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Complex organizations and biodiversity conservation: a systemic approach based on case studies of multinational enterprises and the Parisian metropolitan area

Organisations complexes et conservation de la biodiversité : une approche systémique basée sur des études de cas d'entreprises multinationales et de l'agglomération parisienne

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Titre : Organisations complexes et conservation de la biodiversité : une approche systémique basée sur des études de cas d'entreprises multinationales et de l'agglomération parisienne

Mots clés : Biodiversité, Entreprises multinationales, CSRD, Coévolution, Coûts de transaction, Changements organisationnels

Résumé : Il est essentiel d'impliquer les entreprises multinationales et les villes mondiales dans la conservation de la biodiversité. Ces organisations sont complexes et la manière dont les questions liées à la biodiversité peuvent être intégrées dans leurs activités reste floue. Cette thèse étudie quatre leviers d'action pour faire avancer le sujet : la réglementation, les pratiques d'approvisionnement, le processus de prise de décisions et la demande. La première étude mobilise la théorie économique des coûts de transaction pour analyser l'impact de la directive européenne dite CSRD (Corporate Sustainability Reporting Directive) et montre comment la directive devrait se traduire par une plus grande disponibilité de données sur les MNE et la biodiversité, mais aussi par une information de faible qualité, reflétant mal l'impact réel des entreprises sur les écosystèmes. La deuxième étude décrit comment

des dynamiques coévolutives favorise l'adaptation des organisations aux spécificités sociales, culturelles, écologiques, historiques et économiques des territoires d'approvisionnement des MNE, ce qui se facilite la création de bénéfices sociaux et écologiques. La troisième étude examine les processus décisionnels des multinationales à partir d'un échantillon de 16 multinationales françaises. Elle révèle des obstacles à plusieurs niveaux qui entravent une gestion efficace de la biodiversité, tout en suggérant des stratégies pour les surmonter. La quatrième étude examine la transformation organisationnelle induite par la demande à l'aide d'expériences de choix discret. Elle démontre que la prise en compte d'une demande hétérogène dans les politiques de renaturation peuvent accroître les avantages sociaux et écologiques générés.

Title: Complex organizations and biodiversity conservation: a systemic approach based on case studies of multinational enterprises and the Parisian metropolitan area

Keywords: Biodiversity, Multinational Enterprises, CSRD, Coevolution, Transaction costs, Organizational change

Abstract: Involving multinational enterprises (MNEs) and world cities in biodiversity conservation is crucial. These organizations are complex, and how to integrate further biodiversity issues in their operations remains unclear. This thesis investigates four means of action to advance their consideration on the subject: regulation, supply practices, internal decision-making processes, and demand. The first study applies a transaction cost economics perspective to analyze the European Corporate Sustainability Reporting Directive's impact on biodiversity disclosure. It describes how the directive should result in increased information availability but low-quality information, poorly reflecting the firms' actual impacts on ecosystems.

The second study describes how co-evolutionary dynamics support organizational adaptations to social, cultural, ecological, historical and economic specificities of its sourcing territories, ultimately facilitating social and ecological benefits. The third study investigates MNCs' decision-making processes based on a sample of 16 French MNEs. It reveals multi-level obstacles hindering effective biodiversity management while suggesting strategies to overcome them. The fourth study investigates demand-driven organizational transformation using Discrete Choice Experiments. It demonstrates the potential of integrating demand characteristics into greening policies to enhance social and ecological benefits.

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PREAMBULE

Les travaux présentés dans ce manuscrit examinent comment deux types d'organisations, les entreprises multinationales (MNE) et les métropoles, peuvent adapter leurs activités pour atténuer leurs impacts négatifs sur la biodiversité et ainsi contribuer à sa conservation. Une organisation se définit comme un groupe d'individus poursuivant un objectif commun (North, 1992). Selon North, les organisations sont les acteurs d'un jeu régi par des institutions. La biodiversité, quant à elle, désigne la diversité du monde vivant, englobant plusieurs dimensions – fonctionnelle, compositionnelle et structurelle – et plusieurs échelles – génétique, spécifique et écosystémique.

Cette recherche repose sur deux constats principaux. Premièrement, il est impératif d'intégrer les entreprises multinationales et les métropoles dans la lutte contre l'érosion de la biodiversité. Deuxièmement, les entreprises peuvent jouer un rôle plus actif dans la conservation de la biodiversité. En guise de préambule, les paragraphes suivants développent succinctement la démarche de recherche adoptée dans ce travail de thèse.

LA NECESSITE D'INTEGRER LES ENTREPRISES MULTINATIONALES ET LES METROPOLES DANS LA CONSERVATION DE LA BIODIVERSITE

Trois arguments principaux, détaillés dans l'introduction de ce manuscrit, soulignent la nécessité d'intégrer plus activement les entreprises multinationales ainsi que les métropoles dans les efforts de conservation de la biodiversité.

Le premier argument se fonde sur les impacts significatifs que ces deux types d'organisations ont sur la biodiversité, tant directement qu'indirectement à travers des facteurs tels que le choix des matières premières, les volumes d'extraction des ressources naturelles, la localisation de leurs activités, et leurs pratiques de production. À titre d'exemple, Folke et al. (2019) ont évalué que cinq entreprises dominent 90% du marché mondial de l'huile de palme, une industrie associée à la déforestation (Carlson et al., 2018). De plus, quatre entreprises multinationales captent 84% des ventes de pesticides, connus pour avoir des impacts néfastes sur la biodiversité (Brühl & Zaller, 2019). En ce qui concerne les métropoles, la croissance démographique urbaine devrait entraîner la conversion de 290 000 km² d'habitats naturels (McDonald et al., 2019). Au regard de leurs impacts négatifs sur la biodiversité, il est essentiel que les entreprises multinationales et les métropoles assument une part de leurs responsabilités en agissant pour la conservation de la biodiversité.

Le deuxième argument repose sur le rôle central de ces organisations au sein de nos sociétés et économies. Selon l'OCDE (2018), 80% du produit intérieur brut mondial est généré dans les

métropoles, où réside la majorité de la population mondiale (Jiang & O'Neill, 2017). Les entreprises multinationales, quant à elles, contribuent à hauteur de 28% du PIB mondial et à 26% de l'emploi à l'échelle mondiale (OCDE, 2018). Or ces organisations sont en partie dépendantes de la biodiversité pour fournir des produits et des services essentiels (de Carvalho et al., 2023 ; Deutz et al., 2020). Ainsi, exclure leur participation aux efforts de conservation de la biodiversité reviendrait à se priver de leviers importants pour les transformations sociales et économiques nécessaires.

Le troisième argument souligne que ces organisations disposent de ressources financières considérables. Pour stopper l'érosion de la biodiversité, il est estimé - en supposant que les dépenses publiques, l'aide au développement et la philanthropie suivent leur tendance actuelle - qu'un financement annuel de 824 milliards de dollars est nécessaire (Deutz et al., 2020). Ce montant équivaut à 36 fois les profits réalisés par le groupe LVMH en 2022, estimés à 22,7 milliards de dollars. En France, il est particulièrement opportun de solliciter la contribution du secteur privé, étant donné que ses dépenses pour la protection de la nature ont diminué depuis 2000 (Ricaud, 2019). Les métropoles, par leurs décisions budgétaires, ont également le pouvoir de mobiliser des investissements supplémentaires pour la conservation de la biodiversité (Acuto & Leffel, 2021). Ainsi, tant le secteur privé que les métropoles représentent des sources de financement substantielles, indispensables pour compléter les sources actuelles et lutter contre l'érosion de la biodiversité.

A l'aune de ces arguments, il apparaît essentiel d'intégrer les entreprises multinationales et les métropoles afin d'endiguer l'érosion de la biodiversité. Pourtant, des travaux indiquent que ces organisations abordent le sujet de manière superficielle.

UNE CONSIDERATION LIMITEE POUR LES ENJEUX DE CONSERVATION DE LA BIODIVERSITE

Malgré leurs impacts sur la biodiversité et leur potentiel crucial dans la préservation de celle-ci, les entreprises multinationales et les métropoles accordent encore peu d'attention à ce sujet. En ce qui concerne les entreprises multinationales, la divulgation d'informations sur la biodiversité est limitée (Adler, 2019). Lorsqu'elles le font, leur principale motivation semble être la gestion des relations avec les parties prenantes plutôt que la conservation de la biodiversité en tant que telle (Boiral, 2014 ; Boiral & Heras-Saizarbitoria, 2017). Par ailleurs, les entreprises ne sont pas suffisamment encouragées par les investisseurs à divulguer davantage d'informations. En effet, les aspects liés à la biodiversité demeurent peu pris en compte par les investisseurs dans leurs décisions d'investissement (Lambooy et al., 2018).

A la lumière de ces études, cette thèse soutient que les entreprises multinationales comme les métropoles peuvent agir davantage en faveur de la conservation de la biodiversité. Les travaux présentés se concentrent particulièrement sur la manière dont les activités et les pratiques de production de ces organisations évoluent, ou pourraient évoluer, pour engendrer des effets bénéfiques sur la biodiversité.

FAIRE EVOLUER LES FORMES ORGANISATIONNELLES

Une façon pour les entreprises multinationales et les métropoles d’agir davantage pour la conservation de la biodiversité réside dans l’évolution de leurs formes organisationnelles. Ces formes organisationnelles désignent la façon dont les activités sont structurées au sein d’une organisation. Elles recouvrent, entre autres, la nature des activités et des processus de production, la distribution des droits de décisions et des droits de propriété, la structure hiérarchique comme les modes de coordination et d’incitations (Ménard, 2010). Selon leur forme organisationnelle, les impacts d’une entreprise multinationale ou d’une métropole sur la biodiversité peuvent varier. Il est donc envisageable que ces organisations modifient leurs formes organisationnelles pour intégrer systématiquement les enjeux de conservation de la biodiversité dans leurs activités. Cette thèse adopte une approche empirique pour examiner les mécanismes par lesquels une telle évolution peut se produire.

PLUSIEURS LEVIERS INFLUENCENT L’EVOLUTION DES FORMES ORGANISATIONNELLES

Cette thèse se concentre spécifiquement sur quatre facteurs qui influencent les dynamiques organisationnelles : la législation, les interactions avec les territoires d’approvisionnement, les dynamiques internes et la demande. La législation joue un rôle déterminant dans le choix de formes organisationnelles, notamment à travers des aspects tels que le droit de la concurrence ou le droit des contrats. En réponse à ces cadres juridiques, une entreprise pourrait décider, par exemple, de former une joint-venture ou de se développer à travers un réseau de franchises.

Le deuxième levier examiné concerne les interactions avec les territoires d’approvisionnement. Ces interactions sont essentielles pour acquérir une meilleure compréhension des territoires et renforcer l’ancrage territorial d’une entreprise, ce qui influence les décisions organisationnelles concernant leurs impacts écologiques et sociaux (Shrivastana & Kennelly, 2013). Selon la nature des relations entre les organisations et les territoires où elles opèrent, les activités et les pratiques de production peuvent évoluer. Par exemple, Thorlakson et al. (2018) démontrent que le type de relation entre une entreprise et ses fournisseurs, plutôt que la simple contractualisation directe, influence l’adoption de pratiques de production écologiques promues dans le cadre d’un programme de certification volontaire.

Une fois les orientations stratégiques définies, leur opérationnalisation et la façon dont ces orientations vont concrètement prendre forme dépend de la collaboration d'acteurs au sein de l'organisation. Les dynamiques internes, marquées par des négociations entre acteurs et des conflits sous-jacents, jouent ainsi un rôle déterminant dans les évolutions organisationnelles. Ainsi, le troisième chapitre de cette thèse explore les facteurs internes qui encouragent ou restreignent les dynamiques de transformation des formes organisationnelles.

Enfin, le dernier chapitre de ce manuscrit adopte une vision classique des évolutions des formes organisationnelles où celles-ci évoluent en fonction de facteurs exogènes comme les innovations technologiques. En fonction de ces innovations, les caractéristiques des produits et des services demandés sur un marché évoluent. En réponse, une entreprise peut ajuster la structure de ses activités, adoptant, par exemple, une structure divisionnelle basée sur les segments de marché, une structure fonctionnelle centrée sur les compétences des employés et leur rôle dans la production, ou une structure matricielle combinant ces deux approches précédentes.

Cette thèse examine comment quatre leviers influencent, ou peuvent influencer, l'évolution des formes organisationnelles pour y intégrer les enjeux liés à la conservation de la biodiversité : la législation (chapitre 1), les interactions avec les territoires d'approvisionnement (chapitre 2), les dynamiques internes (chapitre 3) et la demande (chapitre 4).

PREAMBLE

The work presented in this manuscript examines how two types of organizations, multinational enterprises (MNEs) and cities, can adapt their activities to mitigate their negative impacts on biodiversity and thus contribute to its conservation. An organization is defined as a group of individuals pursuing a common goal (North, 1992). According to North, organizations are players in a game where rules are defined by institutions. Biodiversity, on the other hand, refers to the diversity of the living world, encompassing several dimensions - functional, compositional and structural - and several scales - genetic, specific and ecosystemic.

This research is guided by two main observations. First, it is imperative to integrate multinational companies and cities to address biodiversity loss. Second, these organizations can play a more active role in biodiversity conservation. The following paragraphs briefly outline the research approach adopted in this thesis.

A NEED TO INVOLVE MULTINATIONAL COMPANIES AND METROPOLITAN CITIES IN BIODIVERSITY CONSERVATION EFFORTS

Three primary arguments, outlined in the introduction of this manuscript, emphasize the necessity of involving multinational corporations and metropolitan areas in biodiversity conservation efforts.

The first argument highlights the significant impacts these organizations have on biodiversity, both directly and indirectly, through factors such as their choice of raw materials, extraction of natural resources, location of producing activities, and production practices. For instance, Folke et al. (2019) estimated that five companies control 90% of the global palm oil trade, a sector linked to deforestation (Carlson et al., 2018). Additionally, the authors show that four multinational corporations dominate 84% of the pesticide market, which is detrimental to biodiversity (Brühl & Zaller, 2019). Urban population growth is also projected to lead to the conversion of 290,000 km² of natural habitats (McDonald et al., 2019). Given these adverse effects on biodiversity, multinational corporations and metropolitan areas are increasingly called to acknowledge their responsibilities and take action to address biodiversity loss.

The second argument emphasizes the pivotal societal and economic roles played by multinational corporations and metropolitan areas. Cities, as highlighted by the OECD (2018), generate 80% of the world's gross domestic product and house a majority of the global population (Jiang & O'Neill, 2017). Similarly, multinational corporations contribute significantly to the global economy, accounting for

28% of the GDP and employing 26% of the global workforce (OECD, 2018). To provide essential goods and services, these entities rely on biodiversity (de Carvalho et al., 2023; Deutz et al., 2020). Excluding them from biodiversity conservation efforts would mean overlooking crucial opportunities for promoting social and economic transformations.

