assessing environmental factors such as precipitation and environmental issues, and physical factors, such as erosion and accessibility; and the *ELC* is the effective carrying capacity, which allows knowing the physical space to be used in a specific period, the sizes of the groups of people, what activities will be allowed and the number of trail guides. The *CF* is calculated throug h the following formula:

$$CF_x = 1 - (Ml_x/Mt_x)$$

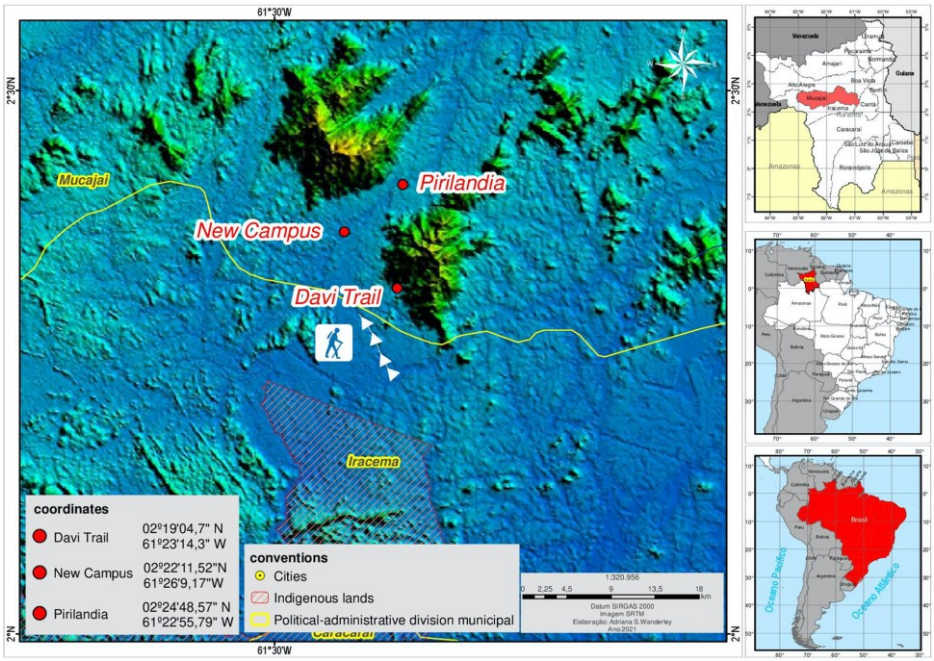

Fig. 1 Location map of the Davi Trail, Central region, in Mucajaí-Brazil, March 2021. Developed by the authors

where *CFx* is the correction factor according to the selected variable, the *Mlx* is the limit magnitude occupied by a person and *Mtx* is the total magnitude. Another criterion used is the capacity of variable management infrastructure, which interconnected with the legal support, public policies, equipment such as bathrooms, selective garbage dumps, internal interpretation boards, information kiosks, human resources, financing, installation, always assigning a value for each item, which varies on a scale from 0 to 4. The results of these calculations support the planning of improvements for the region, translated in the preservation of nature. It is also important not to disregard the users' levels of satisfaction or displeasure with the geosite (Lee et al., 2019). In addition, some relevant environmental correction factors must be considered in the calculation of the carrying capacity of the trail stages, such as precipitation, erosion and accessibility.

Results and discussion

The tourist attractiveness of the region is indisputable, as it brings together numerous places representing geological heritage and natural forms, which constitute a geotouristic granary of this region. On the other hand, there is a set of principles that count for a good service to tourist and/or visitor services, such as the agency's ability to take a group to walk the trail and, in the end, take a healthy waterfall bath.

Geographically, the imposing relief of Mucajaí, Roraima, Brazil, in the NE/SW direction presents the trail in a linear straight line, sometimes with curves and steep climbs. This relief has a network of water resources, but without interfering in the route. The trail is on private property, beginning to be used in the 2000s, it was discovered by the owners and residents of the surrounding area, and is open to visitors from the region. Currently, the situation remains precarious, without significant infrastructure, i.e., without signage

and a guardhouse, which may regulate entry, still free, or technical guidelines to stop impacting actions such as bonfires, noise, waste pollution and, especially, to monitor the disposal of plastic bags. Although actions of this nature are not yet a threat to the environment, they should be a concern to be included in long-term planning.

A bilingual trail guide must work in the region, knowing the place well. On the other hand, the trail should always be walked with a small group so that, in the event of eventual encounters with wild animals or with indigenous people from the region, namely Yanomamis, visitors do not feel threatened.

As for the aspect of formalizing the geotourism professionals to act in the interpretation of the environment, the driver must have a registration with Cadastur at the Ministry of Tourism (MTur), as established for every service provider in the General Tourism Law, No. 11771, of 17 September 2008 and meet the rules regulated in ABNT 15,505–02 that establishes the minimum competencies for hiking (Brazil 2008). The professional must be knowledgeable about the good practices of sustainable tourism and be an active part in the valorisation of local culture and identity, being also an active environmental preservation actor, as ensured by Law n. 8.623, of January 28, 1993 (Brazil, 1993).

The trail resources involving the services of guidance, accompaniment and information to tourists are increasingly an international trend. Geosites are highlighted in the landscape. Geodiversity and its abiotic variability are found in an open-air laboratory, as well as the type of existing rock, its shapes, the age of the features and its evolutionary processes on the Earth's surface. Concerning biodiversity, the region offers oxygenated and pleasant air from the forest vegetation. Also, the quietness promoted by the sound of birds endemic to the region, is a geoecosystem service (Buxton et al., 2021; Levenhagen et al., 2021). At the end of the trail an encounter with the beautiful attraction that arises from the mountains it possible.

According to the topographic profile of the region, the path of the trail in its various angles stands out, Figs. 2 and 3.

Considering the Davi trail are, it can considered a potential geotouristic attraction, located in the geographic coordinates N02°19′47" and W61°23′43″. It is 2 km in length, divided into sections with obstacles (i.e., small stream, unevenness in the ground). Along the walk, granite rocks are visible from the Mucajaí intrusive suite, whose morphology was shaped by the action of the climactic storms that give rise to the landscapes. Among the deformities, there are dissolving lunch boxes that accumulate water, fractures and slabs belonging to the Central Guyana Domain (da Silva Valério et al., 2021). In this area, part of the rock formations is covered by vegetation, characterized as an indicator of the good environmental conditions of the region, as vegetation brings together several rock outcrops of high didactic and scientific value not yet known and valued.

The large vegetation landscape component (e.g., *Bertholletia excelsa*, *Ceiba pentandra*, *Dinizia excelsa*), in its native condition, is very pleasant. A contribution to the geotouristic practice of walking outdoors, without pollution, which makes the service essential, resulting from the density of the leaf area, i.e., pH of the leaf extract, chlorophyll, and relative water content, which has the function of filtering the air and making it healthier for living beings and, consequently, for human exposure (Shrestha et al., 2021).

Given the diversity of fauna and flora on the trail, it is essential to apply the carrying capacity calculation in such a way that excessive anthropic pressure does not occur on the trail, involving the soil in the topography. For this calculation, it is convenient to identify the geotourist public who favours the conservation of the existing resources on the trail, *RLC* which takes into account the environmental factors considering the aspect of the climatic conditions of the Amazon region (i.e., seasonal factors), as well as the *ELC*. It is worth mentioning that the peculiarities inherent to the tourism destination, in this case, the Davi trail, are used to identify factors that influence the demand for the particular place. It is also worth mentioning that due to the peculiarities inherent to the destination, in this case, the Davi trail, and according to the guidelines of the professional Tourism Guide, the maximum number of people (i.e., visitors per group) must total 10 and the minimum distance between groups, with 1 m^2 for each visitor to move, is 50 m. This distance favours silence during the route.

According to the characteristics of the Muncajaí region, Roraima, Brazil, the period of greatest precipitation occurs in April to July and the dry season, from August to April. Therefore, observing this reality for the rain cycle time criteria (10 am to 12 pm) must

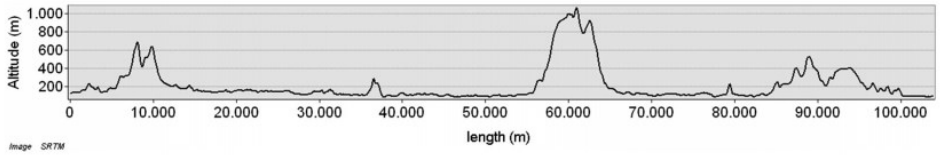

Fig. 2 The altimetric profile of the region, designated on its xx axis (i.e., horizontal dimensions are graduated with a minimum interval of 5,000 m) and yy axis (i.e., in vertical is the height of the morphologies) with a minimum interval of 200 m observed in NE-SW. The morphologies of structured crest relief vary from hills to large mountains, constituted in rocks of the metamorphic and magmatic suites, formed in the Paleoproterozoic and Mesoproterozoic geological times. Information collected in March 2021

Fig. 3 The images represent the reality of the trail area. **a** marks the beginning of the trail's journey, which is still well preserved, and awakens several curiosities that may raise questions for the tour guide; **b** geodiversity is exposed in its explicit form of granitic rock with various erosive processes and cracks, which values the trail's walk; **c** in this part of the trail, an obstacle puts the tourist in full attention, with a very sharp descent; **d** it is the end of the trail, which leads to a waterfall with transparent and pure water that awaits the visitor for a pleasant bath. Information collected in March 2021

taken be considered for the rainy season, staying only 3 h a day, and in the dry period (8 am to 4 pm) being 8 h the limit for the day.

A hiker takes, on average, 8 h to cover the 2 km of Davi trail, already contemplating the obstacles of careful elevations and descents in terrains with erosivity and stops for photos. Through the walk, the geotourist is privileged with the natural beauty of the flora and rocks.

In this way, and following the methodology de Cifuentes (1992), the parameters and values to consider regarding Davi trail are presented in Table 3.

After having found the results of all the correction factors, the following formula was applied to determine the *RLC*:

$$RLC = PLC \times CFsoc \times CFac \times CFprec \times CFeven \times CFsun \times CFflow$$

Table 3 Parameters used to calculate the carrying capacity of the Davi trail Note: Data used in parameters calculation are available under request

Parameters	Values
PLC – Physical load capacity	4125 visitors per day
CFsoc – Correction factor of social	16.7%
CFac – Correction factor of accessibility	30.0%
CFprec – Correction factor of precipitation	84.7%
CFeven – Correction factor of eventual closing	83.2%
CFsun – Correction factor of sunshine	94.0%
CFflow – Correction factor of overflow	99.0%
RLC – Real load capacity	135 visits per day
MC – Management Capacity	75.0%
ELC – Effective load capacity	101 visits per day
DV – Daily visitors	73 visitors per day
AV – Annual visitors	26,645 visitors per year

$$RLC = 4125 \times 0.167 \times 0.3 \times 0.847 \times 0.832 \times 0.940 \times 0.990 = 135.52 \text{ visits/day}$$

The *ELC* represents the maximum number of visits that the trail can withstand in one day. The formula for its calculation is as follows:

$$ELC = RLC \times MC$$

$$ELC = 135.52 \times 0.75 = 101.64 \text{ visits/day}$$

For a better management capacity, these variables must be integrated into the trail management to promote the geoecosystem preservation and respecting leisure purposes. According to Cifuentes (1992), an approximate value of 75.0% is considered satisfactory for a management capacity. Thus, this was the value adopted to the Davi trail in this study. The Davi trail can receive up to 101 visits per day, presenting a higher capacity to receive visits than the Serrinha trail (55 visits; 1200 m) (Teixeira & Oliveira, 2015) and lower than the Santo São Jorge trail (125 visits; 788 m) (Folmann et al., 2010) or the trail of Mata do Limoeiro (1056 visits; 4900 m) (Oliveira et al., 2018). The results in Table 3 are those that will allow to control the number of visitors on the Davi trail, allowing to control the human pressure on this geoecosystem. The *PLC* obtained (4125) is higher than its *RLC* (135), and the *RLC* is higher than the *ELC* (101), which is aligned with the method used (Cifuentes, 1992).

Final remarks

This work aimed to use the concept of carrying capacity as a useful tool for trail planning, using the case study of the Davi trail located in the central region of Mucajái, Roraima, Brazil, as the object of study. The dimension of the landscape where the trail is located is conducive to an alternative of leisure, since it favours geotouristic, educational and contemplation of nature, as long as it is conducted according to the planning, aimed to environmental preservation. Such a planning process must include the participation of local communities, the manager appointed by the same community and/or residents' association. It must also contemplate a value chain for the services of the host community, namely for producers of handicrafts, basketry and bio-jewellery, snacks and typical foods. Thus, a signalling architecture, the placement of interpretive signs in easy language of the local geodiversity and the training of those involved, are key points of this planning. The results showed that the Davi trail can receive up to 101 visits per day (73 visitors per day). However, it would be important to integrate this trail in a protected area. This would be useful to monitor the sustainable use of the land and provide a proper management strategy.

From a geographical perspective, in addition to the geotouristic potential that adds value and income for family property, the trails can be considered a promoter element of the responsible interaction of the geotourist with nature. Consequently, it will result in a better quality of life for everyone in the surroundings, ensuring sustainable geotourism,

enhanced by geodiversity and biodiversity, with the interpretation and positive attitudes of the citizens, agents of change in the Anthropocene era.

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Declarations

Conflict of interest No potential conflict of interest was reported by the authors.

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CAPÍTULO IV – Percepção de sustentabilidade de ecossistemas lóticos e lênticos na Bacia Amazônica pela lente de uma comunidade local. [4]

No Capítulo IV, a sustentabilidade dos recursos hídricos, i.e., áreas lótico e lêntico de água doce constituem o foco da pesquisa para a região remota com rio e lagos abundantes. Estes recursos são parte do apelo que a Agenda 2030 e dos ODS a serem alcançados: o ODS 6, refere água e saneamento um dos desafios contemporâneo, o ODS 10, aborda a redução das desigualdades, e o ODS 15, essencial à vida terrestre, e.g., biomas comuns e suas interações com o ambiente. Nesse contexto, o geoturismo preconiza o cidadão local, respeita a autenticidade da cultura. Desse modo, segundo respondentes, i.e., amostra de cidadãos das áreas em análises para entender o envolvimento destes cidadãos que apontam a proteção aos ambientes vulneráveis aquáticos, ressaltam em suas falas o respeito, e a necessidade do cuidado com as águas, pois, constituem dependência desse recurso e oportunidade de renda.

Ressalta-se que a primeira autora participou do levantamento de conteúdos sobre a ciência, métodos de abordagem e procedimentos para o devido conhecimento científico.

[4] **Veras,** A. S. S., Vidal, D. G., Barros, N. A., Dinis, M. A. P. (2022). **Sustainability Perception of Lotic and Lentic Ecosystems in the Amazon Basin Ecosysrems in Amazon Basin Through the Lens of a Local Community**. In Leal Filho, W., Vidal, D. G., Dinis, M. A. P., Dias, R. C. (Eds.) *Sustainable Policies and Practices in Energy, Environment and Health Research* (pp. 3-20). Switzerland: Springer International Publishing. https://doi.org/10.1007/978-3-030-86304-3_1

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Sustainability Perception of Lotic and Lentic Ecosystems in the Amazon Basin Through the Lens of a Local Community

Ana Sibelonia Saldanha Veras, Diogo Guedes Vidal, Nelson Azevedo Barros, and Maria Alzira Pimenta Dinis

1 Introduction

In the context of hydric resources distribution, Brazil holds the highest hydric availability on the planet, being responsible for almost all the total average change of water bed stream in South America. Brazil has an unequal distribution of its resources, specifically considering the Amazon basin, located in a region with low population density. Therefore, to study the lotic ecosystem is relevant, particularly in the Amazon region, to provide knowledge on lakes comprehension, i.e., naturally formed depression that stores freshwater, and hydrological conditions that play a key role in interactions with terrestrial processes, essential to sustain life through the quality of water in many *igarapés* (streams), i.e., small rivers. This ecosystem is part of the Earth's bloodstream, vital to individuals survival, as well as for nature balance, food and raw material provision, playing a crucial role in remote communities, namely those located in the Amazon Basin.

Water is the second most important component of the Earth, in addition to air, used as irrigation for crops, cooling equipment, industrial chemical processes, city growth, hygiene, as geopolitical divider and means of connectivity, navigation, leisure and recreation (Sabo et al. 2010; Falkenmark 2016; Herrera et al. 2019; Bogardi et al. 2020; Güntzel et al. 2020; Wetser et al. 2020; Plummer and Baird 2021). Individuals cannot survive without water. Accordingly, freshwater man-

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agement has resulted in several concerns and discussions in world forums (e.g., Brundtland Report—Our Common Future), a historical milestone in which sustainable development concept was defined as "… meeting the needs of the present without compromising the survival of future generations". This concept was widely shared in the (United Nations 2000). Thus, the Conference on the Environment—Rio 92, which allowed advances and the adoption of the 21 Agenda, presenting the need to understand the social, cultural, territorial, economic, political (national and international), and environmental dimensions, on the effects of the rapid climate changes and, consequently, on the Earth limits and resilience to support it. Alongside, sustainable tourism practices (i.e., leisure, sport and geotourism) must be committed to a sustainable development vision, depending on proper environmental management, to ensure long-term sustainability (Hummels and Argyrou 2021; Managi et al. 2021; Mihalic et al. 2021).

Considering the background, this work aims to identify the perceptions and attitudes of a local community in the Amazon Basin on lotic and lentic ecosystems in the context of Geotourism activity and its implementation to achieve the Sustainable Development Goals (SDGs). The main sustainability challenges of SDGs 6, 10, 14 and 15 are presented as well as the existing infrastructure to support Geotourism activity.

1.1 Overview of Ecosystem Services of Rivers and Lakes

Ecosystems are open systems comprising environments, both abiotic and biotic, that interact in processes contributing to human well-being, either directly or indirectly. They provide scientific evidence for stakeholders, i.e., public managers and natural water managers, as well as policymakers, to visualise environmental scenarios for future decision-making. In this regard, it is worth noting that these services have been a subject of concern, and their genesis was defined by Walter Westman (1977 *apud* Costanza et al. 2017) in his work "How much are nature's services worth?". This was followed by the development of the concept of "ecosystem services", advocating benefits for human well-being with a focus on the economic and ecological bias (Ehrlich and Ehrlich 1981; MEA 2005; Costanza et al. 2017; Butorac and Buzjak 2020; Aziz 2020; Tengberg et al. 2021). In this complex interaction, there is a heterogeneity of aquatic habitats, including rivers, streams, swamps, and lakes, which points to an enormous potential for research in various areas of the sciences due to its clear, transparent water ecosystems, related to the origins of the Amazon region (Morato 2018; Silva et al. 2020). Although lakes are a small component of the biosphere, they are valuable and necessary, as they cover five million square of the Earth's surface, according to satellite imaging studies (Verpoorter et al. 2014). The Brazilian Amazon, specifically the Northern region of Brazil, is comprised of the Amazon River basin, the most extensive basin on the planet, formed by 25,000 km of navigable rivers in about 6,900,000 km^2, of which approximately 3,800,000 km^2 are in Brazil. The Legal Amazon, as stated in

art. 2 of Law 5.173, of October 1966, includes the states of Acre, Amapá, Amazonas, Mato Grosso, Pará, Rondônia, Roraima, Tocantins and part of Maranhão, and their ecosystems (Brazil 1966; IBGE 2010).

Lotic, e.g., rivers, and lentic, e.g., lakes, ecosystem consist of water bodies that are mostly found in depressed terrain and have no connection with the sea. The fluctuation of a lake's water occurs as a result of the water balance, which emerges from the interaction with the atmosphere, involving precipitation and evaporation, and groundwater, including hydrothermal water (Riccomini et al. 2015, p. 194). Therefore, freshwater ecosystem contributes to climate regulation, assisting nutrient cycling for vegetation, where ecological and biogeographic processes predominate. They are essential and indispensable to individuals living in remote areas, transporting water and materials, maintaining water quality and enabling human development, as these communities not only interact with the place but are also inhabitants of the biosphere and therefore beneficiaries of freshwater services over time (Folke et al. 2016; Janssen et al. 2021; Filocamo et al. 2020; Salinas-Rodríguez et al. 2021).

Amazon, a region with low population density, is a natural environment of floodplain areas, being considered one of the least known environments in the world and one of those that provide more ecosystem services, ensuring the maintenance of life and standing out as an essential ecosystem at a global level (Castello and Macedo 2015; Latrubesse et al. 2020). Despite the worldwide acknowledgement of Amazon contribution to global ecosystem balance, several studies pointed out the dramatic deterioration of these terrestrial and marine freshwater bodies, which implies global vulnerability, originated by overexploitation and with dramatic consequences to biodiversity, livelihoods, and human health (IBGE 2010; Bogardi et al. 2020).

1.1.1 Lotic and Lentic Resources: Rivers and Lakes and Human Use

Lotic and lentic resources in the Amazonian plain are the result of sediment deposition, flooding of floodplains or meander cutoffs. As part of global environmental change, geochemical cycles have received considerable attention from governments since the 1980s. Many lakes had their morphology changed in recent decades as they are affected by climate change and human activity, i.e., the human-induced changes. These lakes may be formed along large rivers when sediments from the main channel are deposited as dykes at the mouth of tributaries, forming a lateral lake, and are permanent in the landscape. Changes are reflected by lake water levels and by the provision of significant habitat for a diverse group of organisms (Hirata 2015; Tan Chao and Kuang 2017; Bucak et al. 2018; Tortajada 2020; Abbasi et al. 2020).

The hydrology of the Amazon basin is significant because it is configured as a enormous complex of rivers, streams, canals, creeks, and lakes with about 20% of all freshwater on Earth. Hydrochemical characteristics are influenced by the Andean mountains, where mineral-rich sediments originate, creating not only the typically

muddy colouration of waters but also originating turbulent waters, as well as watercourses from the Guiana Shield and Central Brazil (De Souza Paes and da Silva 2021).

Of all the regions on the planet, South America is one of the most vulnerable to climate change caused by natural factors, such as the temperature oscillation of the Atlantic and Pacific oceans, a phenomenon which is known as *El Niño*, and anthropic factors originated from the burning of fossil fuel, industrialization and wildfires, leading this region to being severely affected by climate change (Marengo et al. 2011; Lawrence and Vandecar 2015; Andrade et al. 2018; Juelsgaard 2020).

1.2 Sustainable Development Goals (SDGs) 6, 10, 14 and 15

According to the tourism strategy, there are 17 global goals to achieve a true and fair sustainable environment for all within the SDGs, part of the construction of economic, social and environmental indicators necessary for different regions of the planet, along with the 21 Agenda important global commitment. These goals unfold into 169 targets for the period from 2015 to 2030, established by the Assembly of the United Nations Organization-UN, ratified by 193 countries, these being the current sustainability challenges that aim to provide incentives for future generations, leadership, and institutions that carry out the management of environmental dimensions (Lópes-Alcarria et al. 2021).

As a component of the SDGs, geotourism is an activity that correlates geological heritage to tourism in rural areas that emerges in the 1990s. Its benefits are far from being fully known, but current evidence states that this activity can help to reduce rural exodus from remote areas once its development provides new job prospects by using the interpretation of aesthetic resources to address diverse audiences (i.e., highly demanding audiences and scholars). Geotourism activity offers, among other attributes, a better understanding of Earth Sciences, with a focus on conservation and safeguard (Maghsoudi et al. 2019; Veras et al. 2020a, b; Frey 2021). After the recognition of a particular geosite comprising geological, geomorphological, stratigraphic and hydrogeological investigation, the access to fresh surface water is associated with sustainable development (SDGs: 6—essential water; 10—reduced inequalities; 14—life below water, protecting and managing life, and; 15—protecting, promoting and restoring the sustainable use of terrestrial ecosystems). Based on this approach, geotourism can be effective when properly applied in changing the conception of a more committed vision towards geodiversity, biodiversity and the establishment of partnerships with government sectors, stakeholders, and local communities, understood as the main protagonists of change in favour of local progress (Williams et al. 2020; Janssen et al. 2021; Pan et al. 2021).

2 Methodological Procedures

This research is of qualitative-descriptive-exploratory due to the scarcity of work in the area and because it analyses citizens' perceptions of the lotic and lentic ecosystem. The individuals' selection to be interviewed is based on those that are the most experienced in the region as well as those who live close to the water resources. However, due to pandemic scenario was not possible to reach greater number of respondents. Also, being a qualitative approach, the recruitment of respondents should end when theoretical saturation is reached, i.e. when no new properties and dimensions emerge during analysis in terms of observed behaviours and practices (Bloor and Wood 2006). It is expected that this research contributes to the implementation of geotourism within the Brazilian context, aiming to face the challenges of the SDGs 6, 10, 14 and 15.