The third argument emphasizes the significant financial resources available to these organizations. Halting biodiversity loss would require an estimated annual funding of \$824 billion, assuming current trends in expenditure (Deutz et al., 2020). This amount is approximately 36 times the 2022 profits of the LVMH group, which were estimated at \$22.7 billion. In France, it is particularly timely to seek the contribution of the private sector, given that its expenditures on nature conservation have decreased since 2000 (Ricaud, 2019). Cities, through their budgetary decisions, also have the power to mobilize additional investments for biodiversity conservation (Acuto & Leffel, 2021). Thus, both the private sector and cities represent substantial funding sources essential to complement current resources and address biodiversity loss.

In light of these arguments, integrating multinational companies and metropolitan areas appears crucial for biodiversity conservation. However, research indicates a lack of substantial measures and action.

A LIMITED CONSIDERATION FOR BIODIVERSITY CONSERVATION ISSUES

Despite their significant impacts on biodiversity and their potential role in its conservation, multinational companies and metropolises currently allocate limited attention to this issue. Regarding multinational companies, only a handful of them disclose biodiversity-related information (Adler, 2019). When disclosures are made, the primary motivation often appears to be managing stakeholder relationships rather than directly addressing biodiversity conservation (Boiral, 2014; Boiral & Heras-Saizarbitoria, 2017). Furthermore, multinational companies are not sufficiently encouraged by investors to disclose more information. Indeed, biodiversity-related aspects remain little taken into account by investors in their investment decisions (Lambooy et al., 2018).

In light of these findings, this thesis contends that both multinational companies and cities can enhance their contributions to biodiversity conservation. The research presented here specifically investigates how these organizations' practices are currently evolving and how they could be transformed to yield positive outcomes for biodiversity.

TRANSFORMING ORGANIZATIONAL FORMS

One way in which multinational companies and cities can do more to conserve biodiversity is by

changing their organizational forms. Organizational forms refer to the way activities are structured within an organization. They cover, among other things, the nature of production activities and processes, the distribution of decision rights and property rights, the hierarchical structure and the modes of coordination and incentives (Ménard, 2010). Depending on their organizational form, the impacts of a multinational company or a city on biodiversity can vary. Therefore, these organizations could adapt their organizational forms to consider biodiversity conservation concerns in their operations systematically. This thesis employs an empirical approach to investigate how such organizational changes may unfold.

SEVERAL FACTORS INFLUENCE THE EVOLUTION OF ORGANIZATIONAL FORMS

This thesis focuses specifically on four factors that influence organizational dynamics: legislation, interactions with operating territories, internal dynamics and demand. Legislation plays a decisive role in the choice of organizational forms, notably through aspects such as competition law or contract law. In response to these legal aspects, a company might decide, for example, to form a joint venture or expand through franchising.

The second factor examined concerns interactions with operating territories. These interactions are crucial for gaining a better understanding of local social and ecological contexts and strengthening a company's territorial embedding. In turn, this understanding influences decisions regarding their ecological and social impacts (Shrivastana & Kennelly, 2013). Depending on the nature of these relationships, production activities and practices may evolve and, ultimately, ecological disturbances. For example, Thorlakson et al. (2018) demonstrate that the type of relationship between a company and its suppliers, rather than simply direct contractualization, influences the adoption of ecological production practices promoted under a voluntary certification program.

Once strategic orientations have been defined, their operationalization and the way in which these orientations take concrete form depend on the collaboration of actors within the organization. Internal dynamics, characterized by negotiations and underlying conflicts, thus play a decisive role in organizational evolutions. Thus, the third chapter of this thesis explores the internal factors that encourage or restrict the dynamics of organizational evolution.

Finally, the last chapter of this thesis builds on a classical view of the evolution of organizational forms, where they evolve in reaction to exogenous changes such as technological innovations. Indeed, depending on these innovations, the characteristics of the products and services expected on the market evolve. In response, a company may adjust the structure of its activities, adopting, for example, a divisional structure based on market segments, or a functional structure centered on employee skills

and their role in production, or a matrix-type structure combining the two previous approaches.

This Ph.D thesis examines how these four levers influence - or can influence - the evolution of organizational forms to incorporate biodiversity conservation issues: legislation (chapter 1), interactions with operating territories (chapter 2), internal dynamics (chapter 3) and demand (chapter 4).

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GENERAL INTRODUCTION

Indicators of ecosystems and biodiversity show a rapid deterioration, with rates of species extinction tens to hundreds of times higher than those observed over the past 10 million years (IPBES, 2019). International trade and urbanization are closely intertwined with the primary pressures driving biodiversity loss: land use change, the over-exploitation of natural resources, climate change, pollution, and invasive alien species. Much like cities, multinational enterprises (MNEs) emerge as critical actors in the economic, social, and political transformative changes advocated by the IPBES (2019) to curb biodiversity decline.

1. RATIONALE FOR FURTHER INVOLVING MULTINATIONAL ENTERPRISES (MNEs) AND CITIES IN BIODIVERSITY CONSERVATION

1.1. The case of MNEs

Following the Eurostat definition, MNEs are enterprises producing goods or delivering services in more than one country (Eurostat, 2019). Their further involvement in biodiversity conservation is crucial for several reasons.

First, MNEs contribute to the pressures driving biodiversity loss, notably through international trade. Lenzen et al. (2012) demonstrate that international trade drives 30% of species threats on the IUCN Red List and BirdLife International Threatened Bird List. Henders et al. (2015) show that the production of four exported commodities - timber, beef, soy, and palm oil – in Argentina, Bolivia, Brazil, Paraguay, Indonesia, Malaysia, and Papua New Guinea is responsible for 40% of the deforestation in these countries. Nguyen & Keiichiro (2021) demonstrate that in G7 countries, the total imported resources used for domestic consumption, minus total exports, lead to the deforestation of 1.8 trees worldwide per person per year. Similarly, DeFries et al. (2010) demonstrate a positive correlation between international trade and deforestation across 41 countries between 2000 and 2005. Dalin et al. (2017) estimate that international crop trade contributes to 11% of non-renewable groundwater depletion used for irrigation. Westphal et al. (2008) find a positive correlation between a country's imports and the number of invasive species. International trade also contributes to greenhouse gas emissions (GHG) emissions. Pendrill et al. (2019) assess that between 29% and 39% of GHG associated with global deforestation are attributable to international trade.

However, these estimates do not reflect the impacts of MNEs exclusively, as small and medium-sized enterprises also participate in international trade. Nevertheless, MNEs play an essential role in this trade, accounting for 55% of global exports (OECD, 2018) and 80% of global commodity trade.

(UNCTAD, 2013). Noticeably, Folke et al. (2019) link the impacts of international trade on biodiversity to MNEs by evaluating levels of firm concentration among 24 industrial sectors, including those significantly affecting ecosystems like agriculture and forestry, agrochemicals, seafood, animal pharmaceuticals, fossil fuels, or mining. For example, the authors reveal that in the mining sector, only five companies account for 91% of the world's platinum production, 88% of palladium, and 62% of cobalt. Ten companies account for 56% of the global fertilizer market, and four companies control 84% of the pesticide market, which has been associated with biodiversity decline (Li et al., 2020), surface and groundwater contamination (Zhang et al., 2011), marine eutrophication (Cruzeiro et al., 2016) and toxic waste (Damalas et al., 2008) and pesticide-resistant organisms development (Jansen et al., 2011). Folke et al. (2019) thereby show how MNEs have a disproportionate capacity to affect a significant portion of industrial biodiversity use worldwide.

In addition to their direct contributions to the primary pressures to biodiversity loss, MNEs also indirectly affect biodiversity through the effects of their activities on the social and economic organization of the territories where they operate. These influences can, in turn, affect natural resource governance (Agrawal & Yadama, 1997) and, eventually, ecosystems (Cinner, 2005; Lu, 2001). For instance, MNEs have been associated with population displacement (Yakovleva & Vazquez-Brust, 2018); land loss (Banks, 2009); weakened collective responsibility (Bastakoti et al., 2010); and social ties (Becker & León, 1998), which are factors influencing local governance of biodiversity (Ostrom, 2009).

Their indirect influence also concerns institutional arenas and the design of the rules for deviating from the status quo. Especially concerning European corporate policies on biodiversity conservation, their influence is reflected in the composition of the Commission mandated to provide technical advice on the European Sustainable Reporting Standards (ESRS), the European Financial Reporting Advisory Group (EFRAG). The EFRAG is a not-for-profit association that gathers European stakeholders interested in international reporting and accounting standards. Among EFRAG's 25 members in charge of providing technical advice on the ESRSs, 15 are or have been employed by MNEs, with ten of them for over a decade. The other ten members are representatives of NGOs (6 members in total, including one representing Polish listed companies and another representing European SMEs), academics (3 members), and one representative of the Social and Economic Council of the Netherlands. Another example of policy advocacy is Natura, a Brazilian MNE of the cosmetics sector, which took advantage of Brazil's 2022 presidential elections to launch a campaign challenging candidates on deforestation in the Amazon (Natura&Co, 2022).

Second, MNEs generate essential social and economic benefits, affecting livelihoods worldwide

through producing goods and services and creating jobs. Consequently, transforming their models to support biodiversity conservation involves navigating trade-offs and path dependencies. MNEs are responsible for 28% of the global GDP (OECD, 2018), and 26% of the world's jobs (OECD, 2018). A few MNEs exert substantial influence over the world's economies. Vitali et al. (2011) show that, among a sample of 43,060 MNEs, a narrow group of 147 controls¹ 40% of the operating revenues generated by the overall network. This group of 147 also holds complete control over itself. Thus, targeting this group of influential corporations could leverage massive actions supporting biodiversity conservation. The authors also find that three-quarters of the 147 core MNEs act within the financial industry, underscoring the importance of influencing these key international financial actors.

In the Global South, addressing the economic and social trade-offs associated with reversing MNEs' adverse impacts on biodiversity can become particularly challenging. This is due to the significant socio-economic influence exerted by MNEs, which often provide job opportunities and investments that complement public spending, thereby playing a central role in local development. Consequently, local authorities, citizens, or NGOs may face limited leverage in pressuring MNEs to address biodiversity conservation issues. For example, in the mining sector, MNEs have taken on significant social responsibilities by implementing micro-credit projects or community health programs to compensate for the loss of livelihoods, including environmental degradation and natural resource exploitation (Jenkins & Obara, 2006). However, as these initiatives can result in local communities becoming dependent on their support (Awuah et al., 2021; Frynas, 2005; Jenkins & Obara, 2006), it appears necessary to explore ways of reconciling the presence of these MNEs with biodiversity conservation.

Third, MNEs depend on biodiversity and ecosystem services for their activities. Therefore, conserving biodiversity is crucial to maintaining MNEs' economic and social benefits. According to the World Economic Forum (2020), approximately USD 44 trillion, over half of the global GDP, relies moderately or highly on nature. This finding is consistent with the assessment by the Swiss Re Institute² (Retsa et al., 2020), which evaluates that 55% of global GDP relies to a moderate or high extent on biodiversity and ecosystem services. The study examines the dependence on ten ecosystem services across various economic sectors. Agriculture, forestry, and fishing are the most reliant on biodiversity, followed by mining and quarrying, with manufacturing ranking third. Interestingly, the sectors posing the most

¹ Defined as possessing a majority of ownership (at least equal to 50% of ownership shares)

² The Swiss Re Institute is the research organization of The Swiss Re Group, a global leading reinsurance and insurance provider.

significant risk to value-added output are not the most reliant on biodiversity. Manufacturing ranks first, followed by real estate; professional and administrative activities; and third, wholesale and retail trade, repair of motor vehicles, and motorcycles. Interestingly, the biodiversity-dependent outputs potentially at risk from financial services appear limited comparatively to other sectors. This is due to its relatively low contribution to global GDP. However, taking a sectoral perspective, biodiversity loss emerges as a threat to the financial sector. For instance, the Dutch National Bank determined that €510 billion, equivalent to 36% of the €1.4 trillion investments managed by Dutch financial institutions, significantly relies on one or more ecosystem services (Joris et al., 2020).

In addition to maintaining MNEs' economic and social benefits, some studies suggest that biodiversity conservation could increase annual profits. For example, Barbier et al. (2018) highlight the economic benefits of investing in biodiversity preservation, citing the global seafood industry as an example. They suggest that by allocating USD 5–10 billion annually towards biodiversity conservation efforts, the industry, which generates USD 252 billion in annual revenue, could potentially increase its yearly profits by USD 53 billion. Altogether, dependencies and potential increased revenues should incentivize MNEs to consider biodiversity conservation.

Fourth, MNEs possess considerable financial resources that could be directed to support biodiversity conservation. According to Deutz et al. (2020), maintaining current ecosystems' integrity requires between USD 598 billion and USD 824 billion per year, assuming that traditional spending (government spending, philanthropy, and official development assistance) on biodiversity conservation remains at its current level. Therefore, the private sector plays a crucial role, representing the greatest financing opportunities to fill this gap. Indeed, MNEs' financial capacities can exceed those of governments. For example, LVMH group represents the 76th wealthiest country if we equate its 2022 sales (79 billion euros in 2022) with GDP (World Bank, 2022) and 118th country if we refer to its profits (21 billion euros in 2022). The group could increase its investments in biodiversity conservation as the current allocation to its Life360 program, focused on biodiversity conservation, climate mitigation, and adaptation, reaches 60 million euros, or 0.07% of its 2022 revenues and less than 0.3% of its profits. Starbucks, a worldwide coffee brand that declares purchasing 3% of the world's coffee (Starbucks, 2024), has initially dedicated USD 50 million to support farmers in implementing its Coffee and Farmer Equity standards by creating its Global Farmer Fund, developed jointly with Conservation International. According to the company, this commitment has doubled to USD 100 million, accounting for 0.3% of its 2022 annual revenues (USD 32.3 billion) and 3% of its profits (Starbucks, 2022). However, recent assessments suggest that private investments in biodiversity are far behind public spending in conservation efforts. And this situation is worse than 20 years ago. In France, private sector

investments have decreased in the ratio of total expenditure for biodiversity, representing 20% of total national spending in 2000 compared to 41% in 2000 (Ricaud, 2022).

Additionally, transforming MNEs' production practices could represent significant financial capital inflows to support biodiversity conservation. In their report, Deutz et al. (2020) evaluate that sustainable supply chains represent investments of USD 5.5–8.2 billion annually, representing between 0.2 and 0.4% of the overall 2022 CAC40 turnover (as computed by EY, 2023).

1.2. The case of cities

Like MNEs, cities play a major role in the transformative changes necessary to halt biodiversity loss. Cities can be defined as productive areas characterized by population and investment concentration providing various services, including transportation, housing, healthcare, employment opportunities, and financial markets (Ernstson et al., 2010). World cities, in particular, centralize political influence globally and nationally, acting as national and international trade centers, providing access to public services, generating knowledge through universities, fostering technology development, and influencing consumption patterns by mediating national policies. They are essential hubs supporting globalization processes, connecting people with the natural environment, and representing a significant demand for ecosystem services (Gómez-Baggethun et al., 2013). However, they simultaneously act as contributors to environmental impacts. Their further involvement in biodiversity conservation is needed for reasons similar to those of MNEs.

First, world cities contribute to the main pressures driving biodiversity loss. They account for 60% of the world's energy consumption, 75% of global carbon emissions, and 70% of global waste (UNESCO, 2019). As the urban population is expected to grow, managing cities' impacts and dependencies on biodiversity is crucial. Over the next 50 years, 58% of the world's population is expected to live in urban areas (UN-Habitat, 2022). When taking into account different societal scenarios based on the IPCC's Shared Socioeconomic Pathways (SSP), Jiang & O'Neill (2017) project that the share of the urban population will reach between 60 and 92% by the end of the century. Urban population growth is expected to result in urban expansion and land-use change, particularly in low-income countries (UN-Habitat, 2022). Cities expansion is projected to convert approximately 290,000 km² of natural habitats by 2030 (McDonald et al., 2019), potentially degrading 40% of strictly protected areas globally (Deutz et al., 2020). Broadleaf forests and tropical moist forests are expected to be the most impacted biomes, while the boreal forest and tundra are the least (McDonald et al., 2019). Additionally, urban expansion endangers 13% of vertebrate ecoregional endemic species (McDonald et al., 2018) and contributes to habitat fragmentation (M. Luck & Wu, 2002; Nagendra et al., 2012), leading to ecological disturbances

such as changes in microclimate, wind patterns, water flux, and ecological discontinuities (Lloyd et al., 2005; Saunders et al., 1991). Studies also find water contamination in urban areas attributed to heavy metals (Girgin et al., 2010), nitrite and ammonium concentrations, and sewage sludge (Carvalho et al., 2011). Like water, urban soils show contamination (Horváth et al., 2015; Mitchell et al., 2014), potentially disrupting ecological functions (Pouyat & Turechek, 2001). Cities' impacts on biodiversity are not only the result of urban expansion but also of socio-economic development factors.

Indeed, socio-economic factors shape urbanites' demand for resources. Kennedy et al. (2015) assess that the world's 27 megacities, with more than 10 million inhabitants as of 2010, generate significant energy and material flows, representing 9% of global electricity, 10% of gasoline, and 13% of solid waste. Globally, the resources consumed by urban residents contribute to roughly 40 to 71% of all anthropogenic greenhouse gas emissions (Solecki & Marcotullio, 2013). Cities' ecological footprint – the hypothetical area needed to produce and absorb the flow of energy, goods, and services used by city-dwellers – can exceed their area's biophysical assimilative capacities (Folke et al., 1997; Luck et al., 2001; Rashid et al., 2018). Especially urbanites' food consumption is a major driver of cities' ecological footprint (Luck et al., 2001; Moore et al., 2013), suggesting that cities' indirect ecological impacts might be greater than the direct ones (McDonald et al., 2019).

Regarding invasive alien species, Müller et al. (2013) indicate that urbanization fosters the rise of invasive non-native species, resulting in decreased species diversity and biotic homogenization. This finding aligns with Clergeau et al. (2006), who observed a similar homogenization effect on bird species across urbanization gradients in Italy, France, and Finland.

Second, like MNEs, cities generate economic and social benefits essential to sustain the livelihoods of urban dwellers. Consequently, integrating biodiversity conservation into their operations requires careful consideration of the economic and social trade-offs involved. Concerning economic benefits, cities contribute to over 80% of global GDP (UN-Habitat, 2022). Global cities receive the majority of foreign direct investments (FDIs) (Nielsen et al., 2017), which enhances R&D employment and innovation (Bettencourt et al., 2007) while animating regional development by supporting local SMEs (Pan et al., 2020). Well-connected global cities attract MNEs' regional headquarters (Belderbos et al., 2017). Urbanization has been positively correlated to economic growth in many countries, although findings are more nuanced for African cities (Page et al., 2020). Bettencourt et al. (2007) demonstrate a scaling effect of cities' population size on the GDP of metropolitan areas across different nations, economic systems, and levels of development. Studies emphasize the role of agglomeration for entrepreneurial activities (Pindado et al., 2023), the attractiveness of skilled labor (Verginer & Riccaboni, 2021), and increased labor productivity (Glaeser & Xiong, 2017; Venables, 2018), among

others. These benefits emerge from economies of scale resulting from enhanced connectivity among individuals and businesses, enabling the pooling of labor market resources, cost savings in the transportation of goods, and dissemination of technology and information (Cervero, 2001; Page et al., 2020). Moreover, global cities play critical key roles in global value chains, concentrating value-added activities, such as R&D, marketing, and financial services, in addition to centers of decisions (Adler & Florida, 2020; Gibbon et al., 2008)

Concerning social benefits, urban workers receive higher wages than rural (Bettencourt et al., 2007). Chauvin et al. (2017) find that if density or population size doubles in U.S. cities, wages rise by about 5%. In Africa, individuals earn up to 23 percent more in urban areas than rural areas (Henderson & Kriticos, 2018). However, the distribution of these higher wages suggests a polarization effect between skilled and unskilled labor (Chakravarty et al., 2021). In addition, cities enable economies of scale in infrastructure and the provision of public services, including education and healthcare (Zhao et al., 2022)

Third, biodiversity conservation is crucial for world cities that depend on biodiversity and ecosystem services (Gómez-Baggethun et al., 2013). They often rely on ecosystems located outside their boundaries (Grimm et al., 2008; Kaye et al., 2006) for their food supply (Ackerman, 2012; Lin et al., 2015; O'Farrell et al., 2012) and water supply (Brown & Magoba, 2009; Jujnovsky et al., 2012; McPhearson et al., 2014). Cities also benefit from regulating services for urban temperature (Marando et al., 2019), noise reduction, air purification (Escobedo et al., 2011), water runoff mitigation (Villarreal & Bengtsson, 2005), and waste treatment (Vauramo & Setälä, 2011). Besides, green infrastructure offers cultural services such as recreation (Fischer et al., 2018; Niemelä et al., 2010) and aesthetics (Palmer, 2004) while providing habitat for biodiversity (Andersson et al., 2007). As urban populations continue to increase, so does the demand for these ecosystem services. In addition, in Western countries, global societal changes have qualitatively reshaped this demand. Initially focused on provisioning services, food, and water supply, the emphasis has shifted towards services that enhance the quality of life, such as recreational activities and the appreciation of natural landscapes (Buijs et al., 2006; Hall et al., 2004). For example, peri-urban agriculture areas are now recognized for offering recreational and aesthetic benefits to city dwellers. This has shifted the focus towards a multifunctional approach to peri-urban agriculture, which complements the previous emphasis on commodity production (Zasada, 2011). Another example illustrating the evolving demand for urban ecosystem services concerns the increased awareness of the urban heat island mitigation effect and flood

protection of vegetation. London's "Right Trees for a Changing Climate"³ initiative advises on which suitable tree species to plant and where to mitigate heat waves and adapt to climate change, underscoring the importance of vegetation in cooling the urban environment. Interviewing 200 Rotterdam residents, Derkzen et al. (2017) show that flood protection emerged as the second most valued service over various green infrastructures. However, cooling benefits were less frequently cited. Eventually, these findings suggest that urban governance should integrate the evolving and multifunctional demand for urban ecosystem services.

Third, cities can leverage financial and political resources to invest in biodiversity conservation. Their increased involvement in global partnerships, such as the C40 initiatives, mobilizes proper budgets. Based on a sample of 100 international partnerships, Acuto & Leffel (2021) analyze a city network covering 10,536 cities worldwide and reveal that the majority of the sampled networks have an annual budget of over USD 250,000, while 36% have a budget between USD 1 million and USD 5 million and 6% between USD 5 million and USD 10 million. In comparison, Paris' 2018 – 2024 Biodiversity plan budget reached around USD 87,000. Participatory budgeting is another tool cities could use to direct more investment in biodiversity conservation. Analyzing 20,000 participatory budgets from 20 cities worldwide, Cabannes (2015) reveals that the most commonly funded projects prioritize roads, paths, and street paving, followed by wastewater management, energy, and public lighting. Initiatives addressing storm and rainwater damage rank third. Since these projects relate to significant drivers of biodiversity loss, such as land-use change or pollution, it indicates that participatory budgeting already funds projects impacting biodiversity, positively or negatively. The challenge lies in designing these projects to integrate biodiversity conservation objectives and expanding them.

In this section, I have set the context and motivations for this thesis by exposing why it is crucial to involve world cities and MNEs in biodiversity conservation. The following sections argue that despite growing engagement and awareness (section 2), MNEs and global cities insufficiently integrate biodiversity conservation into their decisions and actions (section 3). Then, I reflect on the motivations for this work, emphasizing the need to understand better how these organizations evolve to integrate conservation issues further (section 4). I particularly focus on exploring the complexities within these organizations and the mechanisms mediating their impacts on the socio-ecosystems⁴ they are part of.

³ See <http://www.righttrees4cc.org.uk/>

⁴ According to the IPBES glossary, socio-ecosystems are “complex adaptive systems in which people and nature are inextricably linked, in which both the social and ecological components exert a strong influence over outcomes.” The glossary definition is available at: <https://www.ipbes.net/glossary-tag/socio-ecological-system>

This consideration sets the basis for the main research question addressed in this Ph.D. thesis (section 5). Last, I synthesize the contributions of this work and outline the manuscript (section 6).

2. MNEs' AND CITIES' GROWING INTERESTS IN BIODIVERSITY CONSERVATION

2.1. The case of MNEs

MNE executives, like urban planners, have shown increased interest in biodiversity conservation since the early 2000s and the call to the private sector at the World Summit on Sustainable Development in 2002. In particular, since the first publication of biodiversity guidelines for businesses, the TEEB Report for Business (TEEB, 2010), private initiatives supporting biodiversity conservation have multiplied. In France, we can list the work carried out by Orée, EpE (Entreprises pour l'environnement), the FRB (Fondation pour la recherche sur la biodiversité), the Mission on biodiversity economics by the CDC biodiversité, the Lab Natural capital by the WWF or the Forum biodiversité et économie by the Office Français de la Biodiversité. In 2018, 65 companies made a public commitment to biodiversity conservation through the Act4Nature initiative. At the international level, we can mention organizations such as the World Business Council for Sustainable Development or the Business for Social Responsibility. Notably, the World Economic Forum has recognized biodiversity erosion as one of five major threats to the global economy (World Economic Forum, 2020).

Besides public commitments, certain companies demonstrate their interest in biodiversity conservation by creating sustainable supply chains for specific raw materials. These efforts mainly target the natural resources that MNEs consider crucial either due to (i) their substantial negative impact on biodiversity, like timber products which are associated with deforestation; (ii) the threats posed by biodiversity loss on the availability of resources vital for their production; or (iii) public scrutiny, like palm oil. These sustainable supply chains are deployed in different ways. For example, MNEs can invest directly in sourcing territories through producers' training and payments for ecosystem services (Van Noordwijk & Leimona, 2010). They can also participate in inter-enterprise initiatives such as the Roundtable on Sustainable Palm Oil, and rely on certification schemes like the Rainforest Alliance (Grabs & Carodenuto, 2021; Heilmayr & Lambin, 2016; Thorlakson, 2018).

Illustrating direct investment in sourcing territories, Kering has partnered with the Wildlife Conservation Society, Rio Tinto – an MNE of the mining industry – Stanford University, and NASA to improve the ecological impacts of its cashmere production in Mongolia. The project aims to transform breeding and reproduction techniques, improve goat welfare, and minimize impacts on local ecosystems. It also trains breeders in herd management while enabling them to sell older animals and access markets for goat meat, cheese, and milk (Kering, 2019b).

Regarding certification, Gruère (2015) analyzes the EcoLabel Index database and reveals that the number of labels and information schemes addressing biodiversity conservation rose between 1970 and 2012. However, the author shows a decrease in their share compared to broader environmental labeling schemes, falling from 20% to 11%. Meanwhile, schemes linked to climate or energy grew from 4% and 5%, respectively, to 12%. Even though the outcomes of certification schemes are complex to evaluate, DeFries et al. (2017) review agricultural voluntary certification schemes⁵ and find positive ecological results, measured as impacts on habitat conservation; and positive social impacts, measured as non-income well-being. The Roundtable on Sustainable Palm Oil (RSPO) certification has been associated with a 33% reduction in deforestation in Indonesian plantations but has had no impact on forest cover loss in peatlands (Carlson et al., 2018). In Colombia, RSPO and IFOAM programs were associated with the substitution of synthetic fertilizers for organic ones, lower use of chemical herbicides, and greater plantation areas dedicated to conservation, but the lower yields limited job creation despite price premiums between 12-18% (Furumo et al., 2020). Another example lies in the Better Cotton Initiative (BCI), a program on sustainable cotton farming. According to BCI's 2018-2019 annual report, the program yielded positive ecological and economic outcomes (Better Cotton Initiative, 2021). BCI-affiliated farmers in China, India, and Pakistan reported reduced water and pesticide usage, increased yields, and higher profits than their non-BCI counterparts. In the specific case of Pakistan, BCI farmers utilized 15% less synthetic fertilizer, 15% less water, and 18% fewer pesticides than non-BCI farmers while experiencing a 38% increase in profits and an 11% higher yield. BCI also declares contributing to child labor awareness by educating farmers on differentiating "between acceptable forms of children's help on family farms and hazardous child labor" (p.3) and to women's inclusion, with females representing more than one-third of all farm workers trained.

Alternatively to certifications available on the market, MNEs develop in-house programs. Drawing on the analysis of the global cocoa supply chain between 2000 and 2017, Thorlakson (2018) shows that sustainable sourcing practices evolved from industry initiatives, such as the International Cocoa Initiative, to sustainable certification like the Rainforest Alliance. The author finds that firms are increasingly moving toward developing their supply chain programs. The author mentions the example of Mondelez International Inc., which evolved from a cocoa Fairtrade certification approach to a partnership approach based on their Cocoa Life program (FairTrade, 2021). Studying one of the five largest retailers in the South African food sector, Woolworths Holding Ltd., Thorlakson et al. (2018) show that its in-house program Farming for the Future is associated with increased adoption of

⁵ The study considered the following certification schemes: organic, Rainforest Alliance, UTZ Certified, Roundtable for Sustainable Palm Oil, Fair Trade International, and GlobalGAP.

environmental management practices such as disposing of chemical containers, prohibiting burning waste, having a formal invasive species management plan, recycling, and monitoring soil moisture, compared to non-participatory farmers.