The research design comprises three stages:

1. A literature review concerning relevant works in the area of lotic environments and sustainable development;
2. The fieldwork which carried out directly with local eight participants. A semi-structured interview script was designed and applied to household, either women or men, using quotes for subsequent content analysis, configuring a descriptive and exploratory methodology (Bardin 1977). The script (Table 1) covers the perception of lotic and lentic ecosystems trough six questions (Minayo 2001; Babbie 2003; Günther 2003; Marconi and Lakatos 2012). The interviews were conducted in homes distributed over a geographical space of 1.7–3 km on so-called vicinal roads or country roads.
3. An audition regarding the available infrastructure at the municipal headquarters, at the Mayor's Hall, as well as on the field. The number of hotels, points of sale of handicrafts, transportation, security, health and sanitation were tracked since these sectors provide indispensable services to the tourism chain. The coordinates through the Global Positioning System (GPS), for the design of a localization map of the research area (Fig. 1), were also recorded.

Table 1 Interview script

Questions
1. The importance of the region's natural water sources
2. Whether you have noticed any change in the water sources since you moved into this place
3. How the maintenance of natural sources is done, and whether you have seen any kind of intervention by the local authorities
4. How the tourist activity in the region is carried out, if they use these natural elements, and whether there is any impact
5. Whether you consider that it should be the local community's responsibility to maintain these natural elements
6. Whether you would do something different if you were responsible for maintaining these water

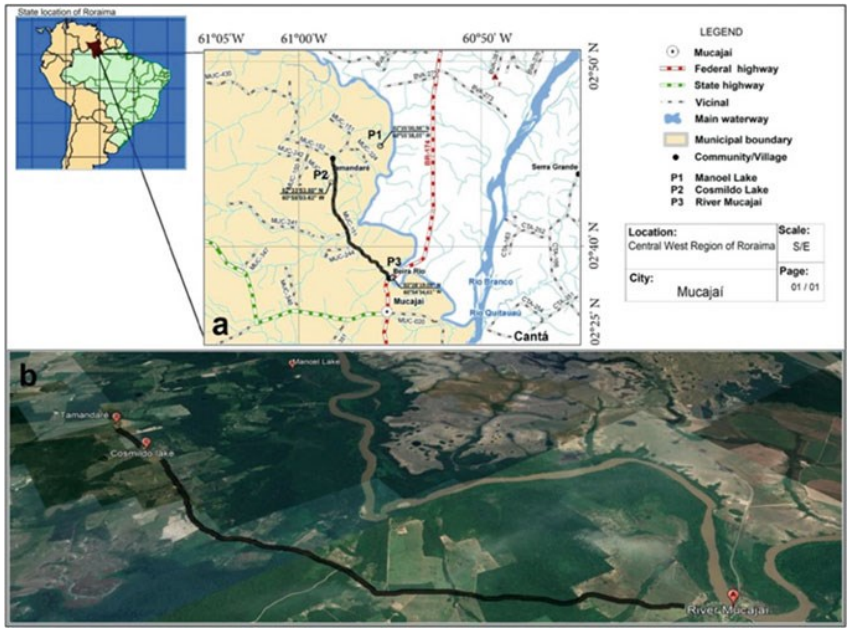

Fig. 1 The geographic location of the Municipality of Mucajaí—Roraima, Brazil. **a** Panoramic aerial landscape view; **b** localisation map and the main water resource the Mucajaí River, Manoel, and Cosmildo Lake

Table 2 Geographical coordinates of the sampling points

Sampling points	Coordinates		Elevation
	Latitude	Longitude	
P 1 Manoel Lake	N 02° 35′ 00.98″	W 60° 55′ 38.01″	79
P 2 Cosmildo Lake	N 02° 33′ 53.80″	W 60° 58′ 03.62″	77
P 3 River Mucajaí	N 02° 28′ 19.09″	W 60° 54′ 54.61″	90

The studied area is located in the Central part of Roraima, the northernmost state in Brazil, well-known for the Amazon Rainforest. The population observed was 18,172 inhabitants, resulting in a demographic density of 1.19 inhabit./km^2. The municipality has a territorial area of 12,351 km^2. According to Köppen climate classification, in its northern area, the altimetric quotas are above 1,000 m of altitude, presenting a tropical wet climate with water deficits around 3–5 months with reduced rainfall (Alvares et al. 2014). The sampling points were chosen because they exhibit expressiveness in the community and more varied uses (Table 2).

3 Results and Discussion

3.1 Analysis of the Interviews with Community Citizens

This section provides the analysis and interpretation of the eight interviews conducted in the field regarding the citizens' perception of lotic and lentic ecosystems based on the SDGs 6, 10, 14, and 15. The respondents are mostly males (n = 6), with middle school level (n = 4), with a mean of 60 years old (Min = 37; Max = 73), living in the region for an average of 41 years (Min = 33; Max = 51) and being agricultural workers (n = 6) (Table 3).

In each household, it was requested that respondents shared their perception about lotic ecosystems. Table 4 presents the interview results and correspondent responses to better illustrate.

Regarding the importance of natural resources, local citizens believe that rivers and lakes are essential to their livelihoods, which highlights their awareness of the importance to safeguard and protect this ecosystem. On the other hand, this resource is ensured by the Federal Constitution of 1988 (Brazil 1988; Hasan et al. 2021). The primary need for safe sanitation is assessed, which would improve resilience and, in turn, lead to a greater and more constant interest in SDG 6.

About the role of the municipal management, a lack of actions and investments are identified regarding basic sanitation to improve the quality of life of its citizens, specifically those located further away, which would partly allow the achievement of sustainability in compliance with the Global Agenda (Maasri et al. 2021). The new legal framework for basic sanitation states within its main focuses: (i) A target of 99% of the population with access to drinking water; (ii) a target of 90% of the population with access to sewage collection and treatment; and (iii) actions to reduce water waste and use rainwater. In the Amazon region it rains a minimum of 471.3 mm/month (Barni et al. 2020; Brazil 2020). The lack of basic sanitation in most remote locations results in many occurrences of diseases due to lack of drinking water. These remote regions are the most vulnerable to the impacts of

Table 3 Respondents' sociodemographic characteristics

Respondent	Sex	Age	Education level	Residence in the region (Years)	Occupation
1	Female	65	Elementary school	33	Agricultural worker
2	Male	41	Middle school	41	Agricultural worker
3	Female	67	Elementary school	40	Housekeeper
4	Male	72	Middle school	51	Agricultural worker
5	Male	67	Elementary school	40	Agricultural worker
6	Male	73	Middle school	51	Agricultural worker
7	Male	51	University	37	Teacher
8	Male	44	Middle school	33	Agricultural worker

Table 4 Questions and correspondent respondents' quotes

Questions	Quotes
The importance of the region's natural water sources	"*It is very rich for us who live here, the land that has a water source adds value to the place, it provides life, sustenance, and entertainment for all. Here we have an association and we all have the concern of not letting the insecticide contaminate the water of the river and the lake. We often fish from these water sources… and our families are all our wealth*" (Respondent 4) "*It is essential for us human beings, for the animals and even for the forests and plants that we have in the region*" (Respondent 5)
Whether you have noticed any change in the water sources since you moved into this place	"*We have observed that these rivers and lakes have decreased in volume year by year. Exactly after the dry season*" (Respondent 5) "*We noticed a change at the top of the water. At that time, few and almost no one frequented Manoel Lake … because they thought that the dark water hid some danger*" (Respondent 6)
How the maintenance of natural sources is done, and whether you have seen any kind of intervention by the local authorities	"*Maintenance should be done on private property to improve the structure that the producer has, but we do not get from the government. The municipality has not done much …*" (Respondent 2) "*The Residents' Association does the maintenance, they get together and on a leisure day they clean up the rubbish (plastics, falling branches and others)*" (Respondent 3)
How the tourist activity in the region is carried out, if they use these natural elements, and whether there is any impact	"*Tourist activity is practically non-existent in these environments… What we see in the region are bicycle rides on trails and there is no participation in the freshwater springs*" (Respondent 5) "*Here in this region, in terms of rural tourism, there is almost zero, but I heard that the municipality is working to bring resources to invest in tourism, especially during this time of pandemic…*" (Respondent 2)
Whether you consider that it should be the local community's responsibility to maintain these natural elements	"*If the community had the support of the authorities, we could do it ourselves, with canoes and boats, to go around and see what they are doing wrong*" (Respondent 1) "*The community knows everything, the best seasons to treat the environment. And there*

(continued)

Table 4 (continued)

Questions	Quotes
	are many young people here who can make a difference in the future" (Respondent 8)
Whether you would do something different if you were responsible for maintaining these water sources	"*These aquifers are the patrimony of all of us citizens. I would raise awareness among everyone, up to the authorities. What mankind needs to do is to be more careful with their attitudes and waste regarding nature*" (Respondent 5) "*I would form a team to assess and look after the river and lake more closely, but those who come from far away have to pay, just a little, but this is for us to organise trips and fishing*" (Respondent 2)

polluted waters and waste disposal, e.g., insecticide chemicals and This represents a significant threat across the planet to the health of humans, biodiversity, and the environment, ultimately ending up in the seas, which is contrary to SDG 14—life in water (Debrah et al. 2021). Awareness of water importance was reported through the interviews, as well as the dependence on water for everything, and the perception of climate change, excessive heat in the summer period, and/or even in the rainy period. Although these citizens are aware of the seriousness of human action, they do not stop setting fire to their lands, which they claim to be an ancestral practice, arguing that the ashes would make the land more fertile. They reiterate the importance of buying land with watercourses because this kind of land is more valued.

While respondents do not take responsibility for the changes identified in the lakes, they perceive changes in the vegetation of the water sheet through the growth and invasion of aquatic plants, found unanimous. As mentioned by Damtew et al. (2021), vegetation is the result of anthropic stressors and climate change, emerging with floating and rooted leaves, part of the ecosystem, and playing a key role in neutralizing pollutants, regulating the production of contaminants, oxygen generation, and the carbon cycle. However, respondents know and describe the vegetation, but are unaware of the reason for the ecosystem's defensive reaction. It is worth to note that experimental projects for the implementation of geotourism activities are welcome in this territory, even if they start with a short duration itinerary.

The perception about the reduction and colour of the water during the dry season shows that citizens, even in remote areas, feel the climate change and are among the most affected. The report of plants on the lamina water signals a probable change in and the colouration is influenced by the vegetables, animals, minerals, tannins and algae in these surface water bodies such as lakes (Ghosal et al. 2020; Abel et al. 2021).

The interviewees were unanimous when they stated that there is no maintenance of natural sources by the local authorities, which do therefore reflect the neglection by the public authorities. In this sense, waters and forests are assets that belong to

the Union and the state, and it is not up to the municipalities to legislate on these resources, according to the Brazilian Forest Code (Brazil 2012). The states regulate their use, through authorizations and concessions. Thus, the initiative of the sensitized community preserves the river and lake, and meets locally, in part, the SDG 15—Ensure and Conserve the Aquatic Ecosystem.

Regarding the tourism activity in the region, one interviewee mentioned that the word tourism is known to all, but not in an alternative way, yet, in this locality. This denotes the citizen's understanding that for every activity an investment must be made, with training and necessary infrastructure to welcome the visitor. It is therefore assumed that the natural will of the community must be in harmony with all relevant stakeholders, which include the leaders, municipal planning and the private sector. However, for other respondents, tourism is limited to walks and physical itineraries, bathing in the river, and taking pictures to send to friends, and this is their understanding of local tourism. The expressive set of scenic landscapes that contemplate the hydric resources and the exploitation of these environments can be worked within what the tripod of the segment advocates, i.e., transportation, lodging, and operationalization of the trip by a travel agent. From this understanding, sustainable tourism should take advantage of environmental resources, respect the authenticity of local culture, ensure long-term local economic sustainability and ensure income opportunities for the host community, and in this aspect also contributes to the mitigation of poverty (UNWTO 2020).

Most of the respondents are fully aware that the river and the lakes need maintenance, which has not been conducted by the public authorities, and that everyone needs to do something for the nature that serves them, e.g., awareness-raising campaigns. In this regard, it is worth highlighting everyone's efforts, within their possibilities, to avoid that waters to be the target of disposable waste, as water is considered a finite and vulnerable resource. If there is a terrible misuse of these resources, it will be translated into a series of complications for humanity, and this is a concern of the, which highlights water security as a global concern (Waseem 2021).

Finally, a consensus among the respondents is identified in relation to the investments in infrastructure and training to attract people to the region. This consensus is based on good planning practices accompanied by a specialist for the development of tourism in the location. Therefore, all this unanimity goes through good planning practices accompanied by a specialist for the development of geotourism in the locality.

3.2 Study Area Assessment Regarding Infrastructures for the Implementation of Geotourism Activity

Visits to natural environments have become increasingly pursued. Geotourism presents itself as a sustainable alternative because it is not seasonal and, to check the specificness of these abiotic resources, the Mucajaí River, the Cosmildo Lake, and

the Manoel Lake are available for geological interpretation, verification of importance and multiple uses, which include leisure and recreation activities, landscaping, diving, fishing and boat trips. Looking at these open-air laboratories from a geomorphological point of view reveals an opportunity to fulfil the Global Agenda goals. The diversity of freshwaters can be found in Fig. 2.

3.2.1 Mucajaí River

The geological and structural framework of the region allows describes Mucajaí River, a lotic system, as a perennial river of particular notoriety, as it not only benefits the people who live in its surroundings but also offers various advantages, especially for agriculture, sustains the unique biodiversity elements in its ecosystem, and is also a cultural and geotouristic element because of its waterfalls. Its location is characterized as feature on the Guiana Shield, of Precambrian origin, formed by a set of lineaments with NE-SW direction extending from a part of the Amazonas State to the proximities of Paramaribo and the Republic of Guyana (Feitoza et al. 2007). With its sinuous geomorphology, the Mucajaí River is about full of natural elements that promote the geotourism scenarios in its middle and upper course, such as the waterfalls known as Prego; da Lata; do Funil; dos Índios; Querosene; and do Arromba. Throughout its course, it is located in a forest region (Ferreira et al. 1988; Veras 2014; Santos et al. 2018). It is representative of the rich natural heritage and can provide a unique, authentic, and unforgettable experience to the Geotourist, in addition to the high diversity of freshwater fish (e.g., Hoplias

Fig. 2 **a** Mucajaí River, belonging to the lotic ecosystem, is the main water resource. **b** Cosmildo Lake and **c** Manoel Lake belong to the lentic ecosystem, surrounded by a terrestrial system of natural vegetation, aquatic macrophytes and small communities (i.e., fish and frogs)

malabaricus; Traira (Wolf fish); Boulengerella ocellata—Bicuda; *Semaprochilodus* spp.—Jaraqui; Hemiodus spp.—Piau; Colossoma macropomum—Tambaqui; Pygocentrus spp.—Piranha).

3.2.2 Manoel Lake

This lake is located at geographical coordinates N 02° 35′ 00.98″ and W 60° 55′ 38.01″ and elevation 77 m above sea level, in the central region of Roraima, in the municipality of Mucajaí. Access is via a side road, known as RR 325 or Tamandaré. With transparent waters, the lake has a depth of 6 m, and 40 cm at its shallowest point. As a true phenomenon of nature, it contributes to agriculture and other economic activities in the region. The landscape around the lake is rich in species, formed by an almost untouched riparian forest with intense green colours. Belonging to the lentic ecosystem, the lake nourishes the biodiversity contained in its waters and terrestrial surroundings, with algae vegetation and endemic insects, and offers specific fish species: Semaprochilodus spp.—Jaraqui; *Hemiodus* spp.—Piau; Colossoma macropomum—Tambaqui. Its enchanting tropical scenery of waters and beauty in a pure state of conservation invites the tourist into taking a boat ride and contemplating nature.

3.2.3 Cosmildo Lake

Geological environment belonging to the Guiana Shield and, finally, to the Central Amazon. It has a direct relationship with the Mucajaí River, the main water resource in the region. Access to the lake is via the Highway RR 325, approximately 30 km away, and can be found according to the geographical coordinates N 60° 57′ 55.89″ and W 60° 57′ 55.89″. Its elevation is 90 m above sea level. The name of the geo-resource is a tribute to the owner of the farm where it is located. The physiographic characteristics are preserved and it is suitable for visits. The landscape scenery in its waters allows boat trips and fishing in favourable seasons, and geotourism activity can be implemented.

3.3 Tourism Infrastructure

The set of implementations of the physical structure and basic services that support the development of tourism enable dynamism for this territory's vocation for tourism. The Urban Equipment available is presented in Tables 5 and 6.

Table 5 Equipment for tourism logistics in Mucajaí-RR

Hotels (beds in HU)	Access infrastructure (roads)	Transportation	Basic sanitation
4 hotels 32 HU's, 40 beds	BR 174 (federal highway) RR 325, 205 and country roads 6, 11	Cooperatives for alternative transportation, Cooperative-Cootam, Macuxi Motorbike Taxi Association Road transportation	Only at houses in urban areas, and it counts with 3 water treatment stations, with 175,000 l

Source Municipal Secretary of Culture, Sports and Tourism of Mucajaí-RR. *UH = Housing units

Table 6 Equipment and services

Theatre	Security	Health	Centre for the commercialization of handcrafted products
1 Centre for conventions 1 Area for the performance of the play 'Passion of Christ' 10,000 m^2	1 Department of the Military Police	2 Health clinics 1 Hospital	3 Basket, wood and bio jewellery stores

Source Municipal Secretary of Culture, Sports and Tourism of Mucajaí-RR

4 Final Remarks

The challenge of universalising the sustainable use of water is a contemporary frontier to be overcome regarding the Global Agenda 2030, based on the premise that humans are the main responsible for the success or failure in the protection of water resources. The plenty of ecosystem services provided by water resources must be stated: store freshwater, provide fishing resources and favour the well-being of citizens with leisure and educational recreation, while considering the interpretation carried out by geotourism. Thus, in the face of so many advantages, it has been a source of prosperity for all living beings, legitimising the objectives of the Global Agenda with the challenge of improving management in remote places (Maasri et al. 2021).

Lastly, it is worth mentioning that geotourism is a process for everyone's participation, in which citizens, water resources management authorities, national and local territories should consider the institutional and legal frameworks, while the numerous sectors that move the economy must be committed to guaranteeing a sustainable water resource. Among the strengths of the SDGs 6, 10, 14 and 15, the goals that stand out are those advocating for harmony and integration not only with environmental dimensions, but also with people, prosperity, the planet, peace, and partnership. This work shows that when asked about the importance of freshwater and its uses including geotourism, citizens reveal that they are committed to

preservation, thus showing the need to receive attention from authorities and investments in infrastructure, and training for managers.

This work shows that when asked about the importance of freshwater and its uses including geotourism, the local community reveals to be committed to preservation, thus showing the need to receive attention from authorities and investments in infrastructure, and training for managers.

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CAPÍTULO V – Rodovia BR-174, geoturismo e conflitos socioambientais nas regiões remotas do Norte da Amazônia.[5]

Mucajaí teve sua integração consolidada com a construção do modal terrestre iniciada em 1970 e concluída em 1977, portanto, a BR-174 a rodovia mais setentrional que integra a tríplice fronteira do Brasil, Venezuela e Guiana e a região brasileira. O modal trouxe agilidade significativas às populações, no entanto, o bioma amazônico sofreu o desflorestamento e conflitos no território indígena Waimiri-Atroari. Assim, os fatores de transformações favoreceram loteamentos no entorno da estrada e potencializaram a exuberante paisagem que pode ser propulsora do geoturismo enriquecida pelas experiências socioculturais. Há ainda, áreas pouco povoadas e selvagens, favorecendo a momentos de apreciações de cenários com belezas naturais em condições climáticas da Amazônia.

Essa integração da região em termos de possibilidades geoturística não só valoriza, mas apresenta alternativas de renda a partir da interpretação dos recursos estratégicos como a água doce, relevo, biodiversidade, e a salvaguarda da geodiversidade em direção aos ODS.

Para a consecução deste, a primeira autora contribuiu no processo da pesquisa e na recolha dos dados em campo e na escrita do texto que resultou no artigo.

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BR-174 highway, geotourism and socio-environmental conflicts in the northern remote regions of the Amazon

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Abstract BR-174 in Brazil, also known as Manaus–Boa Vista, is a longitudinal highway that connects the Brazilian states of Mato Grosso, Rondônia, Amazonas and Roraima to Venezuela, being the only terrestrial connection between Roraima and the rest of Brazil. Its construction took place in 1968 and its inauguration in 1977, aiming to promote the interconnection of the State of Roraima, as a geopolitical strategy, with the rest of the country and, later, with South America. The construction of the BR-174 crossed the Waimiri Atroaris indigenous land, resulting in serious socio-environmental conflicts in the 1970s. Furthermore, recent research indicates that the deforestation process in the Amazon is associated with the opening of roads, as it favours the migratory flow, the occupation of land and logging. In this context, the arrival of migrants and, consequently, the pressing need to settle newly arrived people in search of land, favoured the damming of watercourses, the reduction of wild fauna and deforestation as a result of the construction of the road and neighbouring areas. However, and currently, BR-174 translates into a strategy of progress and communication, uniting adjacent communities, on the one hand, and, on the other, allowing the use of biophysical resources in favour of the development of geotourism. Considering this reality and from the perspective of the social and environmental transformations that have occurred, the objective of this paper is to analyse the potential of the BR-174 for the development of

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geotourism, as a way of mitigating its socio-environmental impacts and connecting geographically remote regions. The qualitative nature approach is based on the treatment and analysis of available bibliographic and documental sources. As the only land connection in the State of Roraima, and in addition to the negative impacts on the socio-environmental profile of the region, it can be concluded that the BR-174 highway has the potential to be an element facilitating the promotion of geotourism in the remote region of Amazon, contributing to the socio-environmental safeguard of this region.

Keywords BR-174 highway · Amazon · Socio-environmental conflicts · Geotourism

Introduction

Roraima, the northernmost state of Brazil located in the northern part of the Amazon, underwent several significant changes under the responsibility of the Federal Government, particularly during military administrations (the 1960s to the 1980s). The opening of BR-174 (Fig. 1), a longitudinal highway, stands out for being the only land connection between the states of Mato Grosso, Rondônia, Amazonas and also with Venezuela. Furthermore, BR-174 is the only means of terrestrial communication between the state of Roraima and the rest of Brazil. Many cities in Roraima are considered Geographically Remote Locations (GRL), which are those that are far away from cities and places where most people live and are therefore difficult to get to. Despite the significant amount of research that has been conducted since the publication of the 2030 United Nations Agenda for Sustainable Development (Sachs et al., 2019; United Nations, 2015), with the mission to contribute to solve key issues of the Planet and achieve a fair future for the world, GRL have been put aside from the sustainable development discourse. Alongside, these communities are more likely to be significantly disadvantaged by the loss of connection to the country and the limited infrastructure associated with the locations in remote areas where they reside (Hall et al., 2020; Jaimes, 1994). BR-174 played an important role in the supply of foodstuffs from Amazonas and the Bolivarian Republic of Venezuela between 1980 and 1990, as well as in the supply of imported products such as cement and limestone (Zymler, 1999). This Pan-American Road system, which starts in the United States, cuts through Central America, crossing the coast of the Pacific Ocean and part of the Andes, passing through Colombia towards Caracas (Venezuela), has a length of 975.6 km that extends from Manaus to the Brazil-Bolivarian Republic of Venezuela border.

The consolidation of BR-174, when crossing the *Waimiri-Atroaris* indigenous land in Roraima territory, resulted in serious socio-environmental conflicts in the 1970s. The highway construction process caused a series of land appropriations and deforestation in indigenous lands, resulting in an imbalance of the ecosystem and triggering a health-disease process that led to the death of many indigenous people (Amorim et al., 2019; Miele et al., 2021; Rorato et al., 2021).

Regarding deforestation in the Amazon region, specifically Roraima, there was a different dynamic, as at the time it complied with the government's determination to link a territory to other regions. However, such actions resulted in processes of forest degradation, mining, diversion of watercourses, illegal logging, and the beginning of the imbalance in the Amazon ecosystem (Nepstad et al., 2014). Despite the aforementioned factors, new cartography is evidenced over time, reflecting the recent region's economic growth (Nascimento et al., 2021). Thus, the highway became a modal that generates benefits for the citizens of the region, namely for the export market related to the timber, livestock, agribusiness, and tourism sectors (Gollnow et al., 2018; Paiva et al., 2020).

Given the territorial extension of Roraima, which is the most remote Brazilian state, integrating the triple border of Brazil, Venezuela, and Guyana, it occupies a strategic space for centralist connectivity mainly in the capital, Boa Vista, and from it its distribution to the 14 Roraima municipalities. In this sense, highways represent a relevant mobility corridor, an emergency of road communication for the tourism sector and, consequently, the use of biophysical resources (Mahato & Jana, 2021; Mehdipour Ghazi et al., 2021). From this perspective, this paper aims to

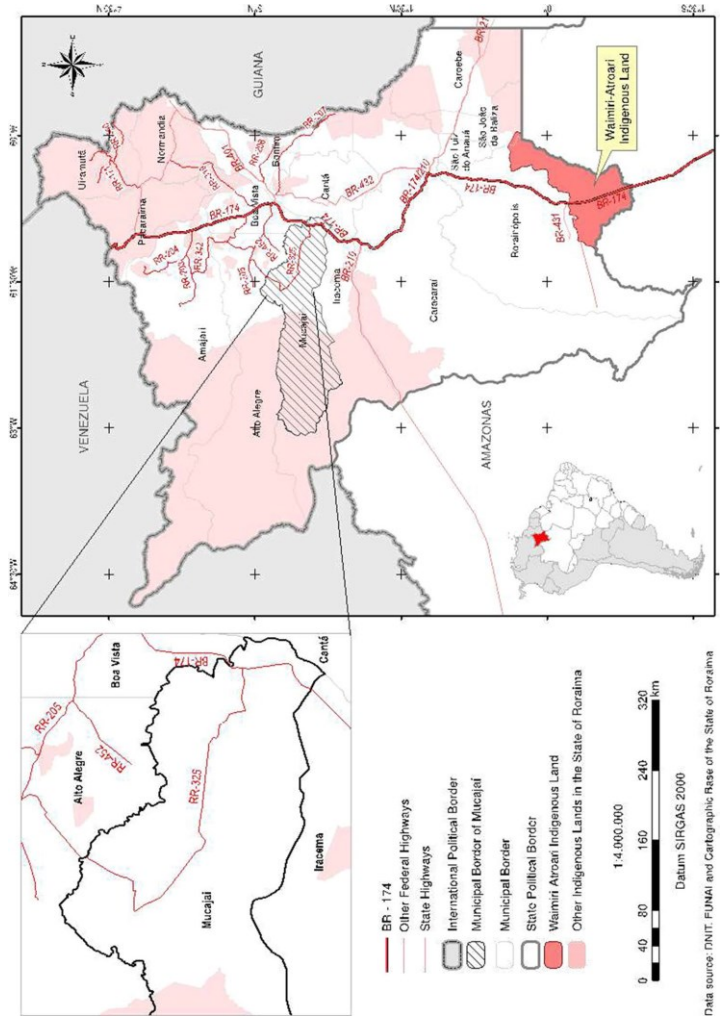

Fig. 1 Location map of the BR-174 highway with the main roads of the municipality of Mucajaí. Authors' elaboration

analyse the potential of the BR-174 for the development of geotourism, as a way of mitigating its socio-environmental impacts and connecting geographically remote regions.

The magnitude of the Amazon region and the people of the forest—geographically remote regions

Roraima holds the most extensive hydrographic basin on the Planet formed by a tangle of 25,000 km of navigable rivers, distributed over 6,925,674 km^2, of which 3,836,520 km^2 are in Brazilian territory. In this universe, the fluvial system is wide and unifies the several contiguous forest ecosystems that make up the South American Amazon, representing the most concentrated expression of life on Earth, as it contains the largest tropical forest in the world formed by a transnational complex. Among its natural resources, such as minerals, valuable woods and aromatic plants, there are also traditional communities and their respective cultures and traditions that make up a diverse socio-cultural mosaic (Bowman et al., 2021).

In Brazil, 45% of the municipalities have low levels of urbanization, 28% are considered rural, and 8% are GRL (IBGE - Instituto Brasileiro de Geografia e Estatística, 2017). Several studies reported that populations living in Brazilian GRL are neglected, presenting the lowest socioeconomic, human development and health indicators (Ranscombe, 2020; Targa et al., 2014). In these areas, geodiversity and natural resources are the main survival sources due to their potential to create employment opportunities and increase income (Veras et al. 2021a). The preservation of these recourses, and more importantly their regeneration, are crucial to move forward on a sustainable path to the GRL (Veras et al., 2020a; Wahl, 2016).

Due to the lack of transport infrastructure, the state of Roraima was awarded by the federal government, through the National Integration Program (Programa de Integração Nacional—PIN), with a budget allocation in the amount of Cr$ 2,000,000,000.00 (two billion cruzeiros) for the first stage, 1971–1974, of the construction of the highway. This endowment was also intended to connect dispersed populations and integrate them, translating into service to transport production to the centre, to value production in regional markets and also the return of industrialized products (Costa, 2020). However, the construction of the road generated, along with the economic benefits for the region, socio-environmental consequences such as deforestation, fragmentation of habitats, deaths of animals when crossing the road from one side to the other, and conflicts with the *Waimiri-Atroari* indigenous population (Nascimento et al., 2021). The concern with the demographic vacuum and the invitations by governments favoured the internal migration of people from various parts of Brazil to Roraima, resulting in the intensification of logging, hunting of exotic species, and illegal logging. On the other hand, it had repercussions on the increased accessibility of agricultural and industrial products, essential public services, such as access to education and health, and impacts arising from government programs that aimed at integrating and occupying a remote Amazon (Nascimento et al., 2021). Therefore, BR-174, like an axis of integration and sustainable development, aimed to reduce disparities (Lima et al., 2012).

The socio-environmental conflicts with the opening of BR-174

The *Waimiri-Atroari* ethnicity

Rivalry and violent aggression are common when local communities face imminent threats, such as the appropriation of land from their territory (Okeke, 2021; Sousa et al., 2020). During the execution of the BR-174 road construction project, the closed jungle region was affected. Despite the numerous pacification efforts that involved priests and FUNAI technicians in an attempt to persuade the indigenous people (IP) to withdraw from the road and thus avoid a confrontation against a large number of soldiers, the expedition to that region where the indigenous community that had a reputation as savages and cannibals were found, was understood by the IP as a sign of disrespect for customs and as an invasion of their territory. The expedition was not successful and the attempts at pacification were not effective, culminating in the execution of IP (Sousa et al., 2020). Several planes and helicopters shot down about forty-six IPs in one day. The survivors, as they attempted a peaceful approach, were met with bursts of machine

guns, decimating six villages. The remnants moved to distant regions of the Amazon. These facts were widely reported by the press in Amazonas, as if these IPs were against the development and progress of the region, distorting the history of the *Waimiri-Atroari* ethnic group (Sousa et al., 2020).

The Brazilian Army and the construction of the road

Major territorial works in the Amazon were of national interest, being carried out after the creation of the 6th Construction Engineering Battalion "Simon Bolívar" by Decree n. 63,184 on August 27, 1968, with headquarters in Boa Vista for the execution of military transport works. These works were important to take the state of Roraima out of isolation in the North and South direction and from the BR 401 to Bonfim, on the eastern border with the Cooperative Republic of Guyana. Conceived by the government of President Médice (1964–1974) to prioritize road transport, the National Integration Plan in the year 1970, with the motto: "Integrate so as not to Hand over" allowed for an occupation front in the Amazon. Within the portfolio, the plan prioritized the construction of the Transamazônica, meeting geopolitical strategies and the flow of wealth, expanding the agricultural frontier with the concept of living frontiers in the northern portion, a very important step toward the consolidation of the South American road network and the Pan-American highway system of Brazil, Venezuela, Uruguay, Argentina and Paraguay (Gill, 2021; Pavani and Mattioni 2020; Lima et al., 2012).

As a vital artery for communication and the flow of people and goods, the highway increased significantly and enabled the emergence of agglomerations around it, such as the Village of the National Institute of Colonization and Agrarian Reform, which directed migrants to the lots. In Vila Novo Paraíso, at the junction of the BR-210 and BR-174 roads, is where the first gas station known as the Quinhentos gas station appears, this name for being exactly at Km 500 of the BR-174, area in which many camps of the 6th Engineering and Construction Battalion and companies that worked on the stretch that headed towards the city of Boa Vista, capital of Roraima, settled (Monteiro and Laroque 2014; Neto, 2016; Oliveira et al., 2021).

The environmental impacts of BR-174 construction

The construction of road networks threatens many natural habitats of high conservation value, especially in tropical and remote regions. Although these highways promote communication among these regions and reduce physical barriers among people, the truth is that they bring negative consequences for ecosystems, translating into more severe impacts such as fires, soil erosion, landslides, and accumulation of sediments in the rich waters, as first-order rivers. During road construction, forests are cut, involving the felling of trees in corridors much wider than just the trail adjacent to the forest (Phillips et al., 2021). In the case of the Amazon, the massive opening of roads in the 1960s and 1970s provided access to loggers who, with their forestry tractors and chainsaws, gave place to the beginning of cattle raising and agriculture in the interior of the forest. Such environmental exploration, with contours uncontrolled and driven by the associated profit, will take about 75 to 100 years to be recovered (Johns et al., 1998).

Studies show that road construction with forest clearing has implications for carbon flux, such as necromass, i.e., all woody biomass contained in non-living parts in mineral or organic environments, an important component of the regional carbon cycle for mature tropical forests such as the case of the Amazon (Fearnside & Laurance, 2003; Feldpausch et al., 2005). Part of these areas was deforested for logging, some were converted into permanent public roads with a subsequent influx of biological invasions, and there is an increase in hunting pressure and the proliferation of shifting agriculture (Kleinschroth & Healey, 2017). In this context, it is worth remembering that to guarantee the sustainability of the forest, it is essential to also safeguard the conservation of game species, i.e., animals that are in natural freedom, therefore, guaranteeing the subsistence of millions of individuals in Nature and, thus, sustaining current lives and future ones (Oso & Babalola, 2021).

Geotourism as an interpretation of heritage today

Geotourism has as its anchor geoscience, whose contribution is critical to delivering the SDGs (Gill, 2017; Gill & Smith, 2021; Scown, 2020), particularly in GRL areas of the planet, where natural resources

are dominant (European Commission, 2021). Within the geosciences field, the geotourism activity aims for the conservation and protection of Nature, with more emphasis on the current Anthropocene era (Crutzen & Stoermer, 2000; Hose, 2006, 2012). Several studies contributed to share the geomorphological profile of regions around the world where geotourism represents an alternative to local communities' income (Dowling, 2014; Dowling & Newsome, 2018; Hose, 2011; Štrba et al., 2020; Veras et al., 2021b).

Public policies for tourism in Brazil are prepared and monitored by the Ministry of Tourism. A national effort has been made regarding the implementation of state tourism bodies, forums or tourism councils as a strategy to compose the Brazilian Tourism Map (Chaves & Secchi, 2022). However, in some Brazilian states, tourism is not considered a strategic priority for development, impacting the effective alignment of national public policy on tourist regionalization.

Geotourism is an activity not yet officialized by the Brazilian government regarding the economically classified segments. Therefore, a specific political instrumental on geotourism activity is missing. Nevertheless, some guidelines can be found at Law no. 6.938/1981 (Brazilian Federal Republic, 1981) which establishes the National Environment Policy and is considered the ground zero of environmental awareness. Concomitantly, the National Environment Council (CONAMA) (Brazilian Ministry of Environment, 2020a), a body created in 1982 of an advisory and deliberative nature of the National Environment System (SISNAMA) (Brazilian Ministry of Environment, 2020b), and supported by Article 4 of Law no. 9.985/2000 (Brazilian Federal Republic, 2000), is intended for the preservation of natural ecosystems. CONAMA was at the origin of the National System of Conservation Units (SNUC) (Brazilian Ministry of Environment, 2020c) and, among its objectives, it ensures the protection of the forms and processes supporting biodiversity. Administratively, the environmental legislation establishes the conditions, constraints and environmental control measures that must be obeyed by the entrepreneur, individual or legal entity to locate, install, expand and operate projects or activities that use resources considered effective or potentially polluting or those that, under in any way, may contribute to cause environmental degradation.

From north to south, the BR-174 route is almost entirely straight and in some stretches, it has curves marked by a vegetation cover of dense forest, savannah with bush vegetation, grasses, and small trees, grading to the relief of elevations ranging from 50 to 1,000 m (Veras et al., 2020b). The surroundings of BR-174 are a special area for the development of geotourism. It appears as an alternative for the preservation and safeguarding of natural heritage as a global practice. In the last fifteen years, geotourism has registered different interpretations of geo-objects and geo-heritages, turning to the understanding of places through a sustainable educational practice where local communities are the main agents of change (Matshusa et al., 2021).

In South Australia and Africa's GRL, their territories include ecological landscapes and indigenous histories that are protected and guaranteed in the Venice Charter published in 1964 (Torre, 2013). The processing begins with the choice of a place that should be the target of protection and conservation of its heritage for future generations, whose principle is in line with the United Nations Educational, Scientific and Cultural Organization (UNESCO), the International Union for Conservation of Nature (IUCN) and with the International Study Center for the Conservation and Restoration of Cultural Property (Lewis, 2020). Such examples should be taken as good practices to be replicated in similar contexts, namely in the GRL in the Amazon, being a challenge for the practice of geotourism, with a need for amenities to attract geotourists, since it is currently one of the activities with exponential growth, dynamic, which continuously interprets and reinterprets geological heritage (Mehdipour Ghazi et al., 2021).

Material and methods

Characterization of the research area

The studied area passes through the state of Roraima from North to South through the terrestrial modal that integrates the road course and promotes regional and national connectivity, linking the capitals of Manaus-AM to Boa Vista-RR. Finally, being paved in 1996, BR-174 crosses the municipalities of Rorainópolis, Caracaraí, Iracema, Mucajaí, Boa Vista (capital), towards the municipality of Pacaraima, on the border with the Bolivarian Republic of Venezuela. The climate for the region is the humid tropical type, with

the rainy season in the summer and dry in the winter, with average annual precipitation ranging between 1,750 and 2,075 mm annually and an average temperature of 27.4 °C and monthly mean variation intervals between 23.4 and 32.4 °C (Alvares et al., 2013). The municipalities of Rorainópolis, Caracaraí, Iracema and Boa Vista have soils in Hidromorphic Quartzous Sand. The municipality of Mucajaí follows the taxonomic unit of Red-Yellow Latosol, Neossol, Plinthosol, Gley Soil, Argisol, predominantly the Red-Yellow Latosol (Gama, 1983). The region's relief is formed by extensive flat surfaces, ranging from smooth to wavy, with the presence of Inselbergs and Bolders (isolated or grouped reliefs) that reach altitudes ranging from 80 to 160 m. Such singularities are formed by acidic volcanic rocks. In the Midwestern part of the Central Guyana Domain (CGD), there are high bands of metamorphism that carved gneiss rocks with altitudes ranging from 100 to 250 m (Holanda et al., 2014). The mosaic for this extension is formed by several forest formations, rainforest, flooded areas (*igapós* and floodplains), in dry land surface, with open areas in which the presence of *buritizais* is significant (*Mauritia fleuxuosa*). In this context, the highway with a road body is inserted, consisting of straights and curves, and has the signalling infrastructure and logistics to support the visitor who travels along the road.

Research strategy

The qualitative approach is based on the treatment and analysis of bibliographic, cartographic, and document sources available for the interpretation of the object under analysis – the construction of the BR-174 and the socio-environmental conflicts arising from it. The qualitative procedure is usually challenging, as it offers a deeper understanding of the content, it is complex, especially in the case of the object under study being the only land connection in the State of Roraima, in addition to the impacts on the socio-environmental profile of the region (Krippendorf, 2018).

For the composition of the cartographic products, the Geographic Information System (GIS) and ArcMap software version 10.3 were used, with the geographic cartographic projection (South America), central meridian – 62° and reference geodetic system: SIRGAS 2000. The cartographic scale used was: 1:4,000,000 from IBGE and INCRA for settlement projects. The vectors were used for the composition of the BR-174 highway, for indigenous lands and the continuous cartographic base of the State of Roraima on a scale of 1:100,000.

Results and discussion

BR-174, the only land road in the region, provides the traveller with a unique itinerary in the Northern Amazon, highlighting the route in which it is possible to combine the history of construction with the exuberant geotouristic landscapes, in addition to providing an ethnocultural experience when crossing the *Waimiri-Atroari* territory on Roraima territory.

Deforestation and its repercussions

With the increase in deforestation, there is an increase in the temperature of the Atlantic Ocean and droughts in the states of the North region, as a result of the increase in biomass (Sousa et al., 2020). Although at the time no legislation required action in the face of such crimes against the ecosystem, such an event was necessary for the integration of the population that was without a land connection. Such deforestation had repercussions on the quality of living beings in local habitats, in addition to contributing to the aggravation of climate change. On the other hand, the territory of the *Waimiri-Atroari* was shaken by noise, burning, and felling of trees, suffering a decline in ecosystems since the 1970s (Mahé et al., 2021; Wright et al., 2021).

The settlement projects were created by the National Institute for Colonization and Agrarian Reform (*Instituto Nacional de Colonização e Reforma Agraria*-INCRA), contributing to the occupation of the great Amazon void by migrants. Between 1970 and 1980, INCRA allocated 221.8 ha of land, an area with the capacity to receive up to 3.4 thousand families, and thus consolidated municipalities such as Rorainópolis in a total of sixty-seven settlement projects, benefiting a total of twenty-two thousand families, being considered one of the greatest anthropic pressures in the balanced landscape (Fig. 2).

The deforestation that took place led to disastrous consequences for biodiversity and geodiversity, areas that were later transformed into pastures for cattle, as

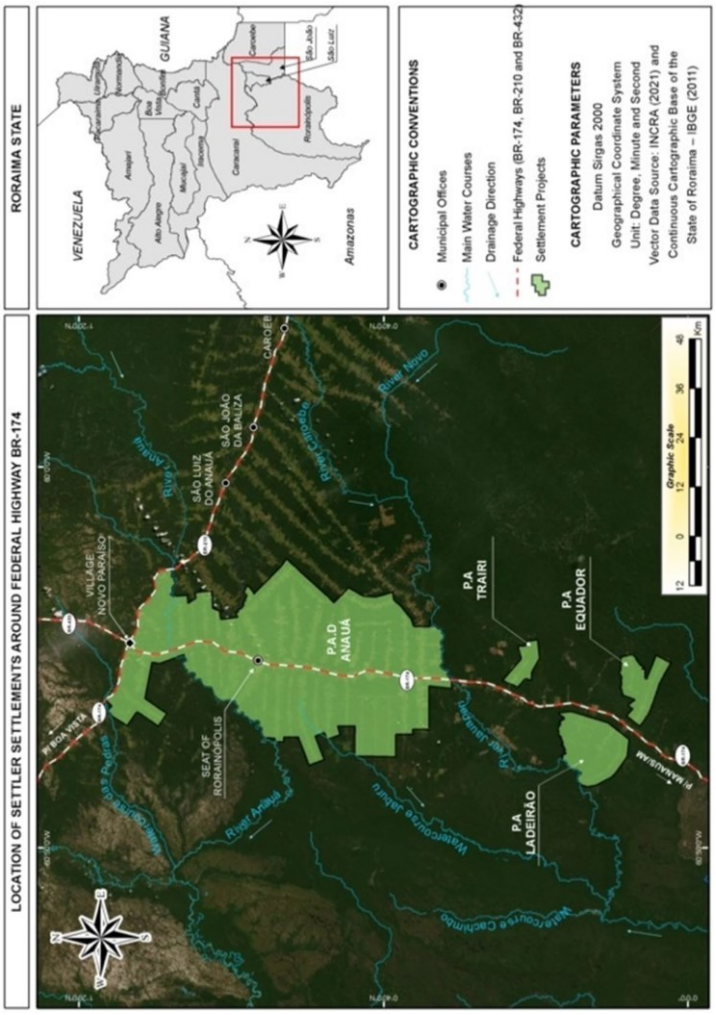

Fig. 2 Location of the Anauá Directed Settlements around the BR-174. Authors' elaboration

a trend for these areas as food support for the exploitation of beef and dairy cattle. The agricultural sector registers the breeds created by genetic similarity and resistance to ecotoparasites: Crioula, Guzerat, Gir, with the municipality of Mucajaí having the largest number of heads today, a favourable factor due to its geographic location.

The construction of the highway and favourable horizons for geotourism

The BR-174 Highway is commonly referred to in travel contexts. Its route passes through sparsely populated areas or wild areas suitable for outdoor living. Its potential goes beyond the social and economic aspects, found in its environmental aspects, and after its asphalting, a factor that promotes the development of tourism and geotourism, materializing in the establishment of companies that provide tourist services in the surrounding areas in the directions Manaus-AM to Boa Vista, as a tourist distribution centre.

Infrastructure and highway projects bring together many stakeholders, crossing different and sometimes contradictory political, social, economic, and cultural views. The BR-174 highway can be considered one of the main achievements in the history of the state of Roraima. From there, the visitor has the opportunity to explore the neighbouring roads, which are roads that connect to the villages. The consolidation of the highway allows for exploration and experience of the deeper Amazon, contacting unique scenarios in Roraima territory, in the first image the beginning of the opening of the road in the predominant forest ecosystem km 180, the second image already at km 200 shows compaction of landfill and natural aggregates suitable for traffic under the climatic conditions of the Amazon.

The unmistakable connection of the BR-174 highway boosted internal and international integration to contemplate the landscape, with the dominant green of the forest, plains, and savannah areas. BR-174 provides vertical signage and a shoulder area for services to visitors from all major capitals (Table 1).

Once the relevance of the BR-174 highway has been recognized, the landscape presents itself with its majesty and includes infrastructure to support the geotourist, so that he or she can get on and off along the road. Complementing the list of tourist services available to geotourists, there are hotels, motels, local guides and conductors, mechanical assistance, convenience stores, mini-market, tour package sales agency and the host community represented by native and non-native people.

As a legacy of past generations, but also a legacy for the coming years, the geotourism activity can contribute not only to the sustainability of Amazon but also to the identification and enhancement of persistent environmental issues, thus promoting policies to safeguard the humanity's common goods (Hall & Saarinen, 2010; Vieira, 2014). Furthermore, it is an activity that brings socioeconomic benefits through the sustainable use of geological structures and unique landscapes (Mikhailenko & Ruban, 2019; Veras et al., 2020a; Wu, 2013). It allows to register processes, aesthetics, natural beauty and local culture for sustainable planning, anchored in the opportunities and limitations of best practices (Maghsoudi et al., 2019; Shekhar et al., 2019; Tourtellot, 2016).

It is worth noting that a sustainable geotourism plan can define strategies for living in harmony with Nature, in common with the participation of the local communities, thus allowing to point out the best practices for safeguarding both the natural and cultural resources, in addition to observing the carrying capacity (Veras, et al., 2021a, 2021b) of specific regions towards sustainability (Assante et al., 2012). GRL can be considered as potentially touristic areas, thus offering a specific geotouristic destination that will depend on the available potential recreational and environmental security in forests, ski slopes, lakes, rivers, mountains or golf courses, where it is possible to contemplate the highlighted physiographic characteristics, and where the right to enjoy a healthy environment is also considered indispensable (Balaguer & Cantavella-Jordá, 2002; Hall & Saarinen, 2010; Ogunmola & Daniel, 2020). The geotourism approach is anchored in the local culture and supports and enhances the identity of the territory, being crucial in advancing the SDGs.

The involvement of local communities in all geoconservation actions, integrating the geotourism activity as a whole, could be an interesting strategy for a co-management of geosites in GRL, with mutual gains for the environment and the society, also contributing to improve the resilience of the communities (Tavares et al., 2015). Alongside this, is also necessary to develop synergies between municipalities and regions since these spaces of

Table 1 Distances from Boa Vista (capital of Roraima) to the main Brazilian cities and neighbouring countries

Roraima-North of Brasil	Capital	Distance (Km)*	Distance (Km)**	Bordering Country with Roraima (Km)	
				Venezuela- capital: Caracas	Guyana-capital Georgetown
Boa Vista, using BR-174* Mucajaí, using BR-174**	Manaus	783	731	1.582	641
	Belém	1.435	1.384		
	Porto Velho	1.620	1.569		
	Rio Branco	2.182	2.131		
	Macapá	2.293	2.242		
	Goiânia	2.503	2.452		
	Campo Grande	2.668	2.617		
	Palmas	4.357	4.306		
	Vitória	3.397	3.346		
	Salvador	3.014	2.963		
	Fortaleza	5.099	5.048		
	São Paulo	3.306	3.255		
	Belo Horizonte	3.119	3.068		
	Brasília	2.501	2.450		
	Rio de Janeiro	3.434	3.383		
	Porto Alegre	3.792	3.741		

geodiversity can integrate different municipalities and states, which implies a necessary shared sustainable management vision (Castro et al., 2016). The development of these visions aligned with geotourism activities should assure that no power relations between all actors involved, which is a key question regarding the role of this activity to mitigate socio-environmental conflicts. In this sense, the local sustainability framed by geotourism must go far beyond the benefits to the communities involved, and integrate their voices and culture into the activity design process.