The growing interest in biodiversity conservation also timidly reaches investors, with some calling for companies to take action. For example, in 2019, 230 investors - including BNP Paribas Asset Management, Amundi Asset Management, and HSBC Global Asset Management - representing USD 16.2 trillion in assets have made a statement on deforestation calling for companies to implement no deforestation policies with quantifiable, time-bounded commitments and establish transparent monitoring and verification systems (Mudaliar et al., 2018)

Besides the development of sustainable supply chains, MNEs' investments in new niche markets also constitute opportunities for biodiversity conservation, although this doesn't necessarily address their negative impacts on ecosystems. For instance, in the food industry, MNEs invest in plant-based alternatives to animal products. According to a 4-year study by the investor group FAIRR⁶, which involved 25 food manufacturers and retailers, including Tesco, Nestlé, and Unilever, approximately 40% of these companies hired teams dedicated explicitly to developing plant-based alternatives to animal-based products (FAIRR, 2019)

Finally, the private sector's growing interest in biodiversity conservation is demonstrated by the increased use of indicators assessing their impacts and dependencies on biodiversity, notably spurred by upcoming regulations such as the European Corporate Sustainable Reporting Directive (CSRD). Indeed, various indicators aiming at assessing the state of biodiversity already exist, and initiatives have recently focused on developing tools adapted to companies' operational constraints. For example, in 2015, the Kering Group developed a methodology for measuring its environmental costs, the Environmental Profit & Loss, with the Cambridge Institute for Sustainability Leadership (Kering, 2019a). In 2019, it developed the Biodiversity Impact Metric. CDC biodiversité has developed the Global Biodiversity Score to measure the impacts and dependencies of companies on biodiversity and tested it within three pilot companies. To help firms navigate the broad landscape of existing biodiversity indicators, organizations such as the CDC Mission économie de la biodiversité (Berger et al., 2018), the World Wide Fund for Nature (WWF, 2019), the Office Français de la Biodiversité (Delavaud et al., 2021) or the Mouvement des Entreprises De France (MEDEF, 2021) have recently

⁶ The FAIRR Initiative is an investor network gathering 400 members, representing over USD 70 trillion in combined assets. It aims at building awareness of the issues linked to intensive animal production across the investor community.

published guides aiming at assisting them in integrating the issue. Taking advantage of these developments, some MNEs begin to evaluate their dependencies on nature (de Camargo et al., 2019), tracing their resource flows as part of raw material inventory, which is necessary to compute biodiversity indicators based on footprint approaches or using the Environmental Profit & Loss framework, like Natura&Co (2022). Although the tools developed for corporate use have faced criticisms for their utilitarian approach (Mace, 2014; McCauley, 2006; Muradian & Gómez-Baggethun, 2021) and their perpetuation of the status quo (Maechler & Boisvert, 2023b), their adoption by MNEs demonstrates attempts to incorporate biodiversity concerns into their operations.

2.2. The case of world cities

Similar to MNEs, addressing environmental risks and dependencies has emerged as a primary focus for local governments. In particular, cities' initiatives supporting the Convention on Biological Diversity (CBD), such as the 2007 Curitiba Declaration On Cities and Biodiversity, created a global movement promoting biodiversity and ecosystem services investments in urban contexts. In 2010, the Plan of Action on Sub-national Governments, Cities, and Other Local Authorities for Biodiversity was endorsed by 193 CBD parties at COP11 in Nagoya. It spurred the development of the City Biodiversity Index⁷, tested in 15 cities worldwide. The index aimed to assist them in developing sustainable trajectories supporting biodiversity and urban ecosystem services. Kohsaka et al. (2013), reviewing these experiences, concluded that the indicator facilitated knowledge sharing and communication between local governments and external stakeholders while increasing awareness of their dependencies on biodiversity and ecosystem services. More recently, multiple initiatives, such as 100 Resilient Cities, C40, Cities Climate Leadership Group, and the UNESCO Creative Cities Network, have emerged to address biodiversity-related issues in urban contexts.

The growing awareness of municipalities on biodiversity conservation topics has led to the enhanced integration of biodiversity and ecosystem services in urban planning (Wilkinson et al., 2013). Synthesizing 138 scientific articles spanning 88 cities across 23 countries, Wilkinson et al. (2013) find that four dynamics support the consideration of environmental issues in urban planning: the introduction of ecological management principles in the management of cities, the ecological redeployment of traditional planning and management tools, the use of economic instruments and

⁷ The City Biodiversity Index (CBI), also known as the Singapore Index on Cities' Biodiversity or Singapore Index (SI), is a self-assessment instrument enabling cities to assess and track their biodiversity conservation policies. This assessment tool encompasses two main components: a) the "Profile of the City," furnishing contextual information about the city, and b) 23 indicators evaluating native biodiversity, ecosystem services derived from biodiversity, and the governance and management of biodiversity.

valuation tools and enhanced participation of civil society into urban governance initiatives. First, the introduction of ecological management principles into urban governance supported the development of connected green and blue areas (Colding, 2007; Yue et al., 2009). Second, the ecological redeployment of traditional planning and management tools involves using zoning to protect areas critical for biodiversity conservation (Gordon et al., 2009) and ecosystem services provision (Balzan et al., 2021; Longato et al., 2023). Traditional tools such as regulation are also used to set targets such as minimum green coverage across cities. For example, Copenhagen has set a target for at least 90% of its inhabitants to live within less than a 15-minute walk from a natural area (City of Copenhagen, 2015). Third, economic instruments and valuation tools supported assessing and prioritizing policies (Boyer & Polasky, 2004) and the development of compensation mechanisms (Bengston & Youn, 2006). Last, the increased cooperation with civil society through participatory governance mechanisms has created shared visions and scenarios, reframing the relationship between local people and nature, fostering a deeper sense of local identity, and enhancing local authorities' capacities to support ecological processes (Seymoar et al., 2010; Wekerle & Abbruzzese, 2010).

Local authorities' interest in biodiversity conservation is also reflected by the development of nature-based solutions (NbS) (Kabisch et al., 2016). NbS are increasingly recognized as efficient tools generating co-benefits (Seddon et al., 2021), enhancing biodiversity conservation while yielding economic and social advantages (Gómez Martín et al., 2020; Seddon et al., 2020). More specifically, urban green spaces (UGS) have attracted the attention of urban planners. Indeed, UGSs contribute to mitigating urban heat islands (Bowler et al., 2010; Wong et al., 2021), air purification (Diener & Mudu, 2021; Matos et al., 2019) while improving mental health (Callaghan et al., 2021; Liu et al., 2021) and physical activity (Richardson et al., 2013). Consequently, strategies to develop UGSs among cities have multiplied across the world. For example, Berlin aims to allocate a minimum of 6 m² of UGS per person with access to at least 0.5 hectares of UGS within a 500-meter radius of a resident's home (Senate Department for Urban Development and Housing, 2020). In the UK, Natural England set a goal of at least 2 hectares within 300 meters of their residence (Handley et al., 2003), while the Dutch "Green City Guidelines" initiative a 500-meter distance from a section of the green network (de Roo, 2011).

Because of their multifunctional aspect and diverse co-benefits, NbS are perceived as efficient and cost-effective responses to climate change challenges compared to conventional methods like standard sewage or air conditioning systems (European Commission, 2015). However, their integration in urban planning faces some obstacles echoing MNEs challenges in integrating biodiversity-related issues: identification of adequate indicators for measuring benefits; knowledge gaps concerning NbS effectiveness; fear of the unknowns associated with uncertainties and risks of implementing NbS; the

disconnect between short-term electoral processes and NbS's long-term goals; the lack of long-term research; centralized governance (Kabisch et al., 2016).

Despite MNE executives and urban planners' growing recognition of the importance of preserving biodiversity, ecosystems continue to deteriorate (IPBES, 2019). The following section shows that MNEs and cities' engagements remain insufficient.

3. DESPITE POSITIVE SIGNALS, CITIES' AND MNEs' INTEGRATION OF BIODIVERSITY-RELATED ISSUES IS NOT SUFFICIENT

3.1. The case of MNEs

Despite MNEs' growing interest depicted in section 2.1, MNEs often fail to achieve tangible, measurable results in biodiversity conservation (Adler et al., 2017; Smith et al., 2019), as evidenced by their lack of substantive commitments to biodiversity conservation (Boiral, 2014; Wagner, 2022).

Studies relying on extra-financial reporting highlight MNEs' insufficient commitment to biodiversity conservation, showing that MNEs generally disclose little information on biodiversity. Analyzing disclosures from 11,812 companies from 2004 to 2018, de Carvalho et al. (2023) find that 29% presented biodiversity policies by 2018, with more than half of the biodiversity-exposed companies not adopting any strategic objectives. These results are in line with other studies reporting little corporate disclosures on biodiversity issues in various countries Frost (2007) in Australia; Rimmel & Jonäll (2013) in Sweden; van Liempd & Busch (2013) in Denmark; Adler et al. (2018) in the USA. Besides, when firms do report biodiversity information, they tend to make symbolic actions rather than substantial ones (Haque & Jones, 2020; Wagner, 2023). Talbot & Boiral (2021) identify four key behaviors explaining why biodiversity disclosures remain symbolic: prevalence of a short-term approach to sustainability, manipulation of data using vague indicators or setting overly easy targets, development of action plans based on already existing initiatives, and incrimination of the lack of ambitious action plans to bureaucracy and confused decision-making process. Although these studies report the absence of substantive commitments, they miss the explanatory factors underlying the observed lack of significant commitments.

Global value chain studies offer insights into that matter by considering power relationships along supply chains. Examining smallholder participation in agricultural standards in global value chains, Lee et al. (2012) argue that the degree of fragmentation in the value chain and the power of the lead firm result in different possible scenarios. According to the authors, short supply chains, characterized by few intermediary firms, and buyer-driven power dynamics — such as those in supermarket supply

chains — facilitate smallholders' adoption of standards in the agriculture industry. Where supply chains are fragmented and controlled by a few manufacturers, adopting quality food standards, including those addressing biodiversity loss, faces limitations. They illustrate this case with the example of the tomato supply chain, where major producers like Heinz and Campbell Soup Co. dominate. These producers require growers to use their patented variety, restricting their flexibility to align their practices with alternative agrifood standards.

However, lead firms' choices influence the supply chain's structure. For example, Neilson (2008) reveals that Starbucks, the global coffee retailer, imposed to join a Producer Support Organization to individual farmers wishing to join its coffee supply chain. These Producer Support Organizations refer to an entity providing assistance, such as a supplier, mill, cooperative, or other association. The author shows that this requirement had two effects. First, small-scale producers unable to organize themselves could not access this new market, which eventually led to the concentration of exports by a few intermediaries. Three foreign exporters ended up holding 72% of the market share of Arabica coffee exports in Sulawesi. Second, the traditional local coffee trade involved numerous intermediaries that disappeared with the Producer Support Organization system. This study illustrates the trade-offs involved with the adoption of environmental standards. The investments to change production practices and verify standards' enforcement can make the programs inaccessible for producers with limited resources (Blandon et al., 2009; Jaffee, 2008). Similarly, Boisvert et al. (2023) consider the potential of perfume, aromatic, and medicinal plants to both conserve ecosystems and offer economic opportunities for local communities. While MNEs may not be directly involved in the development of these opportunities, the authors shed light on power imbalances within the value chain. They highlight how lead firms exert significant influence, imposing requirements on yields and product quality which are arduous to negotiate for local producers.

To sum up, MNEs have demonstrated increased engagement in biodiversity conservation, but their actual implementation of measures remains insufficient to meet the global objective of conserving biodiversity. In particular, the lack of investment hinders the achievement of efficient measures. Indeed, there is a lack of funding dedicated to biodiversity conservation on a larger scale, although public biodiversity expenditures are increasing (Seidl et al., 2020). Research suggests that an additional annual expenditure of USD 598 to USD 824 billion is required to achieve a nature-positive status by 2030, highlighting the imperative of private investment alongside government and philanthropic contributions (Deutz et al., 2020). Yet, the private sector remains behind. Reviewing Fortune 500 companies' Corporate Sustainable Responsibility (CSR) reports, Bhattacharya & Managi (2013) rarely find monetary investments specifically allocated to biodiversity measures. Their finding aligns with

Mudaliar et al. (2018), who assess that only 3% of the total USD 228.1 billion assets managed by a sample of 229 investors seeking to generate positive social and environmental impacts is allocated to biodiversity conservation.

To increase financial flows supporting biodiversity conservation, major policies rely on extra-financial reporting. Enhanced transparency regarding MNEs' impacts and relationships with biodiversity is expected to guide financial investments toward companies demonstrating relatively strong ecological performance. However, in light of climate-reporting policies, the efficiency of such market dynamics can be questioned (Kedward et al., 2022; Steuer & Tröger, 2022). Drawing from research on climate disclosures, these studies suggest that mandatory reporting alone is insufficient to internalize biodiversity risks in financial asset pricing (Kedward et al., 2022; Steuer & Tröger, 2022). A study by ShareAction (2020) suggests that the financial sector pays little attention to biodiversity, as none of the world's 75 largest asset managers have a specific policy addressing it, while 61% mention climate change in their investment policies.

MNEs' lack of substantial action signals a reluctance to fundamentally question their business models and consider potential trade-offs with revenue streams. As a result, their activities persist in adversely impacting biodiversity. The subsequent section details the case of world cities.

3.2. The case of world cities

Cities, like MNEs, continue to have significant impacts on ecosystems. Few cities manage their biodiversity effectively, with urban expansion driving their impacts on ecosystems (Elmqvist et al., 2013). More than 25% of the world's terrestrial protected areas are within 50km of a city (Güneralp & Seto, 2013), and they are exposed to urban expansion, which is expected to continue, driven by urban population growth. This expansion will directly impact biodiversity through land use change and fragmentation and indirectly through resource consumption, waste generation, and pollution. Without being exhaustive, we argue in the following paragraphs that urban governance has carried out limited results in addressing biodiversity loss.

Although urban planners are increasingly considering biodiversity, these changes are embedded in traditional forms of biodiversity governance, which have been criticized for their limited ability to address biodiversity loss effectively (Bulkeley et al., 2022). Xie & Bulkeley (2020) show that urban planners, often constrained by national frameworks and limited resources, struggle to translate requirements into actionable strategies, eventually resorting to conventional planning techniques. This is due to various challenges, including the lack of alignment between global, national, and local policies (Borgström et al., 2006; Cumming et al., 2006); limited institutional capacity, and conflicting

stakeholder interests (Wilkinson et al., 2013); misalignments with ecological spatial boundaries (Bergsten et al., 2014); limited consideration for social and ecological trade-offs (Bomans et al., 2010). Moreover, the absence of quantifiable targets hinders governance effectiveness in achieving concrete results for local biodiversity conservation. Reviewing 135 plans from 40 cities globally, Nilon et al. (2017) find that although city plans include objectives such as habitat conservation, air and water quality improvement, preservation of cultural ecosystem services, and enhancement of ecological connectivity, most of these plans lack specific, measurable targets. These results echo Pierce et al. (2020), who found that, based on the analysis of 39 cities' biodiversity plans, only 29% of the actions mentioned were associated with a measure. Examining the Paris Metropolitan area governance plan, Tardieu et al. (2023) reveal that the Schéma Directeur de la Région Ile-de-France (SDRIF)⁸ does not explicitly mention ecosystem services but refers to ecological functions. Traditional urban planning is thus ill-suited to deploy practical actions, resulting in limited concrete advances in tackling biodiversity loss.

4. THE NEED TO BETTER UNDERSTAND HOW THESE COMPLEX ORGANIZATIONS FUNCTION TO INTEGRATE BIODIVERSITY CONSERVATION FURTHER INTO THEIR ROUTINES

MNEs and cities' efforts have fallen short in addressing the ongoing loss of biodiversity, indicating that their increased commitments to biodiversity conservation don't align with global biodiversity conservation objectives. One way to explore this "big disconnect" (Dyllick & Muff, 2016, p. 1) is by gaining a better understanding of how these organizations currently handle biodiversity issues. Studies suggest that this lack of substantial results is rooted in the dominant technocentric approach to environmental problems (Landrum & Ohsowski, 2018). Relying on innovations and green technologies, such approaches lack systemic consideration for temporal and scale effects and overlook issues such as pollution transfers (Aggeri, 2023c).