Conclusions

The consolidation of BR-174, and the entire process related to its implementation, brought about a set of significant changes in the region's panorama. Despite the socio-environmental conflicts identified, which reveal deficiencies in intercultural communication and the inexistence of mediation practices, the truth is that the highway helped to relocate the state of Roraima and the GRL on the map of Brazil. Alongside, the benefits that such transport infrastructure has had in improving the living standards of local populations and in the communication link of many small and medium-sized Amazonian cities should be highlighted. The efficient management of these highways requires planning of services, and the provision of services must guarantee economic compensation for the citizen involved.

Geotourism can act as this compensation, encouraging citizens to recognize and promote their wealth and the feeling of belonging to a particular place. On the other hand, through its knowledge, it enhances the gain of financial resources, in addition to contributing to the conservation of geodiversity. Therefore, it is concluded that the activities that have emerged around the BR-174 highway are essential tools, when properly planned, contributing to the reduction of environmental risks, helping to preserve geodiversity and enhancing the value of endogenous products.

The transformations of geotouristic spaces stimulate knowledge about the Amazon region, boosting sustainable practices combined with a logic of mimicry, subsidizing sustainable businesses, and using the knowledge of the indigenous culture of the *Waimiri-Atroari* and non-indigenous communities about landscapes, empowering the Amazon region.

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Declarations

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CAPÍTULO VI – Construindo pontes entre os povos indígenas e a atividade geoturística: o caso da etnoregião da Raposa em Roraima, Brasil.[6]

No Capítulo VI tratou-se de duas etnias que habitam territórios indígenas, tendo em vista seu afastamento geográfico, no entanto, são impulsionadores de cultura singular e são considerados os guardiões das florestas convictos por suas visões sagradas, e.g., a geodiversidade de grande magnitude para aqueles que habitam planaltos bordejados de serras e morros entendidos como ambientes veneráveis. Os Macuxi dominam as técnicas de artesanatos, agricultura e conhecem as melhores épocas de contemplação para visitação geoturística.

Os Yanomami preservam a sabedoria vital de gerações que viveram em harmonia com a natureza. Essas etnias são respaldadas por instrumentos normativos para apresentar propostas de planos de visitação turística. A sensibilidade pelas lentes desses povos soma-se aos ODS. O ODS 1 prioriza acabar com a pobreza, o ODS 15 apoia a preservar a vida terrestre, e o ODS 17 apoia e reconhece o direito tradicional em suas terras e aos recursos. Enfatiza-se a contribuição da primeira autora participação na parte escrita compondo-se de metodologia, recolha de dados em instituições oficiais públicas e privadas.

[6] **Veras**, A.S.S., Vidal, D.G., Barros, N., Dinis, M.A.P. (2022**). Building Bridges Between Indigenous Peoples and Geotourism Activity: The Case of the Raposa Ethnoregion in Roraima, Brazil**. In *Indigenous Methodologies, Research and Practices for Sustainable Development* (pp. 355-370). Springer, Cham. https://doi.org/10.1007/978-3-031-12326-9_21

Building Bridges Between Indigenous Peoples and Geotourism Activity: The Case of the Raposa Ethnoregion in Roraima, Brazil

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Abstract The state of Roraima in Brazil registers a significant number of Indigenous People (IP), distributed throughout a diversity of ethnoregions. Among them, the municipalities of Amajari, located near the region of the riverbed of Baixo Cotingo, and in the upper Ajarani River, stand out. These IP include the ethnic groups of *Macuxi, Ingaricó, Taurepang* and *Wapixanas*, which together aggregate a culturally well-developed contingent. In the municipality of Mucajaí lives another IP community, the *Yanomami,* recognized as the most isolated IP from South America. These communities live in two regions with potential for geotourism activity: the Extreme North Tourist Region of Brazil, covering an environment which is extremely rich in diversity of landforms, such as hills, plateaus, and valleys, and the Roraima Tourist Region in the Amazon Savanna forests. The objective of this research is to present the *Macuxi* and *Yanomami* communities in the region, which are engaged with ethnic tourism activities, highlighting their skills in promoting sustainable tourism management, namely geotourism. The methodology is qualitative exploratory, based on literature and document research in the division of ecotourism in the Mucajaí State Department for Planning. This review work was carried out from June to August 2021. Among the distinct realities relating to the environment, the results indicate that the IP from the Raposa Serra do Sol Indigenous Land feel the need for training

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to better understand how to welcome the tourist, and, thus, attend the requirements of the Normative Instruction n. 03/2015, which establishes norms and guidelines regarding visitation activities for tourism purposes in indigenous lands (IL). The *Yanomami* indigenous community also seeks partnership with institutions, either under the form of events, workshops or meetings to conceptualize and carry out strategies allowing to structure the geotourism activity. Accordingly, tourism workshops were implemented, aiming to attend the planning and development of indigenous community tourism to offer a unique tourist experience, thus contributing to build bridges between the indigenous communities and the geotourism activity, in a broader context of the concept of sustainable development.

Keywords Indigenous peoples · *Yanomami* · *Macuxi* · Nature-Society Relations · Geotourism · Roraima

1 Introduction

There are between 370 and 500 million Indigenous People (IP) worldwide, in over 90 countries (The World Bank, 2021). According to the "The Indigenous World 2020" report (Mamo, 2020), IP represent 5% of the global world population. However, the same report states that they account for about 15% of the extreme poor, along with a life expectancy up to 20 years lower than of non-indigenous people worldwide. Despite these vital inequalities (Therborn, 2006), IP hold ancestral knowledge, transmitted from past generations and justified by living side by side with nature (von Seggern, 2021), crucial to learn how to live in balance and harmony with the natural ecosystem cycles. The need to respect and to live according to nature is part of the United Nations 2030 Agenda philosophy (United Nations, 2015), translated in the Sustainable Development Goal (SDG) 15, Life on Earth. The protection of the forests is crucial because it represents a vital resource from which about 1.6 billion people worldwide depend for subsistence. In this context, in addition to fostering new sustainable activities in which geotourism is part of, SDGs are globally linked to facilitating economic means and benefits that cover ethnic groups, since indigenous knowledge constitute valuable and dense inputs that act as a lens from the perspective of sustainable development (Newsome & Dowling, 2018; Santafe-Troncoso & Loring, 2021; Souza et al., 2021).

Located in the littoral-east coast of South America, Brazil is a country with a significant number of IP, more than 734,000 people. Among these are people who have recognized themselves as indigenous, mainly in the country's urban areas (IBGE - Instituto Brasileiro de Geografia e Estatística, 2010; The International Work Group for Indigenous Affairs (IWGIA), 2020). IP have rights guaranteed by the Brazilian Constitution of 1988 regarding the soil, lands and its territories (Supremo Tribunal Federal, 2020). IP live in demarcated and preserved areas, representing a significant strength to the culture and beliefs within their communities. Thus, ancestral knowledge anchored by IP may pave the way for more sustainable growth in the

context of tourism and heritage safeguard (Santafe-Troncoso & Loring, 2021; World Tourism Organization, 2019), with implications in poverty and subsistence of these communities.

Roraima, the northernmost Brazilian state, comprises one of the largest indigenous populations in the country, estimated at around 55,922 people, distributed through 46,505 hectares (IBGE - Instituto Brasileiro de Geografia e Estatística, 2010). The same source confirms that these Indigenous Lands (IL) represent 83.2% of the region and households, dispersed in two ethnic groups or linguistic trunks, the *Macro-Jê* and *Tupis* that unfold into *Ingaricô* and *Macuxi*, with *Macuxi* being the largest ethnic group. There are also the *Patamona*, *Taurepang*, *Waimiri-Atroari*, *Wapixana*, *Wai-Wai*, *Ye'Kuana* and *Yanomami* (i.e., semi-nomads of Tropical Rainforests) IP that have developed specific forms of relationship with the natural environment (Bortolon, 2014; Niewöhner et al., 2021).

Geotourism is considered a segment of tourism based on information on geological and geomorphological attractions, valuing the integration of the citizens' knowledge to promote the sustainable development of a specific region (Dowling, 2014; Dowling & Newsome, 2005; Hose, 2006; Veras et al., 2020). In this sense, IP are guardians of a natural heritage, offering opportunities to promote attitudes towards sustainability (Satapathy & Bhattacharya, 2021). Aligned with the need to protect the natural heritage, treaties with the mission to defend goods of interest to humanity and to raise the local citizen awareness on sustainability patterns to preserve recognized sites in indigenous communities are welcome (Matshusa et al., 2021). Thus, considering the Roraima state reality regarding the significant diversity of IP, this chapter aims to present the *Macuxi* community from the Raposa region in the Raposa Serra do Sol Indigenous Land, which already taking advantage from the ethnic tourism, as well as the *Yanomami* indigenous community, from Maturuca indigenous land, highlighting the IP skills for the promotion of sustainable tourism management, in particular geotourism. In this work, the *Macuxi* and the *Yanomami* were selected due to their culture and geoecosystem richness, which acts in favour of the geotourism activity. Considering this scenario, the research will present the *Macuxi* and *Yanomami* communities that already work with ethnic tourism, highlighting their skills in promoting sustainable tourism management, namely geotourism.

2 Methodology

2.1 Study Area

Two IP were addressed in this research: the *Macuxi*, who inhabit the Raposa Serra do Sol IL located in the North of the State of Roraima, in a region that occupies 7.5% of the soil in Roraima, and the *Yanomami* from Maturuca IL (Fig. 1). In these IL, the ecological vegetation composition is made of savanna, locally known as *lavrado* and, for the *Yanomami* region, the environment is characterized by a forest system

and extensive plains interrupted by hills and mountains with varying altitudes of 200 to 500 m, as well as the existence of floodplain areas (Morais & Carvalho, 2015). The area is favourable to agriculture (i.e., cattle raising, *Oryza barthii* rice growing, *Zea mays* corn crops, and *Vigna unguiculata* beans) also rich in gold, diamonds and cassiterite, which has been attracting miners clandestinely exploiting these deposits in indigenous areas (Aleixo et al., 2020; Alonso, 2013; Oliveira, 2020).

In this nook, the geological and geomorphological ecosystem groups were shaped by erosional flattening and chemical weathering processes linking the Roraima Group's hill and the mountain ranges to this landscape, which generated acidic and dystrophic soils used by this group (Holanda et al., 2014; Schaeffer et al., 2018).

Raposa Serra do Sol IL experienced a territory demarcation process in 1977, characterized by a long political and judicial battle (Alonso, 2013). This immense area of 1678,800 hectares is occupied by the IP of the *Macuxi, Patamona, Taurepang, Wapixanas* ethnic groups, illegal farmers and squatters. This political and judicial battle ended in 1996 and all contestations were concluded by the Federal Supreme Court, which gave victory to the IP (Yamada, 2008). The full right of traditional occupation refers to the territory, which characterizes IP as the first inhabitants depending on the land. It includes the right to use land and natural resources under their IL tenure systems, as well as the natural role in protecting nature (Supremo Tribunal Federal 2020). The rights of grouped IP to land also encompass economic, social, cultural, civil and political, individual, collective, and development rights (Okeke, 2021). Therefore, these lands may have particular uses, including the tourist activity

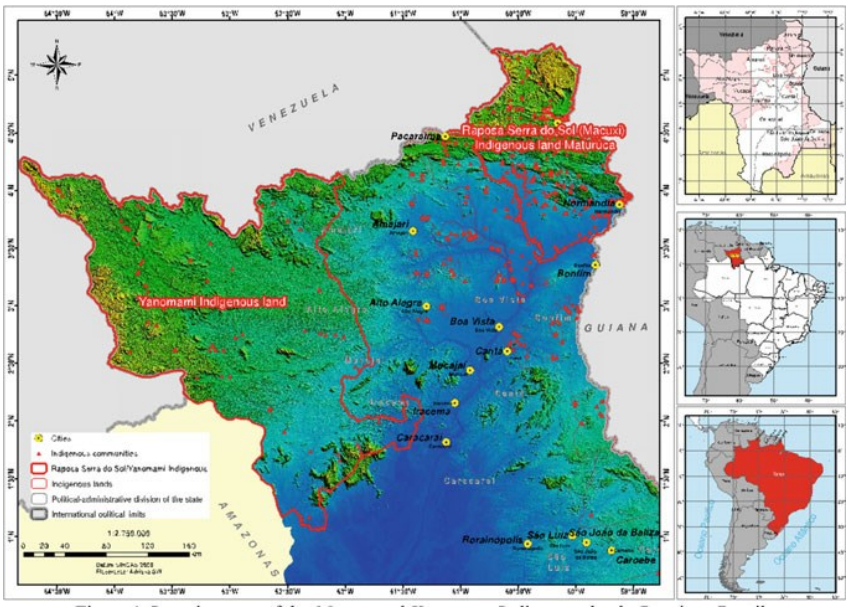

Fig. 1 Location map of the *Macuxi* and *Yanomami* indigenous lands, Roraima, Brazil

use, as long as satisfying the premises for operationalization and comply with the Normative Instruction n. 03/2015 and Law n. 11,771 (Presidency of Republic of Brazil, 2008).

Funai (2021), local institutions and indigenous women who care for the environment have been acting as supporters of the Yanomami ethnic group in the initiative to work with tourism, in a coalition force that brings together various actors around a sustainable project, discussed and submitted in March 2020. The first tourism model, whose protagonists are the managers of the business in their territories, the Yanomami themselves, will provide various services such as guides, porters and cooks. Indigenous women are also involved in the project, according to their President, Floriza da Cruz Pinto (Brasil. Ministério do Meio Ambiente, 2020).

The previous belief that IP should only live in the forest has changed. On the contrary, most national policies in Latin American countries, recognizing the indigenous person as the manager of natural resources and valuing ecological knowledge, triggering various actions, as in the 1980s Venezuelan environmental scientists, considering the Yanomami IP, asked the government to establish a National Park and a joint indigenous area for Yanomami who migrate to lands in the neighbouring country. These actions are supported by the UNESCO Man and the Biosphere Programme (UNESCO, 2020). In Brazil, the lands of the Yanomami ethnic group were recognized as official collective rights. The protection of their lives and survival and other activities, including tourism, through Decree n. 780, on May 15, 1992 (Presidência da República do Brasil, 1992), marks a breakthrough.

2.2 Research Methodology

This research is based on a qualitative exploratory approach to address indigenous communities and describing them in relation to the characteristics of their territories and local manufactured products and goods attracting the tourists. A literature analysis was carried out through journal articles, official websites and document research on the ecotourism division of the Roraima State Department for Planning in Brazil. This review work was carried out from June to August 2021.

Privileged information was obtained from the known Brazilian specialist Enoque Raposo—interlocutor and head of the Ecotourism Division GER/SEPLAN, author of a technical report produced in the Raposa Serra do Sol I Indigenous community (TIRSS)—a clay pot producer centre and an area to operate tourism at a professional level in the near future. Data from the analysis of the Tourist Visitation Plan process with the National Indian Foundation (Funai, 2015) was obtained from the Regional Coordinator of the National Indian Foundation (Funai) in Roraima. Regarding the indigenous names used in this chapter, they were transcribed as suggested by previous works from Barra (2020) and Senra (2020). For the production of the map, the Software ArcMap version 10.3 was used for the geographical cartographic projection (South America), central meridian -62º geodetic reference system: SIRGAS 2000.

The vectors used are IL available at the Funai website (Funai, 2021) and the cartographic base of the State of Roraima, scale 1:100,000, was downloaded at IBGE (2021). A numerical model of the Shuttle Radar Topography Mission (SRTM) shaded terrain was used.

3 Results and Discussion

Roraima is the state with the largest number of IP in Brazil, with more than 25,700 inhabitants. The ethnic groups in this area are: *Wapixana*, *Jaricuna*, *Taulipáng*, *Ingaricó*, *Waimiri*, *Atroari*, *Mawayána*, *Yanomami*, *Wai-Wai*, *Karafawyana*, *Yekuana* and *Makuxi* (Mamo, 2020). These ethnic groups represent a cultural diversity through the criteria of kinship and religion (i.e., cosmovision, the worldview). In this aspect, the worldview in the indigenous world is rooted in the places, in the houses where IP were born (i.e., emergence houses, houses of transformation, in the depths of the land, water and forests, in animals (Fakudze, 2021). IP share the territory, language, irrefutable physical differences and are responsible for the possession of a large geographical area, such as the *Macuxi* ethnic group who inhabit the valley of the Uraricoera River, the TIRSS territory. These IP make up a total of 72% in this region (Fleuri & Fleuri, 2018; Schröder, 2003; Silva, 2019; Spies, 2020). *Macuxi* are transnational people for geographical reasons, as they inhabit part of the Cooperative Republic of Guyana, in the basin of Rio Branco and Rio Rupunini, in Roraima. In Brazilian territory, namely in Roraima, the occupied area is divided into Raposa Serra do Sol IL, São Marcos IL (a large part) and the isolated Amajari and Alto Cauamé (Spies, 2020) lands.

3.1 The Macuxi

Embodied in traditional knowledge about nature, the behavior of this ethnic group is based on the best season for tourist activity, considering then about the animals (i.e., the best time for hunting and fishing; in which the flora season is visibly appreciable with fruits and flowers and it is worth mentioning the buriti vegetable as a resource widely used in the making of buildings, costumes for typical celebrations such as parixara dance and other typical manifestations, in the production of handicrafts such as basketwork; moment and ritual for the collection of clay. Despite the easy access to industrialized materials, this ethnic group (i.e., indigenous people) does not despise the abundant resources, IP dominate deep traditional knowledge linked to biodiversity and a vast knowledge about the land, sustaining a strong relationship with nature and influencing the innate responsibility for preservation, therefore, one can associate sustainability. As the largest population with about 22 thousand represent the majority of the Macuxi population and of this universe, about 53% are in IL, these IP are valuing the Macuxi language that belongs to the Karib trunk (i.e., spoken

in the North and Central region. Western Brazil, Bolivarian Republic of Venezuela, Cooperative Republic of Guyana, French Guiana, Suriname and part of Colombia. In strengthening the Macuxi language, the first Intercultural Licentiate course of the Insikiran Nucleus was implemented by the Federal University of Roraima as an incentive to train indigenous teachers, therefore it is a favorable bias in several areas in conducting tourist activities of preparation to receive the tourist in a moment of experience and immersion and musical rhythm known by the generic designation of forró, in addition to itineraries where the tourist gets to know the stories, legends, cuisine and indigenous drinks, the natural attractions await the tourist to discover waterfalls and bathing in a rejuvenating freshwater lake these activities are autonomously active in accordance with current legislation (Braga and Bethonico, 2018).

3.2 The Yanomami

The *Yanomami* IP are characterized by high mobility in ecosystems, a cosmovision stems from the understanding that the Earth is central for these IP and goes far beyond the simplistic representation of the environment elements, i.e., plants, animals, air and moon. According to the indigenous leader representing the *Yanomami*, Davi Kopenawa, stating "I am the man (i.e., shaman) of the forest and I defend my people and nature, I eat *Bertholleta excelsa*, *Mauritia flexuosa*, everything we need to live well", it is clear the strong bond between these IP and mother earth, since for the *Yanomami* everything is interconnected with invisible beings in the eyes of the *pajés* (shamans) (Kopenawa & Davi, 2015).

Isolation in *Yanomami* is called *moxihatetea*, a particular behaviour of this aloof and reclusive South American ethnic group, living in footpaths in Northern Brazil and Southern Venezuela, where they have been cultivating for over two hundred years in gardens (i.e., called *roça*–farm), plantain (*Musa spp*), sweet potato (*Ipomoea batatas*), cassava (*Manihot esculenta*), *buriti* (*Mauritia flexuosa*), and *açaí* (*Euterpe leracea*), and they feed on small animals such as howler monkey (*Alouatta guariba)*, *pacu* fish (*Piractus mesopotamicus*), wild pig and/or peccary (*Tayssu pecari*), curassow (*Mitu tomen*) and other species. Therefore, to understand the territoriality of the *Yanomami*, and despite the contact they have already made with urban society, it is important to understand thar they still did not develop strategies for food stocking. Their hunts are made at 1 km from the collective house (i.e., village or multifamily house) called *yano* or *xapono*, to avoid the depletion of hunting resources.

Agriculture was intensified in the last decades to observe edaphic conditions (i.e., not to tire the land) as a means of considering local water availability. This relationship with the land is very respectful to a sustainable culture, as described by Melo et al. (2010). In this complex web, the *Yanomami* plant crops such as fruits, roots and collect seeds in addition to fishing and hunting (Albert & Le Tourneau, 2007; Goulart, 2020). Currently, the *Yanomami* ethnic group is part of the cultural mosaic in the Maturuca IL. The pieces they made of fibre are available in virtual stores and can

be found in the Përi si book (Yanomami et al., 2019). The mentioned work explains the fungus that *Yanomami* women use in making basketry. This practice resulted in intercultural research produced by the Socio-Environmental Institute. The work is part of the *Saberes da Floresta* series (i.e., Knowledge of the Forest) and had the collaboration of researchers from the National Institute for Amazonian Research. The innovation of this work made by women is the use of a very strong fabric thread produced by a Përi si fungus. It is a rhizomorph structure, with a morphology similar to a mushroom, but which cannot be eaten, proliferating among the fallen leaves and rotten wood in the rainforest litter.

3.3 Initiatives in Favour of Tourism in the Macuxi *and* Yanomami

In the IL of *Macuxi* and *Yanomami*, the tourism activity is still emerging. However, to reach a desirable sustainable economic level, some initial steps are needed. In this context, some previous initiatives were conducted in the region in the last twenty years. The genesis of this movement in the community occurred in 1998 when the *Macuxi* ethnic group experienced the first workshop of the National Program for the Municipalization of Tourism as a way to encourage cultural recovery, understand tourist concepts and resulting in concomitant socio-economic development, benefiting the entire community. This workshop also stimulated the implementation of a tourism project for the community at the time, an initiative of the State of Roraima and the Brazilian Institute of Tourism (EMBRATUR), an opportune moment in which a group composed of 36 IP registered and made notes based on the worked concepts of "what tourism means and its benefits" and the attractions and rich handicrafts produced. In 2004, an indigenous village of Roraima used tourism as a way to recover the history and millenary traditions of the *Macuxí* people (Folha do Meio Ambiente, 2004), resulting in IP empowerment and social integration.

Recently, the Normative Instruction n. 03/2015 (National Indian Foundation—Funai, 2015) was introduced in support of the National Policy for Territorial and Environmental Management of Indigenous Lands (PNGATI) in the regulatory legislation for tourism visitation. The referred instruction establishes norms for the activity of visitation for touristic purposes, specifying the procedures for visitation plans, obligations, and prohibitions, by imposing state limits on IP and tourists. The legally enforceable PNGATI ensures the sociocultural autonomy of IP resulting from a participatory process of deliberation in the construction and structuring of the following goals: (i) protection of territory and natural resources; (ii) governance and indigenous participation; (iii) protected areas, conservation units and IL; (iv) prevention and recovery of environmental damage; (v) sustainable use of a policy by indigenous organizations to manage natural resources and indigenous productive initiatives; (vi) education, training, exchange, and environmental education highlighting and recognizing the rights guaranteed in Article n. 231 of the Federal Constitution

of 1988 (Brazil 2012; National Indian Foundation—Funai 2015; Supremo Tribunal Federal, 2020).

Based on the legislative instruments that guide the policy to the addressed IP, training courses were held in the TIRSS for handling and counting of fish, reinforcing the partnership with residents of the Sustainable Development Reserve, strengthening and transferring knowledge about the production and marketing of handicrafts, as well as the tourism practice, as required in joint visiting plans. The tourism activity in these regions should be carried out according to the principles of uses, customs and traditions of the ethnic groups recommended by the Normative Instruction n. 03/2015 that states that when an event of overlapping of IL with conservation units happens, the Visitation Plan shall be analysed by agencies such as the Chico Mendes Institute for Biodiversity Conservation and the Funai (Goulart, 2020) (Table 1).

The identified advance shown in Table 1 demonstrates an effort that came from the IP in favour of tourism. Therefore, it considers the non-migratory impact of IP to the city and how to adequately manage (i.e., innate sustainable management) their territories (Díaz et al., 2019).

In accordance with the state tourism policy, developed by the Official Tourism Agency in partnership with the State University of Roraima and the Federal University of Roraima, and in response to community requests converging with the autonomy of IP, workshops and training courses were held resulting in a booklet for the operationalization of tourism that started in 2019, resulting in the execution of the Action Plan and Guidelines for the Development of Tourism in Indigenous Lands, according to the temporality, specificity and needs of each community of the Extreme North of Brazil tourist region. Such actions benefited from the knowledge of the National Funai and the Federal Prosecution Service. Thus, these actions had a wide scope, through subsidized exchanges, knowledge, experiences, and the point of view of the participants, which can be considered an achieved milestone regarding the evolution of the *Macuxi* IP (Table 2).

Among the available courses, Food Handling was the one with the largest number of people who chose to attend it. This course worked on basic principles such as good personal hygiene, sanitary safety practices, with the philosophy of not attacking or underestimating the IP culture, based on millenary mechanisms for the conservation and handling of food (Semeghini et al., 2020). The second most frequented course was the one to make Clay Pots as it is a tradition of the community in TIRSS to commercialize these items. In this sense, there is a whole context in the process of clay collection, of the sacred place with offerings to the clay's grandmother (i.e., *Ko'kono*), and the space where they are produced in absolute silence accompanied by rituals. This production process ends through drying in fires and ovens, so these procedures preserve the pans from cracking. For the training to be effectively carried out, there was an intense mobilization to identify the women mastering the arts involved in these practices, to rescue and consolidate the culture to the youngest (Barra, 2020).

Table 1 Timeline of official advances that favoured the indigenous population in Roraima, Brazil

1970	1998	2012	2020	2021
Indigenous Council of Roraima -CIR	First Tourism Workshop	Decree n. 7747	Leadership training	Projects filed with Funai
The creation of the CIR-to strengthen, defend the rights and autonomy of indigenous peoples	Fax Community (Indigenous Land Raposa Serra do Sol) 36 participants Realization: Embratur/Ger/Seplan-Codetur	Institute the National Environmental and Territorial Management Policy of Indigenous Lands	Partnerships: Ger/Ufrr/Ufam/Seplan-Detur/Sei/Uerr Preparation of tourism operational booklet; Technical visits	Process: 08620.002445/2020-91 Tourist Visit Plan Movie release: The Last Forest- a film that gives visibility to the situation of the Yanomami ethnic group

Table 2 Training of environmental and tourist agents (2019–2020)

Partnerships GER/SEPLAN-DETUR SENAR/UERR/UFRR/ CBMRR (*Short course, Workshop and Technical visit*)	Benefited indigenous community	Course offered	Trained IP
• Introduction to tourism; • Tourist leading in natural areas; • Basics of first aid; • Welcoming; • Crafts and ethno jewellery; • Recognition of tourist resources; • Formulation of tourist itineraries; • Tourism flow monitoring	*Água Fria, Pedra Preta, Cajú, Chuí, Caraparú, Warandá, Flexal, Nova Vida I and II, Arapa, Santa Creuza, Santa Luiza*, and *Barro*	Food handling	115
	Bananal, Boca da Mata, and *Nova Esperança*	Food handling	64
	Raposa I	Making of clay pots	30
	Guariba	Food handling	24
Total	17	04	233

Source Data collected from the Report of the Tourism Program in Indigenous Lands GER/SEPLAN-DETUR. National Rural Learning Service, State University of Roraima—UERR, Federal University of Roraima—UFRR, Military Fire Department of Roraima—CBMRR

3.4 Study Limitations

This study is supported in the consultation of official and scientific documents that demonstrate how geotourism and local activities may favour the engagement of IP and promote their recognition and empowerment. Despite this importance, contacting with IP and apply some interviews regarding the citizens experience in these activities will be necessary in the future, to provide accurate information that can be used to understand if the initiatives were effective. However, to conduct research with IP, the normative instruction n. 01/1995 (FUNAI - National Indian Foundation, 1995) must be respected: national or foreign researchers must submit a certified copy of personal documents and/or passport, curriculum vitae, medical certificates of endemic diseases in the area or contagious diseases, copies of curriculum vitae, letter of inquiry to leaders and, if isolated Indians, send correspondence to the Department of Isolated Indians DII-FUNAI. Such documentation must accompany 2 (two) copies of scientific articles in the intended area to develop the research project. These bureaucratic steps take an average of 12 months.

4 Conclusions

The two particular ethnic groups from Roraima, Brazil addressed in this chapter, *Macuxi* and *Yanomami*, are IP with rights and known as promoters of environmental preservation in their territories, constituting a mantle of traditional knowledge. Aiming to conduct professional tourism among the IP community, specific courses were supported by the Brazilian public institutions and made available to communities, art masters and organizations of women who work with handicrafts sustainably, resulting in an empowerment of these groups towards sustainability change in these communities. These courses acted as workshops of sustainable development.

The emphasis on valuing cultures, types of organizations, sustainable ways of life guaranteed by the PNGATI and Normative Instruction n. 03/2015, a deployment tool in support of the tourism policy, established guidelines for the elaboration of the tourist visitation plans. These must have clear objectives and justifications, and a distribution of competences in the community, considering the social and gender aspects, partners involved, delimitation of the itinerary and object of visits, conditions of transport, accommodation, food, business plan, first aid service strategy, manual of good practice conduct for visitors and the community, among other necessary requirements. Consequently, once the visitation plan is approved by the Funai, all these procedures revert to IP income. This specific aspect is extremely important in the context of tourism to be advanced within IP communities, contributing to alleviate poverty (SDG 1) and overall sustainable development. The mentioned partnerships addressed with local authorities (SDG 17) help supporting the sustainability in these communities.

Building bridges between IP and geotourism may be a path to recognize the value of these communities in sustainable development within ethnoregions and IL and to enhance sustainable tourism. Accordingly, geotourism should be seen as a new opportunity that can work in harmony with other tourism activities, assisting in understanding the depth of the Amazon world on a local and global scale through the natural heritage present in indigenous areas and to implement SDGs able to allow to advance sustainable development. It is noteworthy that more research is needed on the subject and that the results can increase the strength of geotourism activities.

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CAPÍTULO VII – Constrangimentos Sociais do Geoturismo e Instrumentos de Proteção numa Perspetiva de Sustentabilidade. [7]

A pesquisa desenvolvida neste capítulo discute as responsabilidades, compromissos sociais e os instrumentos de proteção pautados na emergência e sensibilização para a completa atividade do geoturismo e.g., a minimizar agressões ao meio biótico e abiótico. A geodiversidade constitui a forte expressão do território em Mucajaí, apresenta formas extraordinárias com ênfase na geologia e geomorfologia esculpindo morros alinhados definidos pela unidade geomorfológica pediplano rio Branco rio Negro a serem utilizadas de forma sustentável pela comunidade.

Tendo em vista o setor turístico ser considerado alternativa econômica, o conhecimento das regras nos diferentes níveis de responsabilidades e.g., fatores favoráveis como o planejamento, inventários de geossítios, leis que protegem os recursos a ser cumpridos soma-se aos desafios os ODS 8 preocupa-se com trabalho decente e ODS 12 apoia o consumo e produção responsável ao meio ambiente. A comunidade por ser conhecedora e anfitriã, gestores públicos no monitoramento das regras de acesso aos ambientes e com a devida inclusão dos povos tradicionais, mas também, como o fortalecimento da instituição de turismo do município de Mucajaí, Roraima, Brasil.

Cabe sublinhar que a primeira autora contribuiu com a escrita, desenvolvimento, metodologia, e pesquisas em sites especializados e oficiais para a publicação desta pesquisa.

[7] **Veras**, A. S. S., Vidal, D. G., Barros, N., Dinis, M. A. P. (2022). **Geotourism Social Constraints and Protection Instruments from a Sustainability Perspective**, In *HandBook of Sustainability Science in the Future.* https://doi.org/10.1007/978-3-03068074-0_133-1

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Geotourism Social Constraints and Protection Instruments from a Sustainability Perspective

Evidence from the Northernmost Brazilian State

Ana Sibelonia Saldanha Veras, Diogo Guedes Vidal, Nelson Azevedo Barros, and Maria Alzira Pimenta Dinis

Contents

Abstract

In the last decades, the anthropogenic actions on the planet have dually gained visibility: on the one hand as promoters of strategies for safeguarding the environment at a global level and on the other hand as protagonists of the excessive exploitation of its natural resources, threatening the natural balance of the planet.

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Considering this scenario that results in a need to seek sustainable renewal, the Brazilian indigenous communities living in regions dominated by rock formations classified as natural heritage assume themselves as important vehicles in safeguarding the geological sites through the information they have. There is a lack of knowledge and devaluation regarding the potential of these indigenous communities. Accordingly, the objective of this chapter is to present a vision of the constraints of geotourism in the northernmost Brazilian state of Mucajaí, Roraima (RR), i.e., the duties and responsibilities necessary for the full implementation of geotourism, seeking to safeguard geodiversity in territories dominated by natural heritage, in which the community is sustainably integrated. A review of the official websites of the RR State and of the official legislation was carried out to understand the current geotourism constraints in this region. Based on the results found, regional leaders will be able to identify the specific needs of the region to fully implement the geotourism activity and to promote more sustainable practices to safeguard this region from the anthropic pressure. The use of strategic environmental assessment tools in decision-making on policies and plans for the development of geotourism in a given region should be considered by the official entities in order to ensure the correct assessment of the economic, social, and environmental impacts of this type of interventions.

Keywords

Sustainability · Geology · Geomorphology · Environmental constraints · Climate · Management · Geotourism

1 Introduction

The need to break an anthropogenic paradigm demanded the emergence and growing awareness in favor of Nature's safeguard. This resulted in an international effort materialized in a set of actions, such as the Convention on the Protection of Cultural and Natural Heritage (Diano et al. 2020). Geotourism, as a sustainable tourism offer, gives priority to the aesthetics of the landscape and its geological features, valuing the local community that best recognizes the attractions involved in the geological landscapes of the surrounding territory (Ruban 2010; Brilha 2016; Bruschi and Coratza 2018; Dowling and Newsome 2018; Gray 2018; Mikhailenko and Ruban 2019; Veras et al. 2020a, b; Zgłobicki et al. 2020; Torabi Farsani 2020).

In the context of geotourism, the geological and geomorphological heritage is the main exponent of the attraction involving the tourist visits. When integrated with other types of activities, such as cultural and archaeological ones, the latter contribute to the local development of that specific region and, consequently, of the country as a whole, e.g., Brazil, in the present case, through the responsible management and use of natural resources and the sharing of duties and responsibilities between all involved in sustainability actions (Moreira 2014).

Considered as a dynamic activity, geotourism results in complex interactions of the physical elements integrating it. Alongside the aesthetic forms in the landscape, the benefits of safeguarding Nature as a challenge for the non-destruction of the biotic and abiotic environment are considered (Brilha 2015a, b). There is a worldwide trend towards the protection and safeguarding of the geological heritage, enabling the didactic and scientific understanding of the dynamics of the landscape to be enhanced (Brilha 2005, 2016; Rosado-González et al. 2020). In the last two decades, studies on safeguarding environmental resources, specifically those with the potential to allow the practice of geotourism, have received great attention from the scientific community (Hose 2011; Ruban and Yashalova 2018; Telbisz et al. 2020). With an emphasis on geology and geomorphology, motivated by the diverse fields of scientific research, both geologists and geographers have promoted the regional importance of specific sites on the planet, unveiling and interpreting the transformation of related geological landscapes (Hose 2011; Stewart and Gill 2017; Zgłobicki et al. 2020).

Since the 1980s of the last century, the visibility of the pro-environment movements is gaining importance (Seixas et al. 2020; Vidal 2020), with sustainability becoming a worldwide concern, enhanced by the growing evidence of profound climate changes and the transformation of the natural environment, also acknowledged as the result of an unregulated tourist practice (Middermann et al. 2020). It then became necessary to create rules and constraints at different levels of action, either at political, environmental, or cultural level. Set against this background, the sustainability and competitiveness must be concomitant. When specific destinations become more attractive, it is important to safeguard the efficient use of resources, promoting sustainability (Word Tourism Organization 2019) and sensitizing the actors involved to the exponentially increasing and irreversible risks of using the available resources without considering the future generations. The increasing level of awareness and how citizens consume natural resources are important and necessary steps to implement actions aimed at major urgent environmental issues, as well as to minimize further degradation of the ecosystem (Diekmann and Franzen 2019).

Although considering the international concern in relation to flora and fauna wildlife conservation (Lindsey et al. 2017), the Brazilian reality still faces serious threats due to its historic land use. The Amazonian forests substantially influence regional and global climate, and deforestation in this region is a regional and global driver of climate change due to the high level of habitat fragmentation that has occurred in this region. To revert this situation, Brazil has established an extensive network of protected areas that covers more than 2 million km^2, representing 25% of the Brazilian national territory, similarly divided between protected natural areas or conservation units and indigenous lands. Despite these important actions, the environmental protection in this region is still a concern, as indigenous tribes and Brazilian environmental activists face farmers, illegal loggers, gold and oil prospectors, and drug traffickers, who continue to illegally devastate the Amazonian forests. Geotourism can act as a new motto for more sustainable management of this territory, namely, enlightening the scientific community about the constraints for this activity at the local level, and its contribution to the preservation of this region,

reflecting on the rights and duties and the level of responsibility of local communities and companies (Zgłobicki et al. 2020). It is important to clarify that the term responsibility is widely discussed in several studies, referring to the responsibilities and roles and duties of agents and to manifest spontaneous responsibilities that strengthen the commitments to public policies. It is in this attitude of responsibility that conscious duties, commitments, and obligations are fulfilled and that the community is mobilized to join forces to minimize the threat to the finite resources (Pereira et al. 2008; Williams 2008; Vincent 2011; Hindriks 2019; Oliveira et al. 2020). Accordingly, this chapter aims to present and discuss the main geotourism constrains in Brazil, through the case study of the northernmost Brazilian state of Mucajaí, Roraima (RR), highlighting the duties and responsibilities necessary for the full sustainable implementation of this activity, contributing to sustainability practices and the UN 2030 Agenda in this South American region.

2 Theoretical Foundation

2.1 Tourism and Sustainable Geotourism

Tourism, together with the more recent activity of geotourism, forms the substrate for sustainable practices at global level, involving the landscape in its broader meaning. It must be emphasized that tourism plays an important developmental role, specifically in the reduction of regional disparities and the distribution of wealth to tourist regions, through the creation of direct jobs, e.g., hotels, restaurants, transportation, travel agencies, and specialized guidance, and also indirect jobs, involving local communities, e.g., in services of manufacture of handicrafts and sale of souvenirs, supply of regional food, local accommodation, and guidance by people from the local communities, among others (Teuscher and Lang 1982; Mahadevan et al. 2016). This dynamic development process results in the search for qualified, semi-qualified, and unqualified people, as well as an increase in the level of short- and long-term awareness of local communities and visitors concerning the responsibilities for the positive and negative effects that may arise within the geotourism space of action (Afrodita 2015; Rafi and Herdiansyah 2020; Štrba et al. 2020). These dimensions are pointed out as important elements in the construction of sustainable government policies, as well as in the participation of local communities, and in awakening to commitments, since the territories are interconnected and form harmonious ecosystems, and must not collapse.

In the epistemological framework of the geological and geographic sciences, the concepts and characteristics of geotouristic activity essentially derive from the geological interpretation on geosites that were originated in the 1980s, in England, in terms of cave exploration, fossil studies, and ancient minerals (Hose 2011). Conceived as a form of sustainable tourism, adding value to the geological and geomorphological heritage, Thomas Hose presented a geotourism definition in 1995, i.e., the provision of services and interpretive facilities that allow tourists to acquire knowledge and understanding of the geology and geomorphology of a site,

including its contribution to the development of earth sciences, in addition to mere aesthetic appreciation (Hose 2006). The National Geographic concept complements that geotourism also supports and enhances the identity of a territory through geology, environment, culture, aesthetic values, and the well-being of its residents, strengthening the sustainability of this geotourism activity, considered so relevant that it is now part of the official UNESCO documents (UNESCO 2017). Therefore, geotourism is in line with the development of remote regions linked to the Sustainable Development Goals (SDGs), playing a fundamental challenge for humanity, evident in the Brundtland Report (Hopwood et al. 2005). SDG 8 corresponds to sustainable and inclusive economic growth, the creation of full employment and productive work for all. In this regard, it is worth mentioning that tourism works as an added value, through the manufacture of products extracted from Nature and packaged creatively and sustainably. Such care and practices also add family value, promoting the local and regional cultures. SDG 12 focuses on sustainable production and consumption patterns, aiming to achieve by 2030 the sustainable use and management of natural resources. As for SDG 14, it emphasizes the challenges inherent to safeguarding Nature in detriment to the impacts resulting from the anthropic action, as well as increasing the economic benefits contemplated in the 2030 Agenda, which encompass remote regions where geotourism can also be developed (Pilogallo et al. 2019; Word Tourism Organization 2019). All these mentioned SDGs have an important role within geotourism.

As a legacy of past generations, but also a legacy for the coming years, the geotourism activity can contribute not only to the sustainability of a particular region but also to the identification and enhancement of persistent environmental issues, thus promoting policies to safeguard the humanity's common goods (Hall and Saarinen 2010; Vieira 2014). Admittedly as an activity that brings socioeconomic benefits through the use and exploration of geological structures and unique landscapes (Wu 2013; Mikhailenko and Ruban 2019; Veras et al. 2020b), geotourism allows to register processes, aesthetics, natural beauty, and local culture for sustainable planning, anchored in the opportunities and limitations of best practices, to be considered for specific geographic regions (Tourtellot 2016; Maghsoudi et al. 2019; Shekhar et al. 2019). It is worth noting that a sustainable geotourism plan is able to define strategies for the appropriate use of Nature, in common with the participation of the local communities, this allowing to point out the best practices for safeguarding both the natural and cultural resources, in addition to observing the carrying capacity (Veras et al. 2021) of specific regions towards sustainability (Assante et al. 2012). Many geographical areas can be considered as potentially touristic areas, thus offering a specific geotouristic destination that will depend on the available potential recreational and environmental security in forests, ski slopes, lakes, rivers, mountains, or golf courses, where it is possible to contemplate the highlighted physiographic characteristics and where the right to enjoy a healthy environment is also considered indispensable (Balaguer and Cantavella-Jordá 2002; Hall and Saarinen 2010; Ogunmola and Daniel 2020).

2.2 Factors Favoring and/or Limiting the Implementation of Geotourism

Geotourism is inclusive and contributes to prevent the environmental damage imposed on Nature. However, this activity requires compliance with legal requirements, in areas authorized for touristic operations. In the context of the Brazilian reality, these areas are pointed out in an Ecological Economic Zoning (EEZ) of the Federation Unit (da Silva et al. 2017), i.e., the state where the region is located. This instrument of organization of the territory, provided in the Decree No. 4.297/2002 (Razlianras 2002), enables sustainable development based on the compatibility of actions and points to the feasibility in territories, as long as they comply with it and fit the environmental or socioeconomic characteristics of the place, also depending on the biome and the geographical region being considered (Neves and Sauer 2016).

Thus, it appears that studies on geotourism, supported by the sustainable planning and inventories, must be considered to identify vulnerable areas and the duties and obligations of all stakeholders in a tourist destination and their specificities, aiming to collectively comply with technical recommendations (Dodds and Butler 2010; Su et al. 2020). In a recent development cycle, the geotouristic activity has entered into use in different European countries (Brilha 2005; Hose 2011), and its implementation was seen in England, Portugal, or Austria, among others, applying geosite research and establishing and guaranteeing a policy of geoconservation and thus the integrity of the terrestrial spaces involved in the geotourism activity. In these terrestrial systems, the anthropic actions bring consequences to the well-being of the local communities, since mankind depends on these ecosystems, and this dependence is directly related with biodiversity (unique and endemic) and geodiversity (forms and processes), emphasizing the functional value of physical Nature. Such connection imposes responsibility, monitoring, and sustainable management by the governments, citizens, and entrepreneurs, who must be part of the decision-making of actions in favor of surrounding landscapes and their functionalities, namely, those of an economic nature, as well involving leisure practices and place safeguard (Steffen et al. 2018; Chlachula 2019).

2.3 Formal Instruments Regulating the Geotourism Activity in Brazil

Law No. 6.938/1981 (Brazilian Federal Republic 1981) establishes the National Environmental Policy and is considered the ground zero of environmental awareness. From this policy, the concepts of environment, sustainable development, and ecological balance emerged, becoming part of the Brazilian legal scope at this respect. Concomitantly, the National Environment Council (CONAMA) (Brazilian Ministry of Environment 2020a), a body created in 1982 of an advisory and deliberative nature of the National Environment System (SISNAMA) (Brazilian Ministry of Environment 2020b) and supported by Article 4 of Law No. 9.985/2000 (Brazilian Federal Republic 2000), is intended for the preservation of natural

ecosystems. The CONAMA was at the origin of the National System of Conservation Units (SNUC) (Brazilian Ministry of Environment 2020c), and, among its objectives, it ensures the protection of the forms and processes supporting biodiversity. Administratively, the environmental legislation establishes the conditions, constraints, and environmental control measures that must be obeyed by the entrepreneur, individual, or legal entity to locate, install, expand, and operate projects or activities that use resources considered effective or potentially polluting or those that, under in any way, may contribute to cause environmental degradation.

In the light of the Brazilian legal system, it should be emphasized that the responsible use of the environment must be complied with by all who intend to economically exploit it in order to guarantee this possibility to future generations as well. Thus, geotourism is the tourism term of the moment, defended by some authors, implying responsibility, respect, and geosite protection (Spenceley 2008; Bittencourt et al. 2020).

3 Material and Methods

3.1 Study Area

The municipality of Mucajaí, part of the northernmost Brazilian state, is located in the middle of the Northern Amazon, distancing 51 km from Boa Vista, capital state. The municipality has an altitude of 70 m above the sea level, and it is accessed by Highway BR-174 towards the south. Its geographical dimension is 12,351.341 km^2, housing non-Indian and indigenous populations in the Yanomami Indigenous Land, in the portion of the immense Roraima (RR)-Flona National Forest, in *arboreal savannah* or thick field of thin physiognomy and *savannah graminosa*. According to Köppen's classification, the climate of this region is rainy tropical, from "Ami" type, with temperatures varying between 28 and 38 °C. The Central/East region has water deficits around 3–5 months, with reduced rainfall. As for the drainage of the municipality, the river basin is composed of the Branco (White) River tributaries, with the Couto de Magalhães, Catrimani, Apiaú, and Mucajaí rivers to the north. The geographical location of the municipality area is shown in Fig. 1.

3.2 Geological, Geomorphological, and Landscape Potential of Mucajaí

Mucajaí is located in a region called residual plateaus of RR and gathers lithological characteristics over an extensive area defined by the Branco River-Negro (Black) River pediplane, with expressive mountains and hills aligned in a flattened to slightly wavy surface, sculpted in igneous and fractured metamorphic rocks. The general altitude of the highest elevations varies between 400 and 900 m approximately, reaching up to 1500 m. The geological aspects of the area consist of *orthogneisses* of the Urubu River Metamorphic Suite, *charnockite* rocks of the Serra da Prata

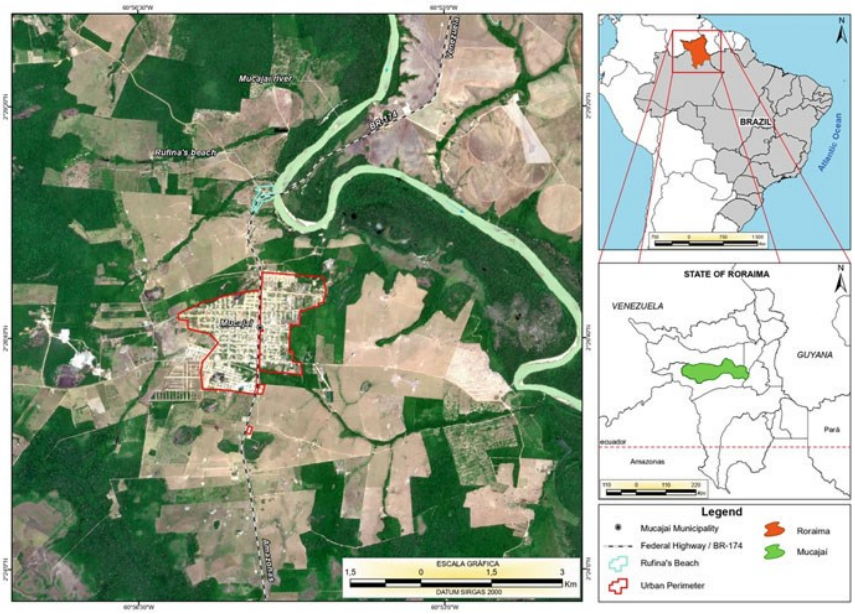

Fig. 1 Location of Mucajaí, RR, Brazil. Cartographic base of the state of RR, by the Brazilian Institute of Geography and Statistics

Intrusive Suite, and Paleoproterozoic and Mesoproterozoic granitic rocks inserted in the Mucajaí Intrusive Suite, with detritus-lateritic cover of Cenozoic age that formed in the landscape sets of mountains with pontoons and large boulders that interrupt the flattened area. All these features are extremely attractive, leading to the contemplation of aesthetic beauty, offering water views and different types of green colors of the vegetation describing the Amazonian singularity (Holanda et al. 2014; Veras 2014). Also noteworthy, at residual plateaus, is the Serra da Prata, supported by rocks of the homonymous Intrusive Suite, containing ravined slopes and flattened tops, supported by detritic-lateritic crust. This feature reaches 550 m, and tributaries are born on the right bank of the Branco River, such as the Branco and Água Boa streams. The right bank of the Mucajaí River is the Serra do Apiaú, carved in rocks of the Surucucus Intrusive Suite, formed by a mountainous set of ridges and pontoons. In this landscape, enhanced by abundant geomorphological features, the Mucajaí River is a tributary of the right bank of the Branco River as the main river in the municipality. The Mucajaí River with transparent waters in some muddy stretches and in other cliffs sometimes forms holes and islands along its course as in section upstream of the Paredão Waterfall (Holanda et al. 2014).