To complement these findings, this Ph.D. thesis draws on North's framework of institutions and organizations, where "institutions are the rules of the game – both formal rules, informal norms and their enforcement characteristics. Together, they define the way the game is played. Organizations are the players. They are made up of groups of individuals held together by some common objectives. The immediate objective of organizations may be profit-maximizing (for firms) or improving reelection prospects (for political parties), but the ultimate objective is survival because all organizations live in a

⁸ The SDRIF, or Schéma Directeur de la Région Île-de-France, is a strategic planning document that guides urban development and land use in the Île-de-France region, which encompasses Paris and its surrounding areas.

world of scarcity and hence competition.” (North, 2008, p. 22). The next paragraph describes different sources of complexity characterizing organizations like world cities and MNEs as a starting point for investigating mechanisms leading to this big disconnection.

World cities, just like MNEs, are complex organizations embedded in socio-ecological systems. Their complexity is related to various aspects. First, world cities and MNEs must deliver diverse products or services across various territories to heterogeneous beneficiaries with differing needs and expectations. Additionally, they face selective pressures influenced by electoral cycles in the case of world cities and market competition in the case of MNEs. Second, they face competing priorities, often prioritizing short-term pay-off goals over longer-term ones (Albrechts, 2004; Lambooy et al., 2018). In the case of world cities, policies supporting ecosystem services are often given lower priority than those concerning economic development or poverty alleviation (Elander et al., 2005; Epstein & Roy, 2007; Nagendra et al., 2012). Likewise, MNEs prioritize biodiversity conservation less (Adler et al., 2017, 2018; Hassan et al., 2020). Third, in both types of organizations, decision rights are shared among actors with varying interests, goals, and perceptions, leading to persistent latent conflicts and coalitions within the organization. These dynamics significantly influence decision-making and prioritization. For example, in the case of China, Fang et al. (2006) show that decision-makers in the coastal city of Xiamen were not ready to accept the “Guideline for Town-level Environmental planning” that aimed at conserving ecosystems. Feger & Mermet (2020) revealed that in the ecological transformation of a leading French company in the sector of sanitation and drinking water service sector, the commercial team encountered resistance from colleagues attached to the old vision of the organization.

Fourth, both types of organizations are characterized by nested decision-making processes, where higher hierarchical levels guide decisions made at lower levels. This dependency on higher governance levels may limit the integration of conservation issues (Peterson et al., 2007; Puppim de Oliveira et al., 2011). In urban planning, studies reveal challenges local authorities face in implementing policies supporting ecological benefits. For instance, in Sweden, Elander et al. (2005) found local urban planners struggle with overly generalized national biodiversity strategies. Similarly, Peterson et al. (2007) highlight the importance of aligning national and regional policies in Queensland, Australia, where timeframes between policy revisions at national levels hinder local conservation efforts. These challenges echo the UN-Habitat (2022) report, indicating a lack of integration between local sustainability policies and national programs. In the case of MNEs, this hierarchical decision-making can be between decision-makers and collaborators in charge of operationally implementing these decisions or between shareholders and managers. For example, based on two case studies, Roome &

Louche (2016) highlight the difficulties associated with “translating” (Roome & Louche, 2016, p. 29) a vision into an operational reality. This translation implies that the vision is understood and its implications for the value chain are made clear.

5. RESEARCH QUESTION: HOW CAN BIODIVERSITY CONSERVATION ISSUES BE FURTHER INTEGRATED INTO COMPLEX ORGANIZATION OPERATIONS?

To better align complex organizations’ operations with biodiversity conservation objectives, it is essential to understand better how complex organizations such as MNEs and cities function internally and in interaction with external entities, including with the ecosystems where they operate. Central to this understanding is the link between organizational forms and firms’ impacts on socio-ecosystems. Organizational forms refer to the structuring of activities within specific institutional environments: what is done, how, and with whom. Depending on its organizational forms, an organization’s activities will impact territories differently, contributing to the socio-ecosystem evolution toward sustainable goals or driving it away. Thus, a driver of the misalignment lies in the study of the mediating role of these organizational forms. How do organizational forms influence organizations’ impacts on the socio-ecological systems in which they are embedded? How do they evolve, in practice, to integrate (or not) biodiversity conservation goals?

There has been little investigation into how complex organizations like MNEs and world cities practically manage biodiversity-related issues and how they adapt their routines and operations to integrate these concerns. Some studies investigate the implementation of specific measures, considered positive, like stakeholder involvement and collaborative management (Boiral & Heras-Saizarbitoria, 2017; Freudenreich et al., 2019); fit between policies and socio-ecosystems patterns (Bodin et al., 2014; Bergsten et al., 2014); implementation of resource efficiency measures (Diaz Lopez et al., 2019; Guldmann & Huulgaard, 2020) or maximization of urban ecosystem services (Barthel et al., 2005); Bush & Doyon, 2019). Although providing useful insights on governance, these studies only address biodiversity conservation indirectly. Other studies focus on evaluating labels and certifications (Carlson et al., 2018; Dietz et al., 2021; Mameno et al., 2021; van Rijsbergen et al., 2016), which only constitute a particular aspect of these organization’s possible action supporting biodiversity. From a supply chain perspective, researchers have explored factors that positively influence social and ecological benefits: the type of relations between producers and exporters (Basurto et al., 2020; A. Bennett & Basurto, 2018), the integration of customary management practices (Cinner & Aswani, 2007), the maintenance of local interactions (Londres et al., 2023) and cross-scale governance (Ovando et al., 2013; Brondízio et al., 2021). While these studies reveal favorable supply chain organizational forms, the mechanisms underlying the emergence of these preferred characteristics remain unclear.

How complex organizations manage biodiversity-conservation issues and adapt their organizational form consequently remains poorly understood. What makes an organization integrate biodiversity conservation issues and adapt to a specific context to generate long-term ecological benefits? How are these decisions made? What factors influence negotiations on the subject? What information do stakeholders have? What is their perception? If decisions are taken, how are they implemented? What is the link between decision-making centers and the decisions' operational implementation?

I address these questions by exploring four means of action: (i) how regulations influence the decisions regarding biodiversity, taking the case of the Corporate Sustainability Reporting Directive (CSRD); (ii) how supply chains locally adapt through their interactions with the socio-ecosystems where they operate; (iii) how internal decision-making processes and negotiations are navigated in practice and, (iv) how demand can drive organizations transformation. Each of these sub-questions explores a different path to close the big disconnection: institutional environment (regulation), production practices (supply), internal negotiations, and incentives (demand).

The main objective of this Ph.D. is thus to understand better how these four levers drive changes in organizational forms and influence complex organizations' decisions and actions in practice. It aims to describe mechanisms driving change, or resistance to change, in these complex organizations. These mechanisms can be internal, linked to organizations' collective routines and rules, and external, coming from the institutional, natural, or economic environment. A better understanding of how these mechanisms influence organizations' ecological transformation is essential to achieving global ecological conservation objectives.

6. OUTLINE OF THE DISSERTATION

This Ph.D. thesis investigates the four drivers mentioned above through case studies of MNEs and one on the Paris Metropolitan area. First, building on transaction cost economics (TCE), this research focuses on the effects of mandatory reporting. Taking the case of the Corporate Sustainability Reporting Directive (CSRD), the first chapter questions whether and how current regulation will enhance the availability and quality of MNEs' biodiversity information.

The second chapter considers supply chains through a coevolutionary ecological economics lens (Kallis & Norgaard, 2010). We describe how a specific supply chain, considered a successful case of sustainable use of biodiversity, has adapted its organizational forms to specific institutional, cultural, demographic, and ecological contexts. By investigating how interactions with territories at the local scale shape organizational forms, we aim to understand how organizations evolve and adapt to these territories.

The third chapter explores internal drivers, investigating organizations' decision-making processes. I examine more closely how new routines are integrated (or not) into the organization. We describe how change is managed internally and identify factors that either catalyze or impede the integration of biodiversity conservation based on a sample of 16 French MNEs. Here, we aim to describe internal change management dynamics, focusing on how organizational change is managed and translated into practical actions.

The last chapter investigates how characterizing the demand for products and services can support the development of a differentiated offer, generating enhanced ecological results. Taking the example of urban green space planning in the Paris Metropolitan area, it relies on discrete choice experiments (DCE), which are stated preference methods, to characterize the demand side of ecosystem services in non-monetary terms.

CHAPTER 1

Chapter not submitted

Contributions:

Mai-Thi Ta: conceptualization, drafting of the original version

Harold Levrel: conceptualization, proofreading methodology, supervision

Michel Trommetter: reviewing

1. HOW WILL THE CORPORATE SUSTAINABILITY REPORTING DIRECTIVE (CSRD) ADVANCE BIODIVERSITY DISCLOSURE BY THE PRIVATE SECTOR? A TRANSACTION COST PERSPECTIVE

1. INTRODUCTION

As of January 1, 2024, the Corporate Sustainable Reporting Directive (CSRD) has been enforced to standardize and enhance the quality of corporate sustainability information. This directive replaces the European Directive 2014/95, also known as the Non-Financial Reporting Directive (NFRD). However, it applies to a broader range of firms and covers a wider scope of sustainability issues. It explicitly addresses 16 sustainability matters, including biodiversity.

The CSRD seeks to improve both the quantity and quality of sustainable corporate information. Increasing the quantity of disclosed information encompasses two main aspects. First, it entails that more firms disclose information on their impact and dependencies on biodiversity. Second, it involves that each firm provides a substantial amount of information. While the quantity of biodiversity information can be clearly defined, information quality is more complex. In the context of the CSRD, qualitative characteristics that information disclosures shall meet are exposed in the first European Sustainable Reporting Standard¹ (ESRS), Appendix B (European Commission, 2023a, app. B): relevance, faithfulness, comparability, and verifiability. Relevance means that disclosed information should “make a difference in the decisions of users under a double materiality approach.” Faithful representation “requires information to be (i) complete, (ii) neutral, and (iii) accurate” (p. 27). Complete information involves disclosing “all material information necessary for the users to understand that impact, risk or opportunity” (p. 27). Neutral information “is without bias in its selection or disclosure of information” (p. 27). Accurate information “implies that the [firm] has implemented adequate processes and internal controls to avoid material errors or material misstatements” (p. 28). Verifiability means that “it is possible to corroborate the information itself or the inputs used to derive it” (p. 28). Comparability entails that information be compared “in previous periods and [...] with information provided by other [firms]” (p. 28).

¹ European Sustainable Reporting Standards (ESRS) provide guidelines and requirements for companies to disclose environmental, social, and governance information in their annual reports, covering 16 sustainability matters, including biodiversity and ecosystems (in the ESRS 4)

Enhancing the quantity and quality of biodiversity information disclosure is crucial, including for investors who can use this information to assess the financial risks of their portfolios. Other stakeholders like citizens, NGOs, corporations, lobbies and public authorities can also use this information to hold firms accountable and increase the likelihood of collective action (Stephan, 2002). For example, Naysnerski & Tietenberg (1992) document how non-financial disclosure has been decisive in the citizen suits against alleged violations of the Clean Water Act in the United States. More recently, litigations against extractive MNEs such as the Royal Dutch Shell or TotalEnergies have used non-financial disclosures to argue for a lack of transparency and non-compliance with the 2030 climate goals of the Paris Agreement (Stephan, 2002). However, to support this type of legal action, the disclosed information must be useful and reliable. Consequently, providing qualitative information that meets the needs of diverse stakeholders is crucial for ensuring that increased transparency leads to concrete actions.

In the context of biodiversity conservation, enhancing transparency entails improving both the quality of corporate information disclosures and its quantity. Indeed, despite the increased quantity of corporate sustainable information available (Ioannou & Serafeim, 2017), reported information concerning biodiversity specifically remains low (Rimmel & Jonäll, 2013; van Liempd & Busch, 2013). In addition, when MNEs disclose information on their impacts and dependencies, they provide anecdotal information, primarily aiming at managing stakeholders' perceptions (Adler et al., 2017; Wagner, 2023). Studying the information disclosures of the Australian Stock Exchange's top 50 metals and mining companies, Adler et al. (2017) find a lack of tangible evidence based on measurable targets, which prevents stakeholders from assessing their biodiversity performance.

By questioning whether the disclosed information meets stakeholders' needs, these studies consider the relevance characteristic of the quality of biodiversity information but overlook other criteria. Consequently, such methodologies only assess particular aspects of information quality. Yet, concerning the quality of biodiversity's corporate information, key aspects concern (i) uncertainty, as many factors can impact the functioning of ecosystems (Bennett et al., 2009; Kremen, 2005), including ecological responses to biodiversity depletion and (ii) representativity, i.e., how well the information represents the phenomenon under study. Representativity differs from the relevance criteria mentioned in the CSRD as it does not depend on users' expectations. Information relevance varies with stakeholders, while representativity relates to how precise ecological dynamics are reflected². The

² Representativity can, therefore, be close to accuracy. However, in the context of the CSRD, this is not the case, as the ESRS 1 states: "Information can be accurate without being perfectly precise in all respects. Accurate information implies that the undertaking has implemented adequate processes and internal controls to avoid

quality of disclosed biodiversity information is, therefore, related to how specific the reported information is. However, collecting and analyzing specific information can be costly. These costs correspond to transaction costs, which, more generally, encompass ex-ante costs related to searching for information, finding a partner to realize a transaction, drafting, negotiating, and securing a contract; and ex-post costs, including the costs incurred by the renegotiation of contracts, the costs of monitoring compliance, and possibly the costs of breaking agreements.

In this chapter, we build on transaction costs economics (TCE) to assess whether, and if so, to what extent the CSRD incentivizes the disclosure of qualitative biodiversity information. To our knowledge, no studies have used transaction cost economics to examine the quality of biodiversity disclosure information. While certain authors have concluded the importance of considering transaction costs for enhancing the efficiency of restoration projects (Scemama & Levrel, 2019) and environmental policies (Coggan et al., 2013; Phan et al., 2017), we found only one on corporate environmental disclosure (Stephan, 2002), and none focusing on biodiversity disclosure.

In the following sections of the chapter, we first present an overview of the current state of corporate biodiversity disclosure (section 2) and discuss the factors influencing the quantity and quality of that information (section 3). Building on TCE, we then formalize the conceptual framework supporting our analysis (section 4) of the transaction costs associated with a cost-effective approach to the CSRD (section 5). Then, we investigate how the CSRD could increase levels of disclosure quality, drawing on eight companies that have developed internal biodiversity information systems. Applying TCE, we characterize the transactional costs associated with the disclosure of this information (section 6) before suggesting building on a recent ecosystem classification developed by the IUCN to enhance information quality while avoiding excessive transaction costs and concluding (section 7).

2. BIODIVERSITY REMAINS UNDER-REPORTED, BOTH QUANTITATIVELY AND QUALITATIVELY

Studies have found limited corporate reporting on biodiversity by listed firms across different countries such as Sweden (Rimmel & Jonäll, 2013); Denmark (van Liempd & Busch, 2013); the United Kingdom and Germany (Atkins & Gräbsch, 2014) and industries, including mining (Adler et al., 2017; Boiral, 2016). Additionally, these studies show that the little information available fails to provide stakeholders with the necessary information to evaluate corporate impacts on biodiversity effectively.

material errors or material misstatements.” (European Commission, 2023a, p.28)

According to Adler et al. (2018), less than 10% of 150 Fortune Global companies report substantial biodiversity information disclosures. Recently, de Carvalho et al. (2023) conducted a study involving 11,812 companies, revealing that 29% report policies related to biodiversity conservation. These results contrast with the 79% of the companies worldwide reporting on environmental, societal, and governance (ESG) issues (KPMG, 2022). This underscores the need to extend biodiversity disclosures compared to other ESG issues.

Only a few studies investigating the quality of sustainability disclosures have focused on biodiversity. Wagner (2023) reveals that firms mostly report symbolic actions rather than substantive ones, which prevents the implementation of suitable biodiversity management strategies. These results align with Boiral (2016), who examines how firms in the mining industry strategically manage stakeholder perceptions regarding biodiversity conservation. Analyzing 148 sustainability reports, the author identifies four “neutralization techniques” (p.751), which refer to rhetoric strategies aiming at legitimizing corporate commitments. First, firms affirm net positive or neutral impact, mentioning positive actions for biodiversity such as the cultivation of plants and seeds in nurseries prior to restoration projects, reintroduction of endangered species, land rehabilitation, and training of the local population on biodiversity protection. By emphasizing these actions, generally carried out as part of compensation projects, MNEs overlook their negative impacts on biodiversity. Second, they deny significant impacts, relativizing and minimizing biodiversity issues. For example, they declare that their mining sites are not located in biodiversity-sensitive areas or that there are no threatened or endangered species close to their operating territories. Third, they distance themselves from the consequences of their activities, recognizing adverse impacts but minimizing and disconnecting them from their activities. For example, companies emphasize the need to consider biodiversity disturbances in broader spatial and temporal scales than their operations. Last, firms dilute their responsibilities, insisting on the role of other actors and presenting their adverse impacts as beyond their managerial control. Additionally, Smith et al. (2019) reveal that firms reporting on biodiversity provide limited relevant information for stakeholders who find scarce local and context-specific information.

These studies establish that biodiversity information disclosure remains limited quantitatively and qualitatively. While enforced regulations such as the CSRD should increase the quantity of information available, how to influence its quality remains unclear (Zarzycka & Krasodomska, 2021).

3. WHAT FACTORS INFLUENCE THE QUALITY LEVEL OF BIODIVERSITY DISCLOSURE?

3.1. Regulation and mandatory non-financial disclosure

Studies comparing the impact of mandatory non-financial disclosure to voluntary ones suggest that while it increases the quantity of information available, it does not necessarily improve its quality. In various countries and sectors, the implementation of mandatory non-financial reporting has led to a notable increase in the number of publicly listed companies reporting such information, as observed in industries such as Australian extraction resources, utilities, and infrastructure (Frost, 2007) or the Chinese mining sector (Dong & Xu, 2016). Mandatory regulations have also led to an expansion in the content provided by firms individually. Research indicates that mandatory non-financial reporting results in an increase in the number of pages dedicated to non-financial information (Chauvey et al., 2015) and in the number of items disclosed per company (Dumitru et al., 2017; Ottenstein et al., 2022; Posadas & Tarquinio, 2021), including increased disclosure of negative information (Kerret et al., 2010). Based on these results, one can expect that the CSRD enhances the quantity of sustainable biodiversity information publicly available.

Qualitatively, more concern has been raised on the effects of mandatory non-financial reporting policies (Chauvey et al., 2015; Dong & Xu, 2016; Haque & Jones, 2020; Kerret et al., 2010; Sulaiman et al., 2015), including concerning NFRD's enforcement (Agostini et al., 2022; Korca et al., 2021; Ottenstein et al., 2022). Studies emphasize the limited comparability of reported information (Aureli et al., 2020; Venturelli et al., 2020). Others show that firms use sophisticated strategies to avoid disclosing transparent information (Criado-Jiménez et al., 2008; Gibassier et al., 2018; Larrinaga et al., 2002; Talbot et al., 2023), driven by the legitimization of their activities (Boiral & Heras-Saizarbitoria, 2017a; Sun & Lange, 2022).

3.2. The legitimacy theory

Following the legitimacy theory (Ashforth & Gibbs, 1990; Boiral et al., 2018; Chauvey et al., 2015), an organization is considered legitimate when its methods and goals align with societal norms. To gain such legitimacy, firms use techniques to manage stakeholders' impressions of their activities. These techniques refer to strategic discourses used to shape their perceptions regarding their corporate social and environmental practices. For example, companies may selectively disclose positive activities while omitting negative aspects of their operations. Building on the legitimacy theory, biodiversity reporting can be considered a "low-cost and easy alternative to more substantial actions" (Boiral, 2016, p. 754) deployed by firms to gain legitimacy and avoid social and political criticism of their policies related to biodiversity conservation.

Following the legitimacy theory, firms disclose information in response to external stakeholder expectations. Extra-financial reporting then serves as a mediation tool between society and private firms, which is determined by their particular understanding of this tool (Aggeri, 2024). In this perspective, increasing the quality of biodiversity information relies on renewed interpretation and expectations towards corporate biodiversity reporting. Consequently, companies would improve the quality of their disclosed information to answer social or political pressure and enhanced information quality would come from broader political and social changes. Yet, such changes happen slowly and seem a necessary but unsatisfactory long-term bet.

3.3. Corporate characteristics

Studies have investigated statistical correlations between the general characteristics of firms and the qualitative degree of disclosed information (Dumitru et al., 2017; Hassan et al., 2020; Sulaiman et al., 2015). For example, Hassan et al. (2020) regress a “biodiversity/extinction disclosure score” (p. 6) on several variables such as firms’ industry exposure to biodiversity risk, its environmental performance, and the type of assurance provided (either assurance by the Big4 auditing companies³ or not). The authors find that exposure of the industry to biodiversity risks, along with the type of assurance provided, positively influence the quality of disclosed biodiversity information. Similarly, Adler et al. (2018) apply a linear regression model to test the effect of corporate characteristics, including company size, industry, and the presence of partnerships supporting biodiversity conservation on a composite index reflecting the quality of biodiversity and threatened species reporting. This index is based on the assessment of 50 items. Their results emphasize the positive influence of partnerships with environmental actors. Haque & Jones (2020) establish a positive correlation with female board representation.

Though informative, these approaches present limited operationality as they fail to identify causal mechanisms influencing the quality of biodiversity disclosures. In the next section, we develop a transaction cost economics perspective to investigate how biodiversity disclosure quality can be improved, arguing that the qualitative degree of reported information depends on the characteristics of the transaction between a firm disclosing biodiversity information and a third-party controller.

³ The "Big Four" auditing companies refer to the four largest international accounting and professional services firms: Deloitte, PricewaterhouseCoopers (PwC), Ernst&Young (EY), and KPMG.

4. A TRANSACTION COSTS ECONOMICS PERSPECTIVE TO ANALYZE THE QUALITATIVE DEGREE OF CORPORATE BIODIVERSITY DISCLOSURE UNDER THE CSRD

Enhancing the quality of information disclosed by companies entails considering the uncertainty associated with ecological dynamics, the geographic scope of corporate activities, and companies' specific production practices. These variables are central to the transaction costs theory, which we apply to formalize the relationship between the characteristics of the transaction (i.e., the exchange of information) and the likelihood that disclosed information is of high quality.

4.1. Analytical framework

TCE considers asset specificity and uncertainty as the main sources of transaction costs (Williamson, 1989). According to Williamson (1989), asset specificity refers to the degree to which an asset is dedicated to a particular economic transaction. Specific assets involve investments that cannot be easily reallocated for alternative uses without incurring additional costs. Asset specificity can be categorized into site specificity, which is related to geographical location; physical asset specificity, which is related to physical characteristics; and human asset specificity, which is related to the skills and human capital specifically developed for the transaction. Transaction specificity also comes from dedicated assets, referring to general investments made for a particular customer.

Uncertainty refers to the unpredictability or lack of perfect information regarding future events, outcomes, or actions of other parties involved in the transaction. TCE distinguishes between environmental uncertainty arising from exogenous disturbances, including institutional ones; and behavioral uncertainty arising from the risk of opportunism among contractors—referring to cases where one party exploits information asymmetries to prioritize its interests over other involved agents. Transactions characterized by high uncertainty require costly coordination mechanisms that are both flexible to adapt to unpredictable disturbances and formalized enough to deter opportunistic behavior.

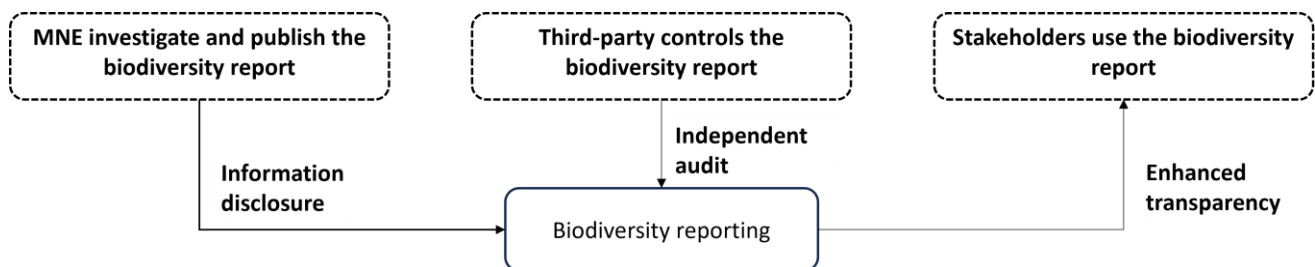
The process of disclosing information on firms' impacts on biodiversity entails the exchange of information that is uncertain. Environmental uncertainty stems from the unpredictabilities in ecosystem dynamics and evolutions, particularly when human activities impact ecosystems, making ecological regime shifts more likely to occur (Folke et al., 2004; Rocha et al., 2015). (Folke et al., 2004; Rocha et al., 2015). In addition, institutional uncertainty can arise from evolutions in regulation and public policies, including in the ESRs' mandatory requirements. Behavioral uncertainty is related to the inability to anticipate strategic behaviors. For example, the third party controlling reporting's compliance could exploit the specific knowledge developed for a customer to generate quasi-rents. Additionally, controlling biodiversity information necessitates specialized human capital familiar with

ecosystem complexity.

In the context of the CSRD, the exchange of biodiversity information (i.e., the asset exchanged) can be formalized through a transaction between (Figure 1.1):

- (i) a company whose interest is having its sustainable reporting audited and validated as compliant with the CSRD, hereafter referred to as “the undertaking firm”;
- (ii) a controller who is paid by the undertaking firm to audit its sustainability reporting; and
- (iii) stakeholders, such as citizens, NGOs, public authorities, and other economic agents, who benefit from enhanced transparency from reported information.

Figure 1.1 - Representation of the transaction studied



4.2. Linking the quality of biodiversity information disclosure to transaction costs

Enhancing the quality of corporate biodiversity information involves not only an uncertain transaction but also a specific one, which considers biodiversity and corporate specificities to faithfully represent a firm’s impact and dependencies’ on biodiversity (Table 1-1). However, TCE anticipates that increasing the specificity of the transaction leads to higher transaction costs.

Table 1-1- Source of transaction cost associated with increased quality of biodiversity corporate disclosures

Asset specificity	
Physical specificity	Disclosed information considers the complexity and diversity of ecosystems and the characteristics of the undertaking firm's activities.
Site specificity	Disclosed information is spatially and temporally aligned with the undertaking firm's operations.
Dedicated asset	Third-party controllers make investments to answer the specific requirements of an undertaking firm.
Human capital specificity	Knowledge is developed by the firm and third-party controller to collect and analyze specific information.
Manufactured capital specificity	Manufactured capital is designed specifically for biodiversity information disclosure purposes.
Transaction uncertainty	
Environmental uncertainty	Exogenous uncertainty associated with unpredictabilities in particular ecosystem dynamics and evolutions.
	Institutional uncertainty related to potential evolutions of legislations and ESRS disclosure requirements, including the guidelines to assess particular impact assessment methodologies compared to standardized ones.
Behavioral uncertainty	Limited ability to anticipate opportunistic behaviors of both the undertaking firm and the third-party controller.

Indeed, providing accurate biodiversity information involves considering the complexity and diversity of ecosystem components and functions (Hanski, 1998; Moreno-Mateos et al., 2012) across different temporal and spatial dimensions (Holling, 1996; Pimm, 1984) as well as the specific activities and production practices of the undertaking firm. In addition, controlling specific information could lead to dedicated specificity related to the third-party controller investments made to answer the specific requirements of an undertaking firm. The transaction may also require higher human capital investments, corresponding to knowledge developed by the firm and third-party controller to gather and analyze singular information. The transaction may also involve the development of manufactured capital, such as customized software, designed specifically for its purpose. Furthermore, collecting data specific to the firm's activities can provide empirical spatialized data aligned with its operations, thus reducing environmental uncertainty. Finally, exchanging information that accounts for the firm's specific activities and production practices may increase behavioral uncertainty, as third-party controllers with access to potentially sensitive information could use it to engage in opportunistic behaviors.

To sum up, the specific and uncertain nature of disclosing information on a business impact on biodiversity, coupled with the need for specialized expertise, leads to high transaction costs. This supports the analysis of the Center for European Policy Studies (de Groen et al., 2022), which finds that ESRS 4, dedicated to biodiversity and ecosystems, accounts for the second most costly chapter among all ESRS, after climate change, in terms of total administrative costs⁴. The single disclosure requirement E4-5 on the impact metrics related to biodiversity and ecosystems is the 5th most costly in terms of recurring administrative costs. Yet, sources of transaction costs have not been explicitly considered in the CSRD's policy assessment. The cost-benefit assessment carried out by the European Financial Reporting Advisory Group (EFRAG⁵) acknowledges that administrative costs vary depending on uncertainty related to the materiality assessment, the supply chain coverage, and methodologies (de Groen et al., 2022). Still, it is not explicitly identified as a factor influencing the quality of disclosed information. It is indirectly taken into account through the Standard Cost Model and the forecasted time required to comply with each data requirement (European Commission, 2023b).

Ultimately, TCE anticipates that MNEs adjust the degree of transaction uncertainty and specificity to align with the CSRD's market-based governance. From a cost-efficient perspective, firms can decrease transaction costs while complying with the CSRD by relying on standardized tools available to all companies on the market of biodiversity impact assessment, implementing a less time-consuming and cost-efficient approach that we call a "low-cost" approach. By specifying disclosure requirements, the CSRD should lower transaction costs. However, methodological choices remain largely at the discretion of firms; the latter have room to adjust the quality of the disclosed information, notably by determining uncertainty and specificity levels, which ultimately accommodate the level of transaction costs and, consequently, the likelihood that high-quality information will be disclosed. There is a trade-off

⁴ While climate information tends to be less specific compared to biodiversity-related data, the CEPS's findings of higher climate-related costs can be attributed to two main factors. First, the CSRD has more stringent and more numerous requirements concerning climate change (ESRS 1) compared to biodiversity (ESRS 4), which involves responding to climate disclosure requirements annually. Second, biases in the cost assessment method could also explain these results. Indeed, the CEPS applied the EU Standard Cost Model (SCM) from the EU 'Better Regulation' Toolbox (2023), which accounts for two types of administrative costs: business-as-usual costs related to administrative activities that would continue if the legal obligation was removed; and administrative burden specifically incurred by the legislation under study. Following the SCM, total administrative costs are assessed based on a questionnaire sent to diverse stakeholders, asking them to assess total administrative costs for each disclosure requirement. Given that firms have more experience reporting information related to climate change than their impacts and dependencies on biodiversity, it is plausible that the lower costs associated with ESRS 4 (biodiversity and ecosystem) than ESRS 1 (climate change) are the consequences of biases in the statements provided by interviewees. These lower statements on costs related to biodiversity disclosure requirements could be explained, for example, by their limited knowledge about biodiversity, its specificities, and uncertainties.