3.3 Data Collection

This research is of an exploratory and descriptive qualitative nature (Liamputtong 2013). A preliminary bibliographic search was carried out concerning the existing Brazilian geotourism activity in the municipality of Mucajaí. Data were collected from official websites, such as the Company for Research in Mineral Resources (Brazilian Ministry of Mines and Energy 2020) and the Boa Vista Municipal Council (Boa Vista City Hall 2020). Data were collected in relation to the geotourism activity in Brazilian official normative and administrative documents. Because the municipality is part of the Amazonic region, the premises of conservation were considered in the search carried out, i.e., the focus of geotourism in terms of the constraints (Pereira et al. 2008), i.e., having environmental impact studies; being registered in the Tourism Ministry; and being capacitated to conduct the activity and to offer a specialized service with quality and to involve local communities. The collected data was manually screened to identify the previous topics. The existing data made it possible to summarize the geotourism constraints with the levels of responsibilities, considering the parameters in accordance with the current Brazilian Ministry of Tourism (Mtur) and other existing legislations.

4 Results

The geological component in the geotourism context comprises a unique condition and should not be neglected at this respect. The rocky outcrops of great territorial expression, where the geological element and the geodiversity are prevalent, constitute a favorable environment to the activity of geotourism. The geological context contained in geographic regions of physical integrity, with sites of real significance and geomorphological features composed of landscape scenarios, considered relevant from a scientific point of view, can be used in a sustainable way to support local populations, in addition to being an open laboratory for understanding earth sciences. Sedimentary coverings, affected by tectonics throughout the geological eras in the majority Precambrian, resulted in geotectonic units that have great morphological diversity. Plateaus, canyons, carved slopes, inselbergs, slabs, mountain ranges, mountain ridges, and mountains used as viewpoints and trails, as well as freshwater courses, are some examples visible in Fig. 2.

The geotourism constraints are important and necessary to compose the first steps of an organized and structured geotourism activity. A sequence of constraints is summarized and detailed in Table 1.

Local management authorities involved in geotourism activity are considered in Table 2.

Climate change can affect geosites and their attractions, since the activity of geotourism is an outdoor practice. In view of the extensive north region of Brazil, and according to the traditional classification of Wilhelm Köppen, the terrestrial phenomena prevalent in the atmosphere are tropical, tropical semiarid, and equatorial humid, typical climates crucial in the prospecting of the destination and the geotouristic product to be worked on. The knowledge of these phenomena is based

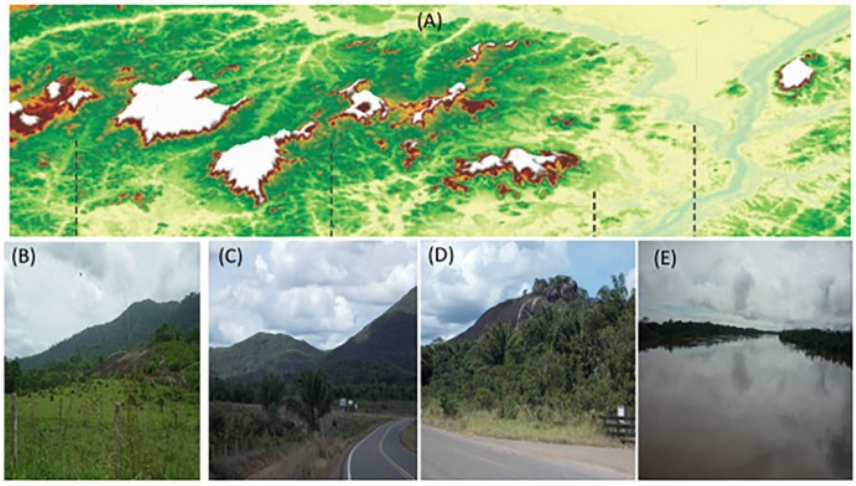

Fig. 2 Geomorphology of Mucajaí. (**a**) The geomorphology of the region presents an abundance of flat surfaces and pronounced relief whose altitude varies between 100 and 900 m, intersected by a drainage network; (**b**) the geodiversity presents itself with all its strength, which demonstrates in the environment a perfect vegetation harmony, that is, the biotic component fed by the rock substrate; (**c**) the regional convex top relief stands out in the region, enhancing the beauty and serving as a refuge for exotic species. Visits to these areas are accessible by side roads (unpaved roads) and paved roads; (**d**) rock walls, namely, the granites ones, are common in the region, being used as art elements designed by the local communities; (**e**) the Mucajaí River is a very important watercourse, intertwining the rapids and forested islands

on temperature and precipitation during the seasons, requiring understanding and constituting an important tool for tourism planning in the current scenario of reaching the SDGs (Table 3).

The good management of tourism resources and services is essential constraints, conducting in a planned, organized, modern, integrated, and shared way in partnership with the local community, trade, class association, nongovernmental organizations, and the municipality. Within the scope of state policy, the MTur in the National Tourism Policy counts on the Tourism Regionalization Program, which aims to organize and support the structuring of destinations, their management, and promotion of tourism in Brazil (Table 4).

Tourism is constitutionally seen as an economic alternative. However, it demands investment in infrastructure and various incentives to generate jobs and minimize regional and social inequalities and the protection of the environment. Therefore, it is the function of the public power to coordinate, support, and guarantee this, through the force of law. The main legislation involved is identified in Table 5.

Tourism interacts with diversified activities exercising good relations with the community, companies, and local drivers using raw materials, which is a natural environment, in line with the environmental legislation (Table 6).

A geotourist who is highly aware about the responsibility for healthy and natural environments ensures the sustainable permanence of the site (Table 7).

Table 1 Geotourism constraints and responsible entities

	Geotourism constraints	Responsibility level
Inventory	Identification of singular geosites with physical description of the territory; conducted by the Mineral Resources Research Company (CPRM) (Brazilian Ministry of Mines and Energy 2020) and higher education institutions (HEIs)	CPRM; geologist, geographer, tourist, archaeologist, biologist, local manager, entrepreneurs and politicians, member of the Municipal Council of Tourism (CONTUR), and the Official Tourism Agency; Brazilian Institute for the Environment and Renewable Resources (IBAMA) (Brazilian Ministry of Environment 2020d); Chico Mendes Institute for Biodiversity Conservation (ICMbio) (Brazilian Ministry of Environment 2020e)
Infrastructure	Roads and signage as interpretative panels in an accessible language in, at least, three languages: Portuguese, English, and Spanish	Governments at the federal, state, and municipal levels; consortium between municipalities
Preserved area	Avoid polluting activities and illegal construction	Municipality through EEZ Code of ethics
Global covenant – contributes to SDGs 8, 12, and 14	Elaboration of projects with measurable impacts	Partnership academies and civil society

Table 2 Different roles of geotourism local management

Local authorities/ touristic agency	Host community	Geotourist
Control activity with emphasis on visitor flow	Good humor and friendliness should be part of the host community's profile	Comply with code of conduct in relation to local geodiversity
Proceed with site carrying capacity studies	Community actively participating in the planning and execution of geotourism activities at economic, physical, and regulatory level	Must present vaccine against endemic diseases in the region if the location is tropical area
Provide for the hiring and training of guides or supervisors	Limit access, indicate point signalling	Respect local culture and the integrity of the environment
Adapt protection measures for pedestrian paths	Contribute with the interpretation of the area, explaining the meaning of the place	
Local development strategies and spatial planning		

Table 3 North Brazil Köppen's classification

Climate symbology	Characteristics	Temperature and rainfall regime	Region of occurrence
Am (equatorial)	Hot with dry season	High temperature 25–27 °C	Much of the Amazon
Af (equatorial)	Hot without dry season	High rainfall 1500–2500 mm/year	Eastern and northwestern part of the northern region
Aw (tropical)	Hot with summer rains	Average temperature 19–28 °C	Central Brazil and Roraima
Aw (tropical)	Hot with summer and autumn rains		North Coast
As (tropical)	Warm with winter and autumn rains	Two seasons: summer (rainy) and winter (dry)	Northeast Coast (*Zona da Mata*)
Bwh (semiarid)	Hot and dry, with summer rain	Annual averages 25 °C. Rainfall 1000 mm/year and irregular rainfall	*Sertão do Nordeste*

Adapted from Mariano (2014)

Table 4 Profile of the manager responsible for resource management

Geotourism constraints	Responsibility level
Suitable multidisciplinary and specialized professional, at least, with bilingual knowledge, with skills in waste management and project development. Submitted to criteria for the position. With no past involvement in illegal hunting, fishing during the closed season, in fires, and illegal extraction of ores, wood, and others	Articulate partnerships Lead landscape management Comprehensive and site planning to be avoided (flooded areas, dangerous cliffs) Demonstrate strong ability to work with traditional people, *quilombola* communities, women and men from the forests, fishermen Develop tourist methodologies, aiming at a growing and essential process of conservation of geodiversity (natural heritage) within the principles of sustainable development of the territory Know the Brazilian environmental and tourism legislation Be exempt from any party or religious activity Monitoring and reporting results is one of the basic requirements for transparent management

5 Discussion

To identify the geotourism constraints in the state of RR, north of Brazil, the official documents and websites available and developed by the local authorities of this region were carefully screened. Aligned with the international UN 2030 Agenda, this

Table 5 Brazilian touristic legislation in favor of the geotourism activity

Geotourism constraints	Service provider responsibility level
General Tourism Law No. 11.771 of September 17, 2008 (Brazilian Federal Republic 2008). The reform is innovative, recognizing and supporting new trends in entrepreneurship and a lucrative opportunity for citizens Article 21 considers the provider of paid tourism services, autonomous social services, and other economic activities to be registered nationally with Cadastur (Brazilian Ministry of Tourism 2020a) Every tourist service provider is required to register, being legalized with MTur Ordinance No. 205, of December 9, 2015. Establishes the tourist regions supported by the State Tourism Forum Ordinance No. 192, of December 27, 2018. Establishes criteria for updating the Brazilian Tourism Map Financing source: General Tourism Fund (FUNGETUR) (Brazilian Ministry of Tourism 2020b); Investment Attraction Program (PAI) (Brazilian Ministry of Tourism 2020c); Prodetur + Tourism (Brazilian Ministry of Environment 2020f)	Mention and use in any form of dissemination and promotion, the registration number, symbols, expressions, and other forms of identification determined by MTur Present, in the form and within the period established by the MTur, information and documents related to the exercise of their activities, undertakings, equipment, and services, as well as the performance profile, quality, and standards of the services offered by them Keep in a visible place a copy of the registration certificate Maintain strict compliance with consumer law and environmental legislation in the exercise of its activities

identification process can be used as a guide to the local authorities regarding the promotion of geotourism in this region. State and local authorities are responsible for managing the use and conservation of geodiversity, an important national resource of all nations (Ruban 2017), which should require inclusive actions aimed at development opportunities. Geotourism is a sustainable development strategy that contributes to strengthen the identity of the territory hosting transcendental geological heritage, used and conserved for future generations (Sánchez-Cortez and Simbaña-Tasiguano 2018; Ateş and Ateş 2019).

Therefore, it is important to implement the activity of geotourism within the requirements of Law No. 6.938/1981 (Brazilian Federal Republic 1981) and the current General Law of Tourism No. 11.771/2008 (Brazilian Federal Republic 2008) for the research region, with the objective of boosting geotourism, through scientific practices involving partnerships such as higher education institutions (HEIs), Mineral Resources Research Company (CPRM), community associations, environmental nongovernmental organizations, and public managers. Although it is not an easy challenge to achieve, it involves good planning, budget availability, training, and infrastructure. The presentation of the proposal can start with the creation of a working group (WG) duly formalized by municipal decree. WG, composed, for example, of members of the institutions mentioned above, will find alternatives that will allow to overcome the obstacles in Mucajaí, RR, Brazil. Within this

Table 6 Environmental Brazilian legislation and related constraints

Geotourism constraints	Service provider responsibility level
Law No. 9.985 of July 18, 2000 (Brazilian Federal Republic 2000); Law No. 6.938 of August 31, 1981 (Brazilian Federal Republic 1981) establishes the National Environment Policy and creates CONAMA (Res. No. 237 includes Tourism): Environmental license – constitutes an administrative act by which the environmental agency establishes the conditions, restrictions, and measures of environmental control that must be obeyed by the entrepreneur, individual, or legal entity, to locate, install, expand, and operate enterprises or activities that use the environmental resources considered effectively or potentially polluting or those that, in any form, may cause environmental degradation Law No. 9.605 of February 12, 1998 (Brazilian Federal Republic 1998) provides penal and administrative sanctions derivative of conducts and activities harmful to the environment and other measures Financial incentives: Amazon Bank aligned with the federal government's policies, plans, and programs supports the Sustainable Amazon Plan (PAS) (Brazilian Ministry of Environment 2020g), using resources from the Northern Constitutional Fund (FNO) (Amazon Bank 2020) Regulatory, licensing, and supervisory bodies: the Ministry of the Environment (MMA) (Brazilian Ministry of Environment 2020h) through its legal representatives ICMbio and the IBAMA issues an opinion within its powers	Instructs the entrepreneur and/individual to present feasibility projects with environmental management and production chain; accessibility tourism projects must comply with rules and regulations Updated region cartography and Global Positioning System (GPS) Keep in a visible place a copy of the registration certificate in MTur Maintain, in the exercise of its activities, strict compliance with consumer rights and environmental legislation Requires environmental impact studies (EIA) and load capacity studies Tourist must fulfil their role in favor of conservation and must not underestimate the culture of traditional peoples

background, considering the local characteristics of the region is an important step to implement effective public policies regarding the geotourism activity. This is the main motto of UN 2030 Agenda, "There is no one-size-fits-all" (United Nations 2015), which reflects the need of place-based approaches concerning specificities of a region, namely, its social, cultural, economic, and natural dynamics. The potentiality of Mucajaí region can be observed when people cross Highway RR325, a highway that cuts through the entire municipality, specifically the endemic flora, rocky surfaces and walls with rock inscriptions that can be archaeologically researched, and escarpments that can be used as viewpoints favorable to contemplation and to the geotourism activity (Veras et al. 2020b). In this sense, the characteristics of the available outstanding attractions present conditions promoting the feasibility of geotourism in the Mucajaí region. The geotourism approach obeys to abiotic, biotic, and local culture and supports and enhances the identity of the

Table 7 Geotourist and responsibilities

Geotourism constraints	Responsibility
Ordinary people, ethical, creative, changeable, and defending the environment. This function is very important to integrate the implementation of geotourism. Citizens are requested to take measures from managers and other authorities, such as the United Nations Organization for Education, Science and Culture (UNESCO) (2020)	Be responsible for the visited environment Bring the waste generated on site Do not burn or bury waste Do not use detergents to wash your hands in water sources Do not spray the rocky walls Do not remove vegetation or rocks as souvenirs Do not build fires Domestic animals must not participate in outings Hire accommodation and local food services so that financial resources circulate in the community Cordiality with the traditional population

territory, being crucial in advancing the SDGs. Beyond these benefits, the geotourism activity can play an important role in the development of local communities by generating extra income for both citizens and investors (Bhaduri and Pandey 2019). In these areas, tourists come into contact with lithology, where they can contemplate hills, e.g., savannah, park, and grassy *phytophysiognomy*, as well as paths of buriti (*Mauritia flexuosa*). These resources present numerous possibilities for the local community to operate tourist circuits and routes. The growing interest regarding geotourism has led to an increase in landscape visits by tourists. As mentioned before, this implies the implementation of responsible practices adopted by tourist but also by local communities as Nature safeguards (Dowling Ross and Newsome 2017; de Almeida Rangel et al. 2019). Beyond this civil responsibility, the protection of Nature needs to have a legal basis, and that resulted in 197 member states signing the Convention on Biological Diversity and the Multilateral International Treaty ratified by Brazil, translated by the Federal Decree No. 2.519, which aims to protect 10–17% of terrestrial environments, i.e., freshwater and sea, as well as to assure close monitoring and conservation measures (Baylis et al. 2016; Schleicher et al. 2019).

The involvement of local communities in all geoconservation actions, integrating the geotourism activity as a whole, could be an interesting strategy for a co-management of geoparks and geosites, with mutual gains for the environment and for the society, also contributing to improve the resilience of the communities (Tavares et al. 2015). Alongside this, it is also necessary to develop synergies between municipalities and regions since these spaces of geodiversity can integrate different municipalities and states, which implies a necessary shared sustainable management vision (de Castro et al. 2016).

Accordingly, geotourism should be recognized as an important tool to share sustainable values and practices, supporting local communities and tourism itself, with important benefits at different levels. Considering that geotourism is mainly based on interpretative activities of natural and cultural landscapes, it can be stated

that this integration guides sustainable landscape use. The management of geotourism is an enormous challenge for public managers in developing good planning, conducting sustainable environmental policies and arousing citizens' commitment to tourism attraction, and seeking partnerships to strengthen and better educate citizens and society in general, particularly in remote Brazilian areas, thus promoting sustainable development at local level. It is, therefore, necessary to correctly identify the geotourism constraints to implement the sustainable use of natural resources available for tourism. In this sense, the identification of those constraints can become a very important tool in the decision-making and licensing of this type of policies and development plans, in order to conduct strategic environmental assessment (SEA) procedures aiming to ensure an integrated and sustainable development vision.

6 Conclusions

Considering the discussed constraints to the geotourism activity, it can be concluded that in general these are the responsibilities of the state, the main inducer in the conduction, authorization, control, and monitoring of the activities carried out in regions with tourist potential, aiming to minimize and even compensate damages to the physical sustainable environment. Therefore, these constraints consist in the commitments, responsibilities, and guarantees that the entrepreneur (tourist trade) must fulfil in relation to the environmental good, as it is the patrimony of the entire community at stake, holding the right to use this responsibly and guarantee it for the generations to come.

In this planetary arena, citizens on equal terms (local to global) are aware of the vital role of their responsibilities when involved in tourism projects and educational practices involving geodiversity, motivating and strengthening their attitudes towards the available environmental resources. However, it is highly complex to expect that everyone involved in activities that use geodiversity will be determined to strictly comply with all constraints in favor of geotourism. Consequently, there is a need to raise awareness of all important links in the geotourism segment related to the duties and responsibilities within the reach of all, citizens and state.

Future studies on the geomorphological constraints of residual reliefs based on the sustainability of the territory directed to the position of local drivers can further contribute to a more sustainable geotourism environmental strategy and support recommendations of educational managers within a potential geotouristic region.

Finally, the use of SEA tools in decision-making on policies and plans for geotourism development in a given region should be considered in order to ensure the correct assessment of the economic, social, and environmental impacts of the interventions.

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DISCUSSÃO E CONCLUSÕES

As pesquisas realizadas subsidiaram esta tese, sustentam os capítulos apresentados anteriormente, os quais resultam dos vários estudos realizados, entretanto traduzidos em diferentes publicações nacionais e internacionais, descreveram uma relevante vocação natural para a atividade do geoturismo no município de Mucajaí, Roraima, Brasil, bem como do seu potencial no âmbito do cumprimento dos ODS e da preservação do patrimônio natural nesta região. Enfatize-se a necessidade do envolvimento de todos os cidadãos, das organizações privadas e poder público, ancorado no empenho sinérgico segundo entendimento da sustentabilidade, temática essencial a todo planeta e premissa na atualidade (Marouli, 2021).

Essa visão integrada é essencial aos cidadãos locais, acadêmicos insertos nesse universo não dimensionável, e uma oportunidade para que o geoturismo possibilite conhecer e interpretar um mosaico de ambientes a ser utilizado de forma harmônica (Pant et al., 2022). Considerando-se que a harmonia, i.e., sustentabilidade, ser a melhor maneira das empresas especialmente as pequenas e médias atuarem em consonância com o que preconiza a Agenda 2030 e os ODS as pessoas priorizando a prosperidade da sociedade e concomitantemente a preservação dos recursos naturais i.e., produção e o consumo sustentável.

De igual modo, um dos principais atores, as pessoas autóctones e não índias, irrigam e fortalecem o território constituindo, portanto, o fio condutor no conhecimento e práticas na natureza para a plenitude geoturística com fins educativos, interpretativos e sustentáveis na área da pesquisa (Sisto et al., 2022, Furfori, 2023).

Nesse universo da pesquisa o geoturismo como atividade promissora identificou pontualmente a superação de barreiras culturais da mulher ao liderar com empenho e respeito pela natureza, levar às áreas potencialmente favoráveis que beneficiam ao geoturismo, que sustenta a identidade da região e fornece a interpretação de serviços ambientais de geossítios (Vu et al., 2022). O papel da mulher e os trabalhos desenvolvidos estão alinhados a Agenda 2030, condição que projeta a igualdade de gênero como uma das metas fundamentais dos ODS 1 a 5, 8, 11 priorizam a prosperidade humana e ODS 15 empenha-se com a vida terrestre e a sua preservação.

Dentre as valiosas ferramentas geocientíficas, destaca-se a trilha geoturística, que aponta variedades de ambientes a serem conservados e destinos geoturísticos. Essa trilha permite o contato com um ecossistema privilegiado, formado por uma revelação natural geológica e geomorfológica em blocos crustais gnáissicos e granitóides (**Veras**, 2021b). Esses ambientes encontrados no percurso da caminhada traduz a importância da conservação e estratégia de conexão entre o geoturista e a prática da responsabilidade com o ambiente, e esse ambiente saudável proporciona bem-estar e desperta o compromisso com o lugar, nesse mote foi possível identificar a capacidade de carga e assim, em direção aos ODS 1 erradicar a pobreza, ODS 3 preocupa-se com a saúde e bem-estar, ODS 4 prioriza a educação e assegura a educação inclusiva, ODS 8 preocupa-se com o trabalho decente para todos, esses são referências à prosperidade humana em conexão com preservação dos recursos naturais os ODS 13 apoia medidas de consumo e produção responsável bem medidas para combater a mudança climática e o ODS 15 gerir de forma sustentável aos ecossistemas terrestres.

Identificou-se uma região expressiva demonstrada pela geodiversidade, destaque para lugares aquáticos abundantes e representativos na ecologia, estes são a espinha dorsal da existência dos seres vivos e num contexto global considerados vulneráveis dentro de seus importantes papéis (Pant et al., 2022). Os rios e lagos são substratos e alicerces indispensáveis para a manutenção e equilíbrio ecológico, portanto, o conhecimento, e o merecimento do respeito destes recursos pelos cidadãos, gestores, e autoridades locais sobre marcos institucionais legais, devem constar como comprometimento e garantia da água doce e os usos às gerações futuras. Quanto ao ODS 6 refere-se água e saneamento,

10 preocupa-se com a redução das desigualdades, e ODS 15 relaciona-se a vida terrestre ao manejo sustentável da Terra.

Cabe destacar o valor na vastidão de terras com a única rodovia que faz a conexão terrestre de Mucajaí no Estado de Roraima. Apesar das alterações causadas no meio físico e social, favoreceu planos de governo para povoar essa parte tão distante da Amazônia (**Veras**, 2022). De caráter facilitador é um aliado do geoturismo por despertar abertura de pequenos negócios, a logística dessa estrada pode oferecer como prioridade pontos de facilidades aos visitantes e geoturistas que tencionam visitar as singularidades que estão no entorno, e usufruir das diferentes paisagens geológicas conduzidas por guias capacitados dentro do que preconiza áreas naturais nos moldes sustentáveis e com infraestrutura adequada a essa atividade emergente.

A predominância de etnias indígenas que vivem em etnoregiões protegidas em seus habitats defendem os princípios da manutenção da floresta com base na cultura da comissão, i.e., dos elementos naturais e portanto, podem contribuir no reforço da preservação de ambientes geológicos ainda não impactados. Essas populações já apontam seus comprometimentos, e contam com a recente conquista com a publicação instrumentos legais que facilitam a condução de visitas em territórios habitados em modo sustentável, assegurando a conexão entre indígenas e o geoturista somando aos compromissos da Agenda 2030 e metas os ODS 1, priorizar acabar com a pobreza, 15, proteger ecossistemas terrestres e ODS 17, apoiando diferentes parcerias, meios de implementação e de incentivo ao empreendedorismo em novos tempos.