⁵ The EFRAG is a not-for-profit association gathering European stakeholders with knowledge and interests in international reporting and accounting standards.

between enhanced information quality, which increases transaction costs, while pressures to reduce costs come from the need to incentivize firms' disclosure and inter-firm comparability.

In the following section, we reflect on the quality of biodiversity disclosures associated with the “low-cost” approach, arguing that the CSRD provides insufficient incentives to disclose improved-quality information.

5. EVALUATING BIODIVERSITY DISCLOSURE QUALITY IN A LOW-COST APPROACH TO THE CSRD

5.1. Multi-correspondence analysis (MCA) of 15 major biodiversity indicators recommended for corporate use

To assess the quality of biodiversity information disclosed in a scenario where firms use readily available tools, we conduct a multi-correspondence analysis of a sample of 15 biodiversity indicators available on the market. Our analysis focuses on indicators based on the Driver-Pressure-State-Response framework, as corporate-level biodiversity indicators mostly use this framework (Addison et al., 2018). Appendix A describes how these 15 biodiversity indicators were selected from recent reports aiming at guiding firms in the abundant offer of corporate biodiversity indicators and published by major biodiversity-conservation advocating EU organizations. We conduct hierarchical clustering on principal components derived from the analysis of 15 indicators described in Table 1-2- Description of the analyzed sample of 15 common biodiversity indicators, utilizing R version 4.2.0 and the HCPC function within the FactoMinR package. The HCPC function first performs a principal component analysis before computing a hierarchical clustering using Ward's criterion (Kassambara, 2017). For each indicator, we characterize degrees of physical, site, and human specificities based on twelve variables (Appendix B). We assess the quality of the sampled indicators based on these variables and group similar indicators together to identify a clustering of these indicators.

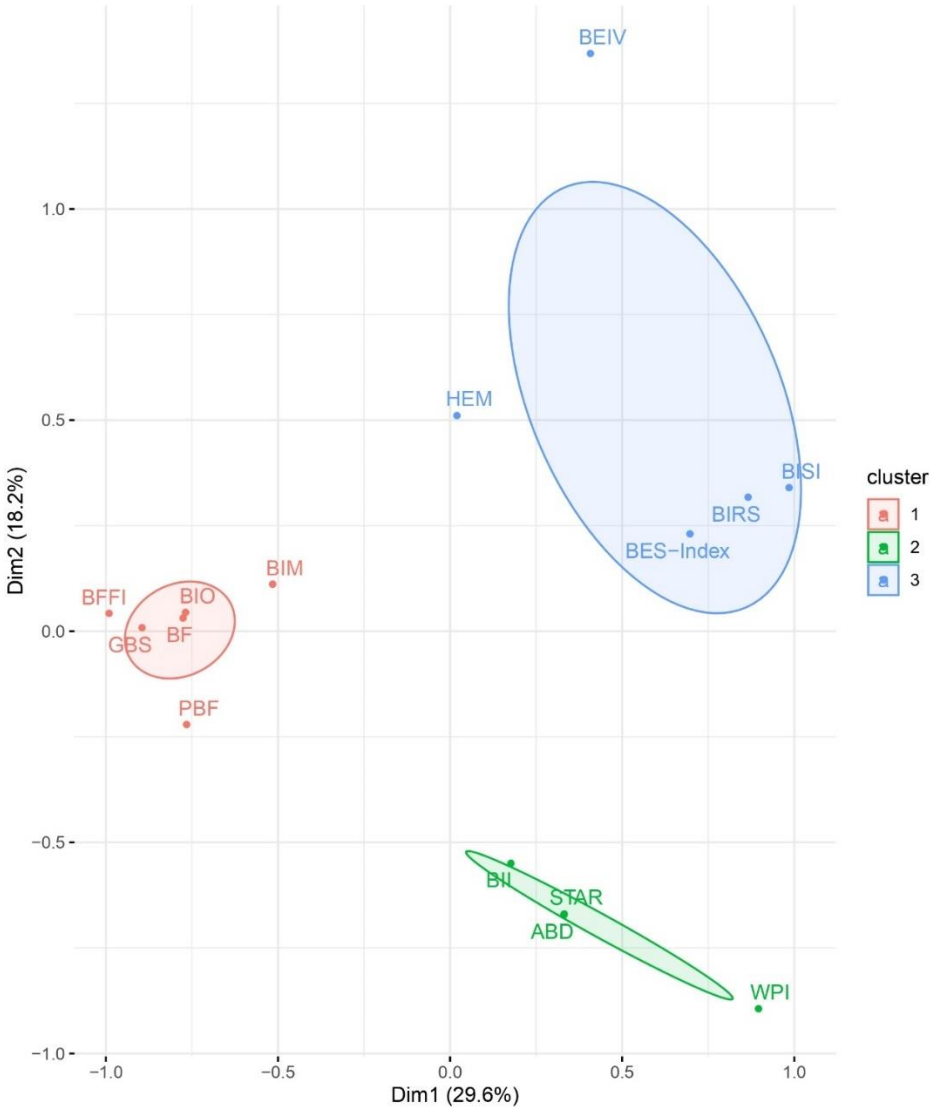
Table 1-2 - Description of the analyzed sample of 15 common biodiversity indicators

Name of the indicator	Acronym	Description
Agrobiodiversity index	ABD	Measures the current state of agrobiodiversity in markets and consumption and in agricultural production
Biodiversity Ecosystem Services Index	BES-Index	Developed for the re-insurance industry, the index provides a detailed and spatial view of the state of biodiversity and ecosystem services in any given location
Biodiversity Estimated Impact Value	BEIV	Evaluates an organization's impact based on five environmental aspects (waste generation, GHG emissions, water usage, energy consumption, area occupation), taking into account quantity and severity criteria
Biodiversity Footprint	BF	Evaluates local impacts of pressure factors on biodiversity in terms of the presence of species and the number of individuals per species
Biodiversity Footprint for Financial Institutions	BFFI	Measures the impacts of a financial portfolio on biodiversity
Biodiversity Impact Metric	BIM	Measures impacts based on producing land area, the estimated proportion of biodiversity lost in MSA (based on Globio and Predicts), and biodiversity importance
Biodiversity Indicator and Reporting System	BIRS	Measures impacts on biodiversity at the site level for the cement and extractive sector
Biodiversity Intactness Index	BII	Measures the average abundance of a set of organisms in a given geographical area relative to their reference population
Biodiversity Indicator for Site-based impact	BISI	Measures impacts on biodiversity at the site level
Bioscope	BIO	Measures impacts on biodiversity in terms of the number of species of vascular plants and lower organisms on land and in water expected to disappear per year
Global Biodiversity Score	GBS	Measures impacts on biodiversity as species abundance ratios between disturbed and undisturbed ecological states counting only species present in the undisturbed state
Healthy Ecosystem Metric	HEM	Measures impacts upon the quantity and quality of biodiversity based on the BII, adding soil and water components
Product Biodiversity Footprint	PBF	Provides indicators for each of the five drivers of biodiversity loss throughout the value-chain
Species Threat Abatement and Recovery Metric	STAR	Measures the reduction of species extinction risk due to threat abatement and habitat restoration
Wildlife Picture Index	WPI	Measures community diversity of ~300 species of tropical forest ground-dwelling mammals and birds that are captured by camera traps

5.2. MCA results

We identify that the twelve variables could be synthesized into two components, collectively accounting for 47.8% of the variance (Figure 1.2). The primary contributors to the first component (on the x-axis) include whether the indicator uses data that reflect firms' operating geographies, the explicitness of the link between corporate activities and biodiversity, and the method used to assess impacts on biodiversity (either no modelization of impacts, assessment of an average effect, or assessment of a specific and localized effect). The second component (on the y-axis) is mainly influenced by the extent of biodiversity components considered (covering several taxons, flora, fauna; terrestrial, aquatic, and marine ecosystems; genetic diversity and ecological functions) and whether ecological impacts are assessed at the ecosystem level or at a larger scale.

Figure 1.2 - Hierarchical Clustering on Principal Components of 15 biodiversity indicators



The MCA reveals that the 15 indicators can be classified into three clusters (Figure 1.2). The first cluster (in red) encompasses six indicators that depict general trends in biodiversity, explicitly linking corporate activities with pressures on biodiversity. These indicators provide impact assessments at the business unit or corporate level but not at the site level. The relationship between corporate activities and biodiversity pressures is modeled and assesses a global average impact. The second cluster (in green) comprises site-level indicators without an explicit link between corporate activities and biodiversity dynamics. These indicators are based on local-scale data. The third cluster (in blue) comprises four indicators supported by peer-reviewed scientific publications and consists of direct indicators of biodiversity condition.

Companies focus on the first cluster, which provides impact assessments at the corporate level and is more easily understandable by non-experts due to the explicit link between corporate activities and pressures on biodiversity. Notably, all six indicators of cluster one are based on Life Cycle Analysis (LCA)-based tools, with two indicators using Globio outputs, two using ReCiPe, one using Globio and Predicts, and one using LC-impact (Table 1-3) to model the effect of corporate activities on pressures exerted on biodiversity.

Table 1-3- Description of the models linking corporate activities and pressures on biodiversity for cluster one indicators

Name of the indicator	Acronym	Model linking corporate activities and pressures on biodiversity
Biodiversity Footprint	BF	Globio
Biodiversity Footprint for Financial Institutions	BFFI	ReCiPe
Biodiversity Impact Metric	BIM	Globio & Predicts
Bioscope	BIO	ReCiPe
Global Biodiversity Score	GBS	Globio
Product Biodiversity Footprint	PBF	LC-Impact

LCA-based models follow a consistent methodology, computing impacts on biodiversity through changes in pressure on ecosystems. Starting with a life-cycle inventory of raw materials used for production across the value chain, volumes of raw materials are translated into pressures on biodiversity by applying characterization factors, which measure the environmental impact of a unit of raw material used. Thus, characterization factors play a crucial role in translating primary data from corporate activities into meaningful impacts on biodiversity.

To ensure an accurate and faithful representation of ecological responses, characterization factors should consider physical and site specificities. Unfortunately, these characterization factors fall short

in this aspect. They do not capture local realities (Schipper et al., 2020), but instead, they reflect effects based on global averages. Their computation derives from meta-analyses of academic papers that estimate cause-effect relationships between increased biodiversity pressure and biodiversity status, often assuming a linear cause-effect dynamic (Alkemade et al., 2009; Koellner & Scholz, 2008). Consequently, these characterization factors, and thus, indicators from cluster one, prove too general to offer sufficient operational insights for companies and their investors. From an investor's perspective, such data fail to assess realistic risk exposure specific to a company's business model. For undertaking firms, these tools lack the necessary sensitivity to reflect local actions they could implement to support biodiversity conservation, thereby failing to demonstrate progress.

The indicators of cluster two are tailored to evaluate biodiversity condition at a local scale. Some, like the Biodiversity Indicator and Reporting System (BIRS) or the Biodiversity Indicator for Site-Based Impacts (BISI), consider local ecological and social contexts. For instance, the BIRS considers species of regional or national concern and takes into account the ecological significance of habitats within the surrounding landscape of a firm's operating territory. It includes the assessment of factors like hydrological connections, biodiversity corridors, or critical breeding sites. The BIRS relies on local managers to define site-level metrics and to prioritize biodiversity actions in consultation with local stakeholders. Additionally, some indicators of this cluster such as the BIRS, involve on-the-ground observations of biodiversity condition, making the results sensitive to the quality of these assessments. Therefore, it's crucial to provide training to employees responsible for conducting these observations and establish standardized procedures to ensure accuracy and reliability. However, since none of the cluster-two indicators model the impacts of corporate activities on biodiversity, designing measures supporting biodiversity conservation at the corporate level by relying exclusively on these indicators is not evident.

Cluster-two indicators have been specifically developed for corporate use, taking into account operational constraints such as human resources and data availability. In contrast, cluster-three indicators have not been designed for corporate application, and companies have shown less interest in using them. These indicators directly assess the condition of biodiversity or specific components of biodiversity, such as wildlife, relying on methodologies backed by peer-reviewed publications. They are more complex than cluster one and cluster two indicators.

In summary, indicators from cluster one and cluster two are unsatisfactory for both MNE executives and investors. Indicators from cluster one are not precise enough to faithfully reflect firms' impacts and dependencies on biodiversity. Indicators from cluster two are site-based, don't inform on the link between corporate activities and ecological responses, and methodologies to scale them are

uncertain. Last, firms might overlook indicators from cluster three because of their complexities.

In reaction to this inadequate offer of biodiversity indicators, some companies have developed in-house methodologies. Empirically, in a previous study, we reveal that eight out of sixteen multinational enterprises (Ta & Levrel, under review) use or were developing internal methodologies to assess their impacts on biodiversity. All had tested and subsequently rejected market-available indicators. The unsuitability of these indicators to their specific activities led these companies to develop their impact assessment tools. These in-house tools are tailored to their operating geographies, production practices, and activities, making them easier for the collaborators to apprehend. To improve the quality of biodiversity disclosure, public policies could leverage these existing internal initiatives. Instead of relying solely on LCA-based information, encouraging the disclosure of this internal information presents an opportunity to provide relevant, more nuanced, and tailored insights.

In the upcoming section, we examine how the CSRD could incentivize the disclosure of these internal assessment conclusions. This involves an analysis of associated transaction costs and characterization of their degrees of specificity and uncertainty (Table 1-4).

6. EVALUATING TRANSACTION COSTS ASSOCIATED WITH DISCLOSING INCREASED QUALITATIVE BIODIVERSITY INFORMATION

The eight firms interviewed anticipated the CSRD not only through compliance objectives but also with operational goals. They take advantage of the due diligence mandatory for CSRD's compliance to question their practices and design biodiversity strategic plans to support biodiversity conservation throughout their value chain. Thus, they develop impact assessment methods that are representative and sensitive to their production practices, based on data spatially coherent with their operating geographies. In this section, we describe each of the eight firms' internally developed tools and characterize the sources of transaction costs that would be associated with the disclosure of their conclusions (Table 1-4). Building on TCE, this analysis provides insights to incentivize higher-quality biodiversity corporate disclosures through the CSRD.

Table 1-4 - Characteristics of the transaction involving disclosures of impact assessments based on internal tools developed by the eight companies interviewed

Firm	Physical specificity	Site specificity	Human specificity	Manufactured capital specificity	Environmental uncertainty (compared to ecological indicators based on LCAs)	Behavioral uncertainty	Institutional uncertainty
A	Focus on functional disruptions (species collisions, disruption of ecological, sedimentary, and fish continuity) and pressures (extracted volumes of water)	Activity-based assessment using data matching operational geographies	Requires knowledge of major pressures on biodiversity and the company's activities and geographies	<i>None to date</i>	Lower as targets ecological functions	Higher due to the potential access to sensible data	Higher due to the control of non-standardized information, which involves higher uncertainty about the required knowledge for control
B	Focus on functional disruptions (ecological continuity) and pressures (land-use change).	Site-based assessment considering proximity with biodiversity-sensitive areas	Requires knowledge of SIG software (iBAT) and own operational-sites locations	<i>None to date</i>	Lower as targets ecological functions and use data matching their site geographies		
C	Focus on threatened or protected species, landscape structure, ecological connectivities and pressures	Site-based assessment considering the proximity with protected areas and the ecological state of the site	Requires tailored knowledge of the specific methodology and software developed	Development of specific software	Lower as it uses data matching own site geographies		
D	Only considers impacts of land-use change on ecosystem services, excluding supporting services	Assessment based on eco-region and land-use type using proxies	Requires tailored knowledge of the specific methodology without advanced ecological knowledge	<i>None to date</i>	Higher as it does not take into account supporting ecosystem services		

E	Focus on land-use change based on LCA conclusions	Mix of site-based assessment (through proximity with protected areas) and activity-based assessment focusing on natural rubber production	Requires knowledge of major pressures on biodiversity, use of a specific software developed with WWF to assess deforestation risks, and the company's operational site locations	Use of a specific software to assess risks of deforestation	Lower as it uses data matching own site geographies	Higher due to the potential access to sensible data	Higher due to the control of non-standardized information, which involves higher uncertainty about the required knowledge for control
F	<i>Not yet defined</i>	Site-based assessment using a SIG tool to assess biodiversity risks surrounding own sites' localisations	Requires using SIG tools	<i>None to date</i>	Lower as it uses data matching own site geographies		
G	Focus on functional disruptions (ecological continuity, species collisions, vegetation management)	Activity-based assessment focusing on vegetation management	Requires advanced ecological knowledge as assessments are part of R&D projects, including dose-response function assessment	R&D equipment to assess on-the-ground ecological response to stressors	Lower as target ecological functions, use data matching own site geographies, and assess a dose-response function over several years		
H	Consideration for major pressure on biodiversity, functional disruptions (habitat fragmentation, water stress), threats to rare or endangered species, and proximity to protected areas	Site-based assessment controlled by an ecologist	Requires knowledge tailored to the specific methodology without advanced ecological knowledge	Development of assessment standards and reporting tools at the corporate level	lower as it uses data matching firms' site geographies		

6.1. Characterizing sources of transaction costs associated with the disclosure of in-house impact assessment conclusions

As exhibited in Table 1-4, five out of the eight internally developed impact assessment tools are designed to enhance or sustain ecological functions at their operational sites. By focusing on maintaining ecological functions rather than keeping constant indicators of biodiversity condition (such as the STAR metric), these tools report on the existence of ecological components rather than their efficiency in maintaining biodiversity. Consequently, they decrease the complexity of the phenomenon under study, thereby lowering its physical asset specificity. Moreover, six out of the eight tools assess ecological functions at the eco-region or site base level, resulting in information with greater site specificity than information derived from global averages used in LCAs.

However, given that these impact assessment methodologies are tailored to specific ecological and business contexts, their implementation and control require higher degrees of human specificity. Collaborators need to familiarize themselves with local biodiversity in addition to getting acquainted with these tailored methodologies, potentially necessitating the creation of training materials or the development of manufactured capital, such as specialized software. In contrast, such materials often already exist for tools available on the market. Moreover, higher institutional and behavioral uncertainties are associated with disclosing information derived from these in-house tools. Institutional uncertainty arises from potential challenges in demonstrating the compliance of these internally developed methodologies with the directive. Behavioral uncertainties stem from concerns about the public disclosure of sensitive information, which may undermine their competitive position (Breuer, 2021).

Ultimately, disclosing the conclusions of the tailored impact assessment tools would involve transactions characterized by lower physical specificity but higher site specificity along with higher behavioral and institutional uncertainties. According to TCE, market-based governance provides little incentive for these transactions to happen. Through price mechanisms, market coordination is efficient for substitutable and reversible transactions. Prices adequately coordinate these transactions, and the potential change in partners helps deter opportunistic behaviors. Market coordination is efficient when contractors can thoroughly and precisely specify future contingencies. However, as transaction assets' uncertainty and specificity increase, so does the need for non-re-deployable investments, making market governance less suitable compared to more integrated governance mechanisms.

In the next section, we suggest a standardized reporting framework to disclose the conclusions of these internally developed impact assessment tools that could lower institutional and behavioral

uncertainties while maintaining higher specificities than in the expected low-cost approach.

6.2. Suggesting a framework for higher quality disclosure while avoiding excessive transaction costs

As mentioned by the Center for European Policy Studies (de Groen et al., 2022), more specific methodological guidance could support companies in complying with the CSRD. Here, we build on the in-house assessment methodologies developed by the eight MNEs mentioned above to suggest a reporting framework that lowers transaction costs.

We argue that using the IUCN Global Ecosystem Typology (Keith et al., 2022), a scalable and spatially explicit classification system designed for generalizations and predictions about ecosystem functions and biodiversity management, can constitute a reporting framework to limit transaction costs while improving the quality of disclosed information. This typology consistently classifies ecosystems globally based on their functional responses to disturbances. It would allow companies to associate their operating geographies with a standardized classification of ecosystems. By relying on the IUCN Global Ecosystem Typology, companies can address the physical, site, and human specificity through existing evaluations of ecosystem ecological responses to disturbances, albeit on a finer ecological scale than with existing 'low-cost' methodologies. This approach thus represents an improvement in the quality of disclosed biodiversity information compared to the low-cost approach. They could additionally address institutional and behavioral uncertainties as they would rely on standardized classifications, which would prevent them from disclosing sensitive information and facilitate the development of human resources competencies.

In sum, relying on a standardized ecosystem-dependent classification would lead to re-deployable investments, thereby lowering transaction costs while providing enhanced-quality information. Using this reporting framework could avoid disclosing site-specific information and, thus, the disclosure of potentially corporate-sensitive information. This approach not only prevents the release of potentially sensitive corporate information but also provides more specific insights than global LCA averages. Furthermore, the use of a standardized ecosystem typology can also mitigate institutional uncertainties, as the knowledge required to control this information would be transferable. Consequently, we suggest that additional methodological guidance based on the IUCN Ecosystem Typology, combined with reporting on ecological functions, could create enhanced quality information without excessive transaction costs. Such a reporting process could consist of first mapping the location of each corporate activity within an undertaking supply chain, then identifying the main ecological functions to monitor, and finally, associating these locations with an IUCN Global type of

ecosystem. Moreover, the typology is scalable, allowing both site-based and corporate-level disclosure, which is convenient for managing and downscaling strategic objectives. Other methodological guidance following similar principles with available spatially explicit data could also be developed to improve information specification and, ultimately, increase disclosure quality levels. This approach could lower transaction costs while providing more representative corporate biodiversity information compared to analysis based on LCAs.

7. DISCUSSION AND CONCLUSION

In this review, we present a novel perspective grounded in transaction cost economics to explain the qualitative degree of corporate biodiversity information disclosure. We formalize factors influencing disclosure quality, focusing on asset specificity and uncertainty, both of which generate transaction costs. This formalization aligns with concerns raised during the public consultation of the CSRD and reported by the CEPS (de Groen et al., 2022). Notably, concerns were expressed about the complexity of biodiversity disclosure requirements, data availability, and the human resources competencies needed to comply with them (European Commission, 2023a).

The CSRD should increase the quantity of biodiversity corporate information available by making its disclosure mandatory. We suggest that TCE anticipates a low-cost (and low-quality) approach to CSRD compliance whereby firms use LCA-based tools. These tools, while globally convenient, present limitations in reflecting local ecological states and operate under a simplified cause-effect relationship. The adoption of a low-cost approach is plausible for several reasons. First, many undertakings that will have to apply the CSRD were not subject to the precedent NFRD (de Groen et al., 2022). They have not yet implemented any non-financial reporting processes, and we expect that they will choose a time- and cost-efficient approach. Second, firms have already expressed concerns about the methodologies to collect data and the necessary resources (de Groen et al., 2022). Third, public authorities also have an interest in lowering the transaction costs associated with implementing their programs, as they can be substantial, potentially undermining public policy implementation (McCann et al., 2005). Furthermore, we explore means of enhancing biodiversity quality disclosure by leveraging information already generated internally.

Lowering transaction costs through enhanced methodological specification is suggested, but other incentives, such as legal action and significant penalties—as in the recent case with Monsanto, which was sentenced in the United States to pay USD 857 million to seven people who developed health problems after exposure to Polychlorinated biphenyls—could lead companies to disclose qualitative

information. Disclosed information should be qualitative enough to allow stakeholders to hold firms accountable.

Ensuring the quality of biodiversity disclosure information also relies on enhanced competencies and skills, both among undertaking firms and third-party controllers. In this area, public policies are needed, too. Martinez et al. (2021) show that under the NFRD, assurance providers paid little attention to the quality of non-financial information. Training programs on biodiversity could be generalized and mainstreamed with the support of public policies.

In conclusion, while the CSRD is expected to increase corporate biodiversity information availability, our review questions its potential impact on the quality of reported information. According to TCE, the substantial transaction costs tied to biodiversity disclosure should lead companies to adjust asset specificity and uncertainty by adopting a low-cost strategy using readily available LCA-based tools. However, the representativity of reported information would be limited, not reflecting local ecological dynamics, thereby limiting leveraging on these assessments to design and operationalize corporate biodiversity policies and actions. Alternatively, we propose that policies capitalize on the development of internal biodiversity information, incentivizing the disclosure of more qualitative biodiversity information without incurring excessive transaction costs. This could be achieved by providing methodological guidelines based on the IUCN Global Ecosystem Typologies. Providing accurate and faithful information on firms' impacts on biodiversity is essential for firms, investors, and public authorities. Firms with more representative impact assessments could combine operational goals with compliance goals on a single budget. For investors, representative data would allow more realistic risk exposure assessments. At the same time, for public authorities, such information could be used to hold firms accountable for their impacts on biodiversity.

CHAPTER 2

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Contributions:

Mai-Thi Ta: conceptualization, data collection and analysis, drafting of the original version of the paper

Harold Levrel: conceptualization, methodology, proofreading, supervision

Michel Trommetter: reviewing

2. HOW COULD MULTINATIONAL ENTERPRISES GENERATE POSITIVE ECOLOGICAL, SOCIAL, AND ECONOMIC IMPACTS LOCALLY? A COEVOLUTIONARY PERSPECTIVE BASED ON THE CASE OF THE VICUÑA FIBER TRADE

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Coevolution, sustainable business models, biodiversity use, development, socio-ecological systems, multinational enterprises

Abstract

Multinational companies (MNEs) are increasingly urged to create positive environmental and social impacts actively. However, examples of such MNEs are rare, and their ecological and social effects are usually assessed from a business perspective rather than a broader socio-ecosystem perspective. This viewpoint limits our understanding of private companies' role in systemic objectives like the sustainable use of biodiversity in their operating territories. Companies need to consider the broader context where they operate and adapt their models to these specificities to reach such goals. The mechanisms that support such adaptation still need to be documented. We lack an understanding of how MNEs interact with their operating territories to generate positive social and ecological outcomes. How do businesses evolve through mutual interactions with the territory where they operate? How do these mutual interactions affect their ecological and social impacts?

Our study is based on a documentary review complemented by a field study investigating the evolution of three forms of businesses – a private company, a cooperative, and a hybrid group composed of local communities and experts - involved in the vicuña fiber industry in Argentina. The vicuña was a threatened species whose economic use has been authorized to limit poaching while benefitting local communities. We analyze 143 documents and 18 semi-directed interviews showing that the three businesses generated additional income, improved the daily life of local communities, and increased

vicuñas' abundance. We then build on coevolutionary ecological economics to identify the mechanisms supporting these outcomes. We find that the cooperative and the hybrid group adapt their business models through complex interactions. They integrate socio-ecological characteristics like vicuñas fiber intermittent shearing, traditional know-how, past trading experiences, and demographics. In turn, these businesses support improving local populations at the individual and community levels through enhanced knowledge and technical skills, reinforced trust relations, and increased access to external organizations. In contrast, although the private company generates stable incomes while bringing financial and equipment support to communities willing to access the vicuña fiber market, it does not fundamentally change its model. This finding indicates that the transition of MNEs towards sustainable business models is an ongoing dynamic process of transformation rather than a linear cause-and-effect relationship.

1. INTRODUCTION

Unfair practices, including social exploitation and environmental destruction, have characterized the history of multinational enterprises (MNEs). During the colonial era, MNEs acted as unofficial government extensions and were actively involved in colonization, manipulating local governance and exploiting indigenous populations (Bown, 2010). After the colonial era, they supported industrialized nations' domination, as United Fruit's example illustrates. The Boston banana trader owned large plantations in Guatemala, influencing the US government to overthrow elected leader Jacopo Arbenz. From the 1980s, increased competition for foreign investment contributed to ongoing social exploitation and ecological harm. MNEs have been associated with population displacement (Yakovleva & Vazquez-Brust, 2018), land loss (Banks, 2009), marine resource overexploitation (Berkes et al., 2006), lower collective responsibility (Bastakoti et al., 2010), and weakened social ties (Becker & León, 2000), among other issues. Today, as public scrutiny of businesses' social and ecological impacts rises, the Corporate Social Responsibility (CSR) concept remains the primary approach MNEs use to manage their impacts.

Specifically concerning ecological consequences, studies have predominantly explored the correlation between market distance and the ecological state of natural resources (Agrawal & Chhatre, 2006; Araral, 2009; Cinner et al., 2012; Meinzen-Dick et al., 2002) while failing to investigate the underlying mechanisms causing the observed relationship. These mechanisms are influenced by how MNEs conduct their activities and how well these activities align with the specific characteristics of the territory where they take place. Reconciling biodiversity conservation and economic development

requires differentiated action on a local scale, and MNEs need to adapt their activities to the larger context in which they operate. Yet, how MNEs adapt their models¹ to the specific characteristics of the territory in which they are involved remains insufficiently documented. Shrivastava and Kennelly (2013) questioned the ongoing “place-less” character of research on sustainability-driven businesses, advocating for place-based enterprises to enhance local, ecological, and social sustainability. Other research explored business-model evolution rather than adaptation, investigating the role of factors like trust, control, and institutional contexts (Cantwell et al., 2010; Inkpen & Currall, 2004; Lewin et al., 1999; Porter, 2006).

In this paper, we explore how the evolution of business models and the evolution of the socio-ecosystems where they operate mutually influenced each other. Socio-ecosystems are “complex adaptive systems in which people and nature are inextricably linked.” (IPBES, 2023, p.31). Our objective is to advance our understanding of how businesses interact with their operating territories and the role of these interactions in shaping their social, ecological, and economic outcomes