As condicionantes ambientais, i.e., conjunto de normas, licenças, resoluções e instrumentos reguladores emitidos por órgãos públicos, compromissos ao uso da geodiversidade, i.e., ambientes com formação rochosa isolada em área aplainada, utilizadas como mirantes e trilhas geoturísticas (**Veras** et al., 2022). Partes significativas constituem berços da vida, podendo ser amplamente utilizadas pela atividade do geoturismo educacional, científico, proteção e valorização de geossítio (Shu et al., 2022, Rutt et al., 2023). Contudo, a partir do conhecimento dos instrumentos reguladores, há um desafio a ser perseguido que é o de sensibilizar todos os envolvidos para os deveres e

responsabilidades e que estes estejam determinados a cumprir papel vital para a geração presente e futura.

Vale ressaltar que a ordem de apresentação das publicações sobre Mucajaí sintetizam geossítios para a conservação e uso do geoturismo, o que reflete o avanço e alerta às políticas públicas para a proteção e manutenção do essencial meio ambiente, meio vital quando se trata de água doce e recursos paisagísticos para as gerações vindouras e, ao mesmo tempo, o que desperta especialistas: a ampliação de pesquisas que enfatizem as vantagens da atividade geoturística, num contexto social de interação com o ambiente natural.

Nessa perspectiva, é importante ressaltar as inúmeras morfologias da região central de Mucajaí, Roraima que favorecem circuitos de visitação geocientífica (Prill et al., 2012). Realçar a necessidade de inventariar, sinalizar e promover vislumbrando-se experiências inovadoras, como a atividade rentável com a exploração de culturas de alta qualidade alimentar, entre outros produtos da agropecuária de grandes fazendas presentes nas planícies, o que fortalece a região para uma integração turismo rural e geoturismo (Silva, 2021).

As perceptíveis feições geológicas na geodiversidade formam paisagens que beneficiam economicamente uma região (Rutt et al., 2023). Integram-se a área do estudo o agronegócio, pois o geoturismo capta turistas exigentes e de alto nível de conscientização enquanto preserva o ambiente amazônico. Ilustra-se esse fato com o sintético mapa geológico e imagens relativas à geodiversidade ricamente presente na área **Figura 4**.

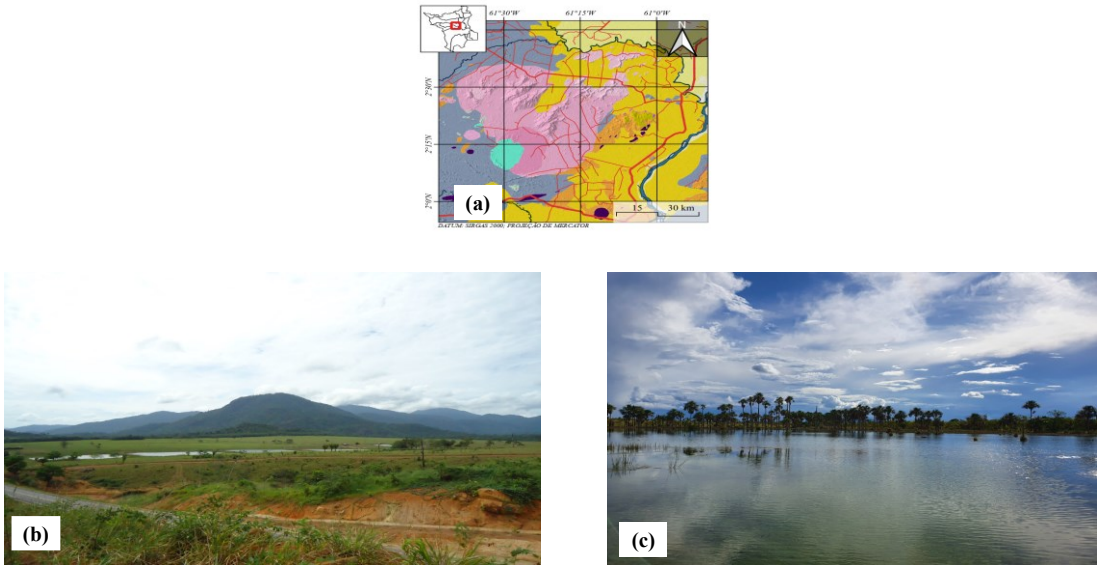

Figura 4: Mapa geológico sintético demonstrando a geodiversidade, i.e., geologia e geomorfologia com imagens: (a) modelados serranos e (b) paisagem aquática. Escala geocodificada 1:50.000. Adaptado de Fraga, (2002) e Lopes et al. (2020).

Nesse sentido, diante de tal valiosa geodiversidade, alerta-se para o papel do cidadão e dos gestores em Mucajaí em redimensionar e ampliar, dentro da política de turismo, ações de conservação i.e., uso racional dos recursos de modo planejado e de gestão, com desdobramentos realizáveis por meio de campanhas educativas e ilustrativas nas propriedades rurais, outras direcionadas aos acadêmicos, jovens e produtores com a colocação de painéis interpretativos. Ações concatenadas e alinhadas às três esferas, i.e., federal, estadual e municipal sendo este o ator fundamental na gestão do território objetivando alta qualidade de vida humana (Furfori, 2023).

Pela presença expressiva de formações rochosas que embelezam a paisagem para a prática do geoturismo, sugere-se incluir também as lideranças indígenas nas divisões de responsabilidades na gestão conjunta por meio de associações comunitárias, assim como aos diversos tipos de ambientes geológicos economicamente rentáveis de Mucajaí.

Os rios sinuosos que cortam as paisagens são palco de aprendizagem e conhecimentos em prol da valorização e preservação do patrimônio geológico e geomorfológico, dentro do que preconizam os ODS. Consubstancia-se vitalidade de bibliotecas a céu aberto para

pesquisas e passeios aprazíveis, interpretados nas diferentes ópticas dos visitantes da Amazônia, sob as narrativas de guias de turismo profissional a ser capacitado nos componentes abióticos, bióticos e culturais na paisagem.

É válido endossar o reconhecimento dos valores imensuráveis do patrimônio da era geológica elaborados na era Mesoproterozóico, i.e., estético existente na área da pesquisa, assim como a importância do setor de turismo desenvolvidos para uso do geoturismo como salientado por Xu et al. (2022). Esse reconhecimento deve ser amparado nos atos formais administrativos do planejamento do território, validado a partir da decisão política e social da região na preservação das vantagens e benefícios da não ocorrência de rupturas dos ecossistemas em prol do bem-estar humano.

É necessário reiterar um plano de capacitação exequível para guias geoturísticos, em parceria com órgão oficial de Turismo de Mucajaí, e instituições como e.g., o Instituto Federal de Educação, Ciência e Tecnologia (IFRR), a Companhia de Pesquisa e Recursos Minerais (CPRM) o Serviço Brasileiro de Apoio às Micro e Pequenas Empresas (SEBRAE) e o Fórum Estadual de Turismo (FETUR), de forma transparente e dentro da óptica sustentável.

Diante da concepção holística sobre as propriedades naturais, o planejamento deve ser integrado e flexível, i.e., delineando um rumo de ação integrada aos demais segmentos turísticos (Fan, 2022). A congregação de entidades públicas e privadas, a sociedade civil organizada, os conselhos de turismo, empresas turísticas e o órgão de turismo municipal. Demais participantes devem ter como pré-requisitos habitar na região ou seu entorno, ser atuante em setores que integrem a cadeia do turismo.

Esse processo sistemático deve prever investimentos com ênfase na captação de geoturistas, tanto nacionais quanto internacionais, criando oportunidades para integrar redes de georoteiros e implementar o caráter geográfico disponível e autêntico, com acomodações, gastronomia e cultura. Assim, tornar-se-á um roteiro único, com a junção do interesse da iniciativa privada na região e o conhecimento local, em prol da valorização dos melhores relevos e planícies férteis, com ricas informações geocientíficas que podem

receber colaboração de IES, Órgão Oficial de Turismo, Consultores de turismo (Russo e Sisto, 2023).

Na operacionalização de georoteiro devidamente formalizado e atendendo às condicionantes em benefício da manutenção da geodiversidade, ao uso pela sociedade e demais atores interessados na atividade, que possam cumprir normas em território com potencial geológico, com vista a fornecer o uso sustentável, apresentam-se instituições que regularizam o arcabouço legal: Sistema Nacional de Unidades de Conservação (SNUC), Prefeitura do Município de Mucajaí (PMM), Companhia de Pesquisa e Recursos Minerais (CPRM) para a interpretação de ambientes paisagísticos encontradas na região Central de Mucajaí, na porção visível constituída por afloramentos rochosos (**Veras**, 2021). As feições geológicas de acordo com suas particularidades devem ser utilizadas para fins geoturísticos apresentadas por meio interpretações, e.g., composição mineralógica, importância para geociências tendo essa o papel de explicar e interpretar o ambiente da geodiversidade para a sociedade, como surgiu, quanto a preservação e assim, garantir a existência dos geossítios conforme orienta os trabalhos de (Brilha, 2005, Brilha, 2016) e num linguajar mais leve sem deixar o viés científico à margem, despertar possibilidades de uso e obter lucro compensatório, síntese confere-se na diversidade de atrativos conforme a **Figura 5**.

Figura 5: Diversidade geográfica do relevo. a) Mapa geomorfológico com relevo e geossítios, (b) Igarapé Serrinha de primeira ordem de águas doces e transparentes, a coloração amarelada típica da região que oferece serviços de lazer a visitantes e geoturistas, (c) Cachoeira de piso granítico rocha abundante na região, (d) Vista aérea de modelado em litologia granítica da suíte intrusiva Mucajaí, (e) Lago, ambiente lêntico bordejado de buritizais, (f) Paredão de Rocha, utilizado na produção de pedras de cantaria que abastecem os mercados de Mucajaí e Boa Vista (capital de RR), (g) Cachoeira com queda d'água em baixo nível, esculpida em degraus em rocha granítica, o perfil conta com mais de 20 metros de queda, (h) Paisagem que apresenta cenário de planície e relevo montanhoso ao fundo, com estrada

asfaltada e sinalizada de boa qualidade e (i) Espécie arbórea centenária denominada castanheira (bertholletia excelsa).

Nesta contemporaneidade, a Agenda 2030 e os ODS definem princípios para superar os maiores desafios do planeta Terra no uso dos bens ambientais (Butte et al., 2022). A presente tese dentre as várias vertentes de pesquisa, voltadas aos recursos geológicos e geomorfológicos, uma das alternativas para preservação de biomas é avançar no uso desses ambientes é interpretar e usar a atividade geradora de renda, inclusiva e de baixo impacto (Alfane, 2023). Para tal ação às mudanças de atitudes, governanças territoriais, e a contribuição do cidadão com atitudes conscientes para que o geoturismo possa promover geossítios tão distantes, sincronicamente, oportunidade para alcançar a salvaguarda local.

Em razão da dinâmica do turismo sofrer mudanças e inovações constantes, é importante sugerir procedimentos para novas atividades turísticas, decorrentes da incontestável potencialidade que pode ser desenvolvida em Mucajaí, Estado de Roraima. Dessa forma, evidenciam-se recomendações para o manejo das áreas considerando o ordenamento e o planejamento do território em prol da valorização, fortalecimento, coesão social, cooperações e forte atuação dos serviços públicos de modo a atender o geoturismo, descritas a seguir.

Em Roraima, (2022), um dos princípios básicos do Zoneamento Ecológico-Econômico (ZEE) é nortear o território no planejamento e, portanto, para a usabilidade, qualidade e impulsionar o nível de desenvolvimento das regiões de Mucajaí em Roraima. Logo, o geoturismo, em sua função, prioriza o cidadão na condução da interpretação e preservação de áreas rurais, apresentando-se como prática inovadora em Mucajaí (Dantas, 2011). Diante da aplicabilidade de projetos que contemplem o patrimônio natural e suas formas de relevo com a geologia e geomorfologia, sugere-se:

(i) Buscar o ZEE, para conhecer recomendações de áreas favoráveis a operacionalização de circuitos turísticos,

(ii) Estabelecer parcerias com Instituições de Ensino Superior (IES), Companhia de Pesquisa em Recursos Minerais bem como, prevenção aos riscos de acidentes aos usuários e turistas, conforme o Serviço Geológico do Brasil

(CPRM, 2021). Buscar apoio junto ao Órgão Oficial de Turismo denominado Departamento do Turismo (DETUR) pertencente ao organograma da Secretaria de Estado da Cultura e Turismo (SECULT) e com Organizações Não Governamentais (ONG's),

(iii) Buscar parcerias internacionais para capacitações nas práticas ambientais, i.e., ter domínio do local ao coletivo, destinadas aos cidadãos em condição de vulnerabilidades e demais interessados, em consonância com os ODS.

Para as condicionantes geológicas, abarca-se o conjunto de recursos contidos na paisagem, que inclui a geodiversidade com destacada beleza e afloramentos de rochas em pontos geológicos, geomorfológicos e paleontológicos notáveis, que devem ser criteriosamente observados quanto a sua identificação acurada sobre riscos de acidentes aos usuários e turistas, segundo Serviço Geológico do Brasil (CPRM, 2021):

(i) Inventariar geossítios, i.e., recorrer à plataforma Geossit para iniciar o processo de quantificação e qualificação, atendendo critérios de valor científico, potencial para uso educativo, geoturístico e risco de degradação,

(ii) Elaborar e implantar sinalização interpretativa, e gestores de projetos deverão dispor de todas as informações geológicas da região, pela localização de coordenadas geográfica, imagens e particularidades,

(iii) Contratar serviços geológicos especializados para elaborar estudos de impacto ambiental e os potenciais efeitos aos recursos a serem utilizados,

(iv) Atender aos princípios da Lei n.º 12.608, de 10 de abril de 2012, sobre a prevenção de desastres naturais (Brasil, 2012a)

Os dispositivos legais garantem o pleno exercício dos direitos do cidadão ao acesso à prática profissional e o compromisso com a preservação no uso de lugares de interesse geoturístico, desde que cumpram os requisitos vigentes:

(i) Constituição do estado de Roraima, em seu art. 20 aborda o incentivo e promoção do turismo como fator de desenvolvimento social, econômico (Roraima, 1991),

(ii) Lei n.º 9.985, de 18 de julho de 2000, que institui o Sistema Nacional de Unidades de Conservação SNUC (Brasil, 2000),

(iii) Lei n.º11.771, de 17 de setembro de 2008, dispõe sobre a política nacional de turismo e desenvolvimento do setor (Brasil, 2008),

(iv) Lei n.º 12.651, de 25 de maio de 2012, prevê a proteção de áreas de preservação permanente APP (Brasil, 2012b).

Além dos instrumentos legais acima referidos, que regem a gestão de ambientes naturais, monitoramento participativo com o apoio da comunidade, há ainda a considerar os agentes financeiros, que auxiliam no desenvolvimento de projetos, e.g., Banco da Amazônia, Caixa Econômica Federal, que viabilizam empreendimentos de finalidade ou interesse geoturístico, e pessoa física que desenvolva atividade ligada à cadeia produtiva da atividade. A linha do governo federal diretamente ligada ao Ministério do Turismo, disponibiliza o Fundo Geral de Turismo (FUNGETUR), é destinado ao setor para implantar, adequar negócios e iniciar outros. Entre os desafios para a tomada de recursos constam: a superação burocrática, a ausência de planejamento com participação das comunidades locais e gestão do projeto (Brasil, 2020).

Nesse contexto, alguns pré-requisitos para a formalização dos procedimentos para legalização da empresa prestadora de serviços turísticos indicam-se a seguir:

(i) Realização de cadastro no Ministério do Turismo — MTur (2022), um diferencial para ter acesso às linhas de financiamentos, o denominado Cadastur— feito gratuitamente,

(ii) Documentos necessários ao Cadastur: Cadastro Nacional de Pessoa Jurídica CNPJ e Classificação Nacional de Atividade Econômica — CNAE, compatível com o cadastro pretendido, como agência de turismo, meio de hospedagem, entre outros,

(iii) Valor de financiamento, a ser pleiteado junto ao agente financeiro representante, projeto de investimento, financeiro, projeto de bens, sendo o valor de financiamento a ser pleiteado ao agente financeiro representante, de financiamento até 100% do investimento, prazo de amortização em até 60 meses, carência para o início do pagamento de até dois anos,

(iv) Sistema de amortização: Sistema de Amortização Constante SAC,

(v) Capital de giro.

Entre os agentes financeiros, responsáveis pelas análises e aprovações dos financiamentos pleiteados pelos cidadãos ou empresários, constam: Bancos da Amazônia, Brasília, Nordeste, Banpará, Agência de Fomento do Amapá e Caixa Econômica Federal .

Em conformidade com as condicionantes da sustentabilidade, devem ser premissas para a postura do cidadão, em qualquer local, atitudes em favor da paz, prosperidade e redução das desigualdades, assim como atitudes positivas em prol do planeta. Para tais, deve-se:

(i) Informar as autoridades quando houver problemas geoespaciais relativos a qualidade dos corpos hídricos, queimadas em florestas e áreas de savanas,

(ii) Requisitar transparência das instituições públicas sobre os dados da região, uma vez que esses se tornam, muitas vezes inacessíveis,

(iii) Ter consciência do papel do cidadão no compartilhamento de conhecimento e contribuição para o alcance da prosperidade, no somatório pelo desenvolvimento sustentável,

(iv) Estimular outros cidadãos menos sensíveis a não queimar e a não poluir os recursos naturais com resíduos, e.g., plásticos, eletrônicos, inseticidas, pesticidas e óleos,

(v) Todas as atitudes pró geoturismo, segundo Gutak et. al., (2023) enfatizam novas descobertas de formações geológicas como cachoeiras, gargantas e cenários paisagísticos de grande beleza, devem ser registrados por imagens fotográficas, vídeos com narração, descrição de corpos hídricos. Essas informações subsidiam banco de imagens da região para futuras gerações.

A geodiversidade e cidadãos não são suficientes para desenvolver o geoturismo, sendo necessário a gestão da comunidade local e atos administrativos, atentando-se para a busca de um auxílio no planejamento, formalização de empreendimento e cumprimento das recomendações ambientais. Diante desses compromissos, sugere-se atenção para o fortalecimento da gestão local em sincronia com os ODS em favor da preservação dos recursos para prosperidade da sociedade.

Com a abertura de pequenos negócios que gerem postos de trabalhos diretos e indiretos, acrescenta-se o valor agregado percebido no preparo de produtos regionais. Nessa dimensão, o apoio por parte do setor público, empresas do setor privado e organizações sem fins lucrativos, fortalece o comprometimento do cidadão local no sustento para as gerações presente e futuras (Leal et al., 2018, El-Fekey e Adel Mostafa, 2023).

Frente ao rol de responsabilidades, há a necessidade de se impactar a cadeia turística em face aos desafios, como a estruturação sócioespacial da região-âncora. Nesse sentido, apresentam-se algumas sugestões de pesquisas futuras na óptica dos ODS, pois, na atualidade, para o pleno alcance e em prol do bem social e ambiental, devem acontecer parcerias. A soma de conhecimento, recursos públicos e privados, são estratégicos e necessários na realização de grandes projetos em busca da prosperidade de lugares remotos (Leal Filho et al., 2022) deve ser incentivada. A exemplo, apresentam-se:

(i) Condicionantes para o clima regional como repercussão no global, que atinge o geoturismo, um dos fatores mais afetados pelas mudanças climáticas decorrentes de ações antropogênicas (INPA, 2008, Matshusa et al., 2021). O clima é fator determinante na escolha de destinos turísticos e os usos de diversos recursos naturais e ambientes prósperos, portanto, ações sinérgicas devem erradicar e/ou minimizar incêndios florestais, poluição hídrica e em nascentes,

(ii) Adoção de protocolos de segurança para dar maior fruição ao local, como identificar responsabilidades conjuntas nas áreas de formação rochosa e de possíveis áreas de riscos, áreas que contenham mirantes e encostas que podem apresentar degradação de material rochoso, visando a segurança do turista e/ou visitante.

Por último e não menos importante, é imprescindível dar sequência as pesquisas, para investigar a pressão pelo desenvolvimento e pela mudança nos usos da terra, traduzidas em danos físicos, poluição e interrupção de processos naturais, as quais não só implicam as mudanças climáticas, mas também resultando em ações da componente socioambiental limitada pela perda de elementos da geodiversidade. A continuidade da pesquisa não se

limita a preencher lacuna de conhecimento na atividade geoturística na Amazônia, mas aprimorar continuamente para ser aplicada e cooperar para novos georoteiros no sentido de implementar estratégias de preservação do município de Mucajaí, Roraima, com consequências socioambientais transformadoras e em cumprimento de ações reais para Agenda 2030.

PUBLICAÇÃO CIENTÍFICA COMPLEMENTAR

Apresenta-se a seguir um conjunto de publicações adicionais produzidas, consignadas em simpósios nacionais e internacionais, permitindo o aumento da abrangência da pesquisa sobre a sustentabilidade do geoturismo. Assim, as pesquisas a seguir apresentadas, não menos importantes e de dimensão integradora com os capítulos da tese, sendo detentoras de qualidade e de caráter científico ainda no âmbito desta tese, foram desenvolvidas a partir de amplo estímulo dos orientadores, com o intuito de ampliar contatos com acadêmicos brasileiros, europeus e de diversas áreas, e visando uma formação científica de excelência. As publicações produzidas estabelecem conexões com as perspectivas geológica e geomorfológica, e são imprescindíveis à visibilidade, progresso da pesquisa e desafios geocientíficos da sustentabilidade do mais recente tipo de turismo, o geoturismo. Este é detentor de caráter científico educacional e favorece o cidadão do entorno do atrativo identificado na região amazônica, mais especificamente em Mucajaí, Roraima, Brasil. Nesse escopo, ressaltam-se as publicações do tema "turismo" no *Congreso Universitario Internacional sobre Contenidos, Investigación y Docencia CUICIID*, em 2020 em Madrid, Espanha, que constam no Livro de Atas "*Contenidos de Humanismo para el siglo XXI"*. Nesse trabalho, comprova-se o resultado do simpósio inserto nas páginas 379-383 e registra-se em sequência.

A SUSTENTABILIDADE DO GEOTURISMO NO NORTE DA AMAZÔNIA: UM ESTUDO DE CASO DE MUCAJAÍ-RR, BRASIL[8]

O *Congreso Universitario Internacional sobre Contenidos, Investigación y Docencia (CUICIID*): realizado em Madrid, Espanha. Esse evento abordou o tema: A profissão e a universidade de hoje, realizado em modalidade virtual. Reuniu uma diversidade vasta de áreas de acadêmicos e discentes, de grande impacto e relevância científica. O meio de verificação são as publicações e livro de atas do evento. O *Congreso* permitiu a disseminação em espaço virtual e científico do tema da pesquisa, resultando num capítulo internacional.

[8] **Veras,** A. S. S., Dinis, M. A. P. (2019). **The Sustainability of geotourism in Northern Amazon, a case study of norte da Mucajaí-RR, Brazil.** *Proceedings of the Congreso Universitario Internacional sobre Contenidos, Investigación y Docencia (CUICIID)*, Madrid, Espanha.

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30 The Sustainability of geotourism in Northern Amazon, a case study of Mucajaí-RR, Brazil

Ana Sibelonia Saldanha Veras[1] *y María Alzira Pimenta Dinis*[2]

1. INTRODUCTION

The diversity of landscape scenarios in Roraima, a Brazilian state located in the north of the Amazon, is linked to its tectonic-structural and lithological history, which shapes the modeling of hills, mountains and extensive flat areas, products of the planet's evolution over time and part of the natural world. Mucajaí, the locale focused on in this study, is part of this scenic wealth, with emphasis on its geological-geomorphological aspects, which promote the potential of a landscape for geotouristic activity (Holanda et al, 2014, Ballesteros-Camaro & Ríos-Guerrero, 2019, p. 19).

Geotourism is increasingly carried out for interpretation and preservation purposes in many parts of the world, such as Europe, South Africa, and, more recently, Brazil. Based on the formations that improve nature's beauty, this kind of tourism is a means of advertising geodiversity and, depending on infrastructure conditions, becomes economically viable while still following the principles of sustainability.

Recent studies have fit landscapes into geoecology because they are pointed as a visual effect of what is perceived through the conjunction of visible objects, such as landforms and also through subjects, bound to their needs and perspectives (Freire et al., 2018, p. 37). It is worth noting that geotourism practices are performed by people interested in discovering and interpreting scenic formations and beauties of mountains with a both scientifically and globally high value (Posen et al., 2019, p. 17). This activity figures as a sustainable development strategy, focused on strengthening the identity of a territory that comprises a transcendental geological heritage, used and preserved for future generations (Sánchez-Cortez, 2018, p. 447) highlights. Nature in Mucajaí has low density of people or no settlements at all, and its citizens are involved and valued by resource management. In

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addition, this modality strengthens and promotes rural areas, as Brzeziñska and Skowronek (2018) and Figueiró (2019) point out. It is in rural areas that significant natural characteristics are found. Samples from different populations, habitats, ecosystems and freshwater sources that add value to the landscapes need to be protected. It is also important to ensure the sustainable use by its population, improving and promoting the economic viability of the natural resources.

According to (Rangel, 2018, p. 70) and (Dowling, 2010, p. 3), geotourism is increasingly used for interpretation and preservation purposes in many parts of the world, such as Europe, South Africa and, more recently, Brazil. Based on the formations that improve nature's beauty, it is a means of advertising geodiversity and, depending on infrastructure conditions, becomes economically viable while still following the principles of sustainability (Piacentin et al, 2019, p.19). There is now a set of administrative directions to be complied with by citizens, entrepreneurs and public entities in search of conditioning factors applicable to resource management. These were created as an instrument of regulation and fulfillment of the responsibilities of each role in case of significant environmental impacts, in order to prevent and reduce undesirable effects.

2. OBJECTIVE

To determine, through a sustainable perspective and within the ecology of the environment, the environmental conditioning factors for a better performance of the ecological services.

3. METHODOLOGY

The stages for this research were an *in loco* description of the environments, where trail and waterfall sites were verified. The exploratory-descriptive methodology aimed at the understanding and interpretation of environmental conditioning factors, considering the responsibilities of citizens towards nature. This is supported (Brilha, 2005, p. 57; Gray, 2013; Pereira, 2006, p.79) and ABNT-ISO 14001 (2015, p. 31), who emphasize the importance of relief formations for the understanding of Earth Sciences and the commitment of citizens, entrepreneurs and public institutions to not degrade, not pollute, and also to provide compensatory measures consistent with environmental policy, conditioning factors that may explain Brazilian legal procedures and requirements for the use of environmental resources towards sustainability.

When researching at the field, the activities were a walking time, observation and description, photographic records and a registration of the geographical location of the waterfall.

Therefore, the aspects considered were the destruction of geological monuments; absence of vegetation cover; and ecosystem loss with reversible damage.

4. RESULTS

Mucajaí has several promising trails and environments favorable to visitation, starting with their tropical climate, and the Mucajaí River, the main tributary of the Branco River, which offers a good visibility of the region, its pre-Cambrian rock formations that originate Granites and Granodiorites, Diorites and Migmatites from the Guianense Complex. The heights of this relief range from 200m to 1000m (Melo et al, 2005, p. 145). Along with its biodiversity, they provide the ingredients for geotourism despite the incipient infrastructure. Cachoeiras do Evandro and other waterfalls are located at coordinates N 02º 25' 27" and W 61° 29' 29", on mountains in which visitation is very popular. It is important to highlight that the endemic vegetation presents floristic homogeneity, formed by a well-preserved ombrophilous forest, which extends over a wide geographical area, so that land has a strong geotouristic appeal. The access trail to the attractions consists on a moderately elevated path, with a handrail to support the climb, as shown in figure 30.1.

Figure 30. 1: a) Visual scheme with details of the environment with interpretive trails; b) Access trail with a length of 1.2 km; c) Environment, close to waterfall, with rocky scenery, composed by granitic lithology from the Mucajaí intrusive suite. Elaboration: Authors.

5. CONCLUSIONS

Liability for the resources may occur before or after their violation. But when the resources are protected beforehand, we should call it a preventive protection, because a primary right has been offered to the environment, the right on which we are all dependent. If protection comes after violation and inflicted damage, then only repairing the damage is possible.

It is evident that challenges are inevitable when launching an activity focused on geotourism. It is also challenging to think about measures within the scope of the legislation available in the national territory that establish the duties and responsibilities of those who wish to use environmental resources for tourism purposes. Given the widespread scarcity of financial resources to supply trail structure, it is necessary to assess the environmental burden in order to know the interaction between ecosystem services and, therefore, improve the planning of activities. The main character, the citizen, should be provided with means and tools to protect, promote, and benefit from nature. Moreover, his or her preparation should happen spontaneously, when they show interest to operationalize an activity, such as the preparation of an interpreter of the rock landscape, the proper welcoming of tourists, handicraft, the promotion of their gastronomy, all of which support a sustainable development of the local population. Interpretive signs will also help communicate relevant information about the place's geology-geomorphology.

The observed conditioning factors allow for interpretation and knowledge acquisition through ecologically sustainable actions, while respecting the principles of responsibility, according to the guidelines of the Brazilian Association of Technical Standards-ABNT, ISO 14001(2015, p. 30) which guides the management system and/or environmental conditioning factors and seeks a balance between environment, citizen, and economy, so that sustainable use of resources is possible. However, the success of citizens regarding the responsible use of these environments is established in various legislation documents and protocols, and they must be followed, especially the cycle *Plan* – to plan the environmental objectives, in tune with the processes necessary for the results; *Do* – to implement the processes as planned; *Check* – monitor, verify and measure processes that concern environmental policy, including their commitments; and *Act* – to act, take action for continuous improvement.

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GEODIVERSIDADE COMO RECURSO DO GEOTURISMO: UMA EXPERÊNCIA NA REGIÃO CENTRAL DE RORAIMA, BRASIL[9]

No IV Congresso Internacional Educação, Ambiente e Desenvolvimento, a modalidade de participação validada foi *on-line* pelo contexto pandêmico ocorrido em escala planetária. A ênfase do evento deu-se na importância do Turismo em diversos ambientes e da Educação no contexto da natureza. Assim, apresenta-se a descrição da geodiversidade dentro da dimensão de beleza da paisagem e sua importância para a atividade do geoturismo sustentável na região central denominada Mucajaí-RR, Brasil.

[9] **Veras, A. S. S**., Vidal, D. G., Dinis, M. A. P., Barros, N. A. (2020). **Geodiversidade como recurso do geoturismo: uma experência na região central de Roraima, Brasil.** *Proceedings of the IV Congresso Internacional Educação, Ambiente e Desenvolvimento*, OIKOS, Leiria, Portugal.

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Conflito Armado de 1954 e a 2ª Conferência Internacional para a Conservação dos Monumentos Históricos de 1964 representam mudanças substanciais, ainda que alicerçadas numa lógica de mera preservação dos monumentos, da valorização e reconhecimento da importância dos bens patrimoniais, não se encontrando alusão à sua intangibilidade (Smith, 2006). Só no pós-guerra mundial, e depois de perdas irreversíveis no património, se adopta uma postura de conservação. Mas foi somente em 1972, com a Convenção para a Proteção do Património Mundial, Cultural e Natural, ainda que com um discurso predominantemente de conservação e proteção dos monumentos, que se assiste a uma reformulação do conceito de património, com a introdução de uma necessidade política de valorizar e reconhecer o património natural (Nogueira e Vidal, 2018). Em 2003, fruto da Convenção para a Salvaguarda do Património Cultural Imaterial da Humanidade, vislumbra-se uma abertura do campo, colocando a tónica na sua dimensão imaterial. Segundo à mesma, o património cultural imaterial fazem parte das expressões culturais e as tradições, formas de vida e de organização social que se preserva como forma de respeito da sua ancestralidade, para as gerações futuras (UNESCO, 2003).

O conceito de sustentabilidade surge mais tarde, bem como a sua prática universal (Vidal, 2019). Alinhado com a sustentabilidade, com as ações depreendidas em favor das comunidades locais, de melhoraria do conforto e dos seus conhecimentos, o geoturismo emerge como uma atividade que usa os recursos estéticos para incentivar o desenvolvimento económico sustentável, promovendo a qualidade de vida da população local, valorizando e potenciando o saber tradicional que é utilizado como ferramenta de transmissão com realismo aos geoturistas e pesquisadores. Nesse sentido, o presente artigo tem como objetivo apresentar algumas vantagens da geodiversidade disponível na Região Central de Roraima, Brasil numa abordagem geográfica. Em termos de abordagem metodológica efetuou-se um levantamento de referencial teórico sobre a geodiversidade multifacetada para a interpretação geoturística. Quanto ao aprofundamento da temática as ilustrações foram captadas na região, através de observação participante e registo in loco.

A Geodiversidade e o desenvolvimento sustentável local

A "geodiversidade" foi usada pela primeira vez em 1993 como equivalente geológico do termo biodiversidade. Aceite internacionalmente nos últimos anos, tornou-se parte do paradigma geológico, amplamente divulgado e utilizado nas agendas internacionais, nomeadamente como um critério básico para selecionar locais de geoconservação que representam a geodiversidade de um país, província ou região.

Como área recente dos estudos das geociências e de amplo escopo, a geodiversidade abarca treze áreas e usos que despertam a salvaguarda mundial: planeamento, gestão e ordenamento territorial, prevenção de desastres naturais, promoção da saúde e de um meio ambiente com qualidade e saudável, estudo da evolução da Terra e da vida, mitigação das mudanças climáticas globais, levantamento geológico e pesquisa mineral, adequada utilização dos recursos hídricos e da agricultura, obras de engenharia, promoção de educação de qualidade para todos e, ainda, uma geoconservação e turismo sustentada nessa visão da biodiversidade de ecossistemas complexos (Ramos et al., 2020; Santos et al., 2020). Analisada como estágios iniciais de ecossistemas jovens de um dado local ou paisagem, pode ter um impacto duradouro na dominação de mecanismo que estabelece o terreno para um desenvolvimento ecológico (Arcos e Franco, 2020; Schaaf, 2020). A geodiversidade apresenta-se no ambiente natural, contrapondo-se ao conceito de biodiversidade, mas aproximando-se ao de variedade de natureza abiótica. Gray (2008) define geodiversidade como "*The natural range (diversity) of geological (rocks, minerals, fóssil) geomorphological (landform, process) and soil features. It include their relationships, properties, interpretations and systems*".

As variedades de recursos abióticos apresentam-se, e dão origem, a cursos de águas, sendo estes procurados para passeios aquáticos e escaladas em rochas, sendo ao mesmo tempo visível a exposição de cavas, amoladores e inscrições em rochas que caracterizam a cultura antepassada disponível aos cidadãos (Reverte et al., 2020). Essa variedade de ambientes com monumentos geológicos, isto é, na sua potencialidade enquanto recurso geoturístico, bem como o envolvimento da comunidade com atitudes de salvaguarda desses recursos, são importantes elementos no desenvolvimento de áreas rurais numa escala local. Para além disto, existe a possibilidade de desencadear o surgimento de pequenos negócios, novos postos de trabalhos diretos e indiretos, para além da redução de migração e da geração de resíduos ou outras fontes de poluição. Um exemplo que ilustra o sucesso da geodiversidade em área deprimida ocorreu marcadamente no território de Lesbos, na Grécia, fato este que dinamizou socioeconomicamente os cidadãos locais da Petrified Forest European Geoparque, satisfazendo a perspectiva da comunidade de forma abrangente, ou seja, não apenas pela comercialização dos serviços turísticos mas também pelo despertar da consciência sobre a importância das características do ambiente (Álvarez, 2020; Stephens, 2020).

Estudo da área: contexto geodiversidade local

Localizada na região Norte do Brasil, na porção central denominada de Planalto Central de Roraima, a área em estudo apresenta uma

geodiversidade de relevo basicamente formado por rochas ígneas e metamórficas, com elevado grau de metamorfismo, da Suíte Metamórfica Rio Urubu, sendo compostas de gnaises, metagranitoides, granulitos de idade Paleoproterozóica. Nessa porção predomina uma superfície de aplainamento conservada onde pontuam elevações que variam de 400 a 1.000 metros e se apresentam com bastantes fraturas e falhas, modelados por águas pluviais e agentes intempéries, bem como por drenagens de primeira ordem (Holanda, 2014). Além desses elementos naturais, a região é cortada pela BR-174, uma importante rodovia que faz ligações com todos municípios e comércios da capital do Estado e tem sido alvo de transformações em decorrência de ocupação populacional no município de Mucajaí com uma área de 12.337.851 Km2 (Figura 1).

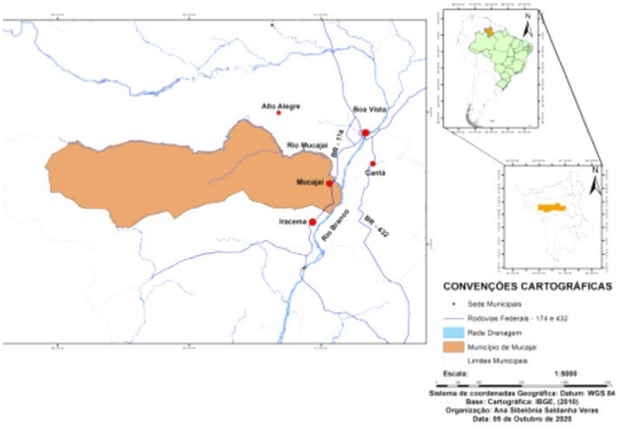

Figura 1
Mapa de localização da área da pesquisa: Município de Mucajaí--RR

Fonte: Base Cartográfica Instituto Brasileiro de Geografia e Estatística -IBGE (2010).

Materiais e métodos

A pesquisa apresenta um caráter descritivo, propondo-se a analisar as características de atrativos de interesse geológico-geomorfológico. Para tal, foi utilizada a Carta planialtimétrica: Mucajaí na escala 1:50.000., pertencentes ao Instituto Brasileiro de Geografia e Estatística-IBGE. Para a descrição dos atrativos mobilizou-se a metodologia de Pereira et al. (2013), assente em três pilares: (i) Pesquisa de referencias para identificar e descrever os recursos abióticos com potencial local para o geoturismo; (ii) Recolha de dados em campo, através do registo fotográfico, entre os dias 17 a 20 de setembro de 2020; (iii) Composição do Mapa temático de localização da área, através do software ArcGis 10.4. Na análise das referências foram identificadas as características consistentes de acordo com o que é preconizado pelo geoturismo, utilizando a geodiversidade como instrumento científico (ver Tabela 1).

Geodiversidade	Área potencial	Objetivo
Elementos abundantes no território	Paisagem	Locus de interpretação das características geológicas-geomorfológicas e geográficas da região de forma a sensibilizar o cidadão à salvaguarda do património natural.
	Geologia	Principal atrativo de interpretação da geodiversidade.
	Rocha	Rochas (i.e., elementos pétreos) são objetos de estudos científicos, usados para promover a geodiversidade.
	Relevo	As diferentes formas de relevos locais que resultaram em escarpas trabalhadas por processos de erosões.
	Cultura	A interpretação das características e o fortalecimento da cultura pelo cidadão local.

Tabela 1
Atividade do Geoturismo e usos no território.

Com base na importância da geodiversidade para o geoturismo foram descritos os atrativos locais da região Central do estado de Roraima, especificamente Mucajaí. Além da estratégia de divulgação a geodiversidade local, e dos seus componentes biológicos, abióticos, paisagísticos, acrescidos aos culturais, os mesmos devem ser salvaguardados pela comunidade e por aqueles que visitam a região (ver Figura 2).

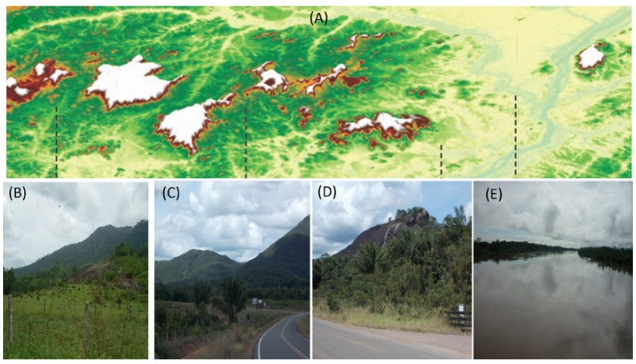

Figura 2
Variedades de recursos na região Central (Mucajaí-RR, Brasil)

Legenda: (A) a região apresenta a geomorfologia da região Central com abundantes superfícies planas e relevo pronunciado cuja altitude varia entre 100 a 900 metros, entrecortado por rede de drenagem; (B) a geodiversidade se apresenta com toda sua pujança o que demonstra no ambiente uma perfeita harmonia da vegetação, isto é, a componente biótica alimentada pelo substrato da rocha; (C) o relevo regional de topo convexo sobressai na região, potenciando a beleza imponente e com função de refúgio de espécies exóticas e

indivíduos. As visitas a essas áreas são acessíveis por vicinais (estradas sem asfalto) e asfaltadas; (D) os paredões rochosos, nomeadamente de granitos da Suíte Mucajaí, são comuns na região, sendo vulgarmente utilizados como motivos de artes concebidas pelo cidadão local; (E) o rio Mucajaí, um curso hídrico muito importante que apresenta ao longo de seu percurso entrelaçando as corredeiras e ilhas florestadas de grande beleza cênica. Fonte: Figuras pertencentes ao Banco de Imagens dos Autores.

Considerações finais

O geoturismo, entendido como uma nova e próspera atividade neste artigo, enfatizou a alta geodiversidade e os elementos obrigatórios que a compõem (i.e., geologia, relevo, hidrologia, cultura), enquanto recursos relevantes e que se configura dentro do que preconiza o desenvolvimento do geoturismo em território, a citar o Amazônico. Neste olhar à tão importante e visada Amazônia, onde insere-se a região Central, Mucajaí, os recursos encontram-se quase intocáveis, preservados e podem ser aproveitados de forma profissional e sustentável conduzida por gestão das comunidades locais que compõem os pequenos núcleos rurais, sincronicamente oferecendo oportunidade de emprego e renda. Dentre essa vasta geodiversidade é essencial que os planejadores, nas suas tomadas de decisões, estejam conscientes da utilização dessas áreas para educação e geoturismo, ensejando áreas prioritárias a geoconservação, a valorização do património geológico e fortalecendo a identidade do território almejado por um bom gestor.

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GEOTURISMO: UMA ATIVIDADE INOVADORA QUANTO AO USO SUSTENTÁVEL DOS RECURSOS NATURAIS[10]

O Simpósio Internacional de Ciências Integradas da Universidade de Ribeirão Preto, em sua edição XVII, na modalidade de participação *on-line,* ocorreu no contexto pandêmico em escala planetária. A edição realçou a importância da integração de todas as ciências, Administração, Economia, Meio Ambiente, entre outras. No que concerne à participação no referido Simpósio, foi apresentada descrição do geoturismo como fenômeno inovador que interpreta a natureza com destaque à sustentabilidade do patrimônio geológico.

[10] **Veras**, A. S. S., Vidal, D. G., Dinis, M. A. P., Barros, N. A. (2020). **Geoturismo: uma atividade inovadora quanto ao uso sustentável dos recursos naturais**. *Proceedings of the XVII Simpósio Internacional de Ciências Integradas da Universidade de Ribeirão Preto*. Guarujá, São Paulo, Brasil**.**

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XVII SIMPÓSIO INTERNACIONAL DE CIÊNCIAS INTEGRADAS DA UNAERP - CAMPUS GUARUJÁ

Geoturismo: uma atividade inovadora quanto ao uso sustentável dos recursos naturais

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Este simpósio tem o apoio da Fundação Fernando Eduardo Lee

Linha de pesquisa: Administração: Meio Ambiente e Sustentabilidade

Apresentação: Oral

O geoturismo tem apresentado crescimento substancial em todo mundo, sendo reconhecido como uma atividade que diferencia a identidade do território, as suas características físicas (i.e., natureza física geológica-geomorfológica), o ambiente e a sua estética, valorizando o cidadão local. Este reconhecimento do cidadão resulta no incentivo do mesmo à prática de conservação, inclusão e empoderamento na comunidade, bem como a interpretação do geossítio com o apoio do especialista para apresentação da geologia-geomorfologia enquanto processo modelador. Amplamente sedimentado em vários países, como Austrália, Grécia, Portugal, Estados Unidos, Malásia, Índia e Irã, só mais recentemente o Brasil adotou a iniciativa de geoconservação do patrimônio geológico, ainda que com adaptações na seleção e cadastro de geossítio incluindo o caráter geográfico (i.e., qualidade única do destino). O geoturismo assume-se como uma atividade inovadora que proporciona ao turista e visitante não apenas uma visão antropogênica, mas a importância da conservação da geodiversidade pelo cidadão. O foco da atividade do geoturismo assenta-se no conhecimento sobre a natureza de uma forma que não seja uma mera contemplação estética no qual o visitante aprenda a gênese dos elementos constituintes da paisagem (i.e., naturais e artificiais) devidamente explicados pela cultura tradicional do cidadão que consubstancia a sinergia da atividade. O objetivo desta pesquisa é o de dar uma maior visibilidade ao geoturismo enquanto prática que busca de forma sustentável utilizar o patrimônio geológico e as características geográficas do lugar, enquanto principais recursos turísticos. Dessa forma, metodologia utilizada ancora-se

numa componente de análise do material pesquisado, apoiado numa abordagem de natureza qualitativa, de levantamento de referências bibliográficas, tratando-se, portanto, de uma discussão teórico metodológica realizada com base em autores que discutem o geoturismo num contexto sustentável. Da revisão dos estudos analisados, salienta-se a componente inovadora desta atividade, materializada no uso da geoconservação dos recursos acinéticos, priorizando a salvaguarda da identidade geológica-geomorfológica (i.e., geossitio). Além do mais, a prática do geoturismo está alinhada aos objetivos do desenvolvimento sustentável (ODS), um dos elementos centrais da Agenda das Nações Unidas para o período de 2030 (ONU, 2015; Mirari et al., 2020), na qual o cidadão é protagonista no meio ambiente para remir com dignidade, o lucro econômico, a valoração dos saberes locais com consciência, a responsabilidade e o uso adequado dos recursos em dada área ou região (e.g., cientifico, educativo e turístico) do patrimônio natural (Farsani, 2017; Dowling e Newsome, 2018; Santangelo e Valente, 2020). A literatura também indicou que, quando bem planejada, a atividade do geoturismo com foco na descrição do lugar sob os pilares sustentáveis e no bem-estar do residente, faz cumprir as atitudes e exigências dos viajantes na atualidade (Neto de Carvalho e Rodrigues, 2020; Sadry, 2020). Mesmo com a existência de ações antropogênicas é possível implementar, por meio de gestão, a geoconservação sustentável de geossítios (e.g., pedreiras, minas abandonadas) com vista a suprimir as fontes contaminantes do ambiente e da geodiversidade (Gray, 2019; Vukoičić et al., 2020). Assim, o geoturismo como atividade inovadora, resgata o desenvolvimento do lugar dando-lhe vida, envolvendo os cidadãos locais, otimizando os benefícios econômicos e promovendo o empreendedorismo, especificamente em áreas rurais, desenvolvendo geoprodutos da cadeia de serviços do turismo (Duarte et al., 2020). Da análise documental realizada, o geoturismo assenta no princípio de um bom planejamento, envolvendo três setores: governo, *trade* turístico e a comunidade, *lócus* de realização da atividade. Para tal, é necessário um inventário com vista a selecionar os geossítios, treinar a comunidade de forma a transmitirem os seus conhecimentos e de como apresentarem em linguagem acessível aos interessados (i.e., público composto pelo turista especializado e/ou visitante casual). A Amazônia Central, enquanto região dominada por um patrimônio natural inestimável, é um exemplo claro das potencialidades da aplicação do geoturismo, onde é possível interpretar a plenitude dos elementos da paisagem: cachoeiras, serras e montanhas para contemplar na paisagem (Figura 1).

Figura 1. Ambientes da geodiversidade geológica-geomorfológica

Fonte: Figuras pertencem ao banco de imagens dos autores.
(A) Serra relevo também conhecido como colina, cordilheira, maciço, monte, escarpa de planalto conferem características geológica por sua formação rochosa, hidrológica por abrigar nascentes em fraturas geológicas. (B) Paredão rochoso fonte de extração de materiais para construção civil, (C) Cachoeira, queda d'água interpretada pela geomorfologia como erosão

diferencial na rocha e produzida pelo choque da água ao cair.

Neste sentido deve-se ressaltar que o ambiente apresentado desperta a comunidade que vê na natureza inspirações para confecção de artesanatos lapidados em rochas, o que demonstra a forte ligação do cidadão com a geodiversidade. As caraterísticas expostas são de compreensão universal e seu caráter multiuso dota o território de um diferencial para alavancar a atividade. Contudo, importa sublinhar que não poderá ser negligenciada uma abordagem educativa do geoturismo com foco na geoconservação. Por fim, espera-se contribuir com uma síntese sobre esta prática através do estado-da-arte atual, salientado o geoturismo enquanto fenômeno turístico inovador em que a sua gênese assenta nos princípios sustentáveis do cidadão e da região.

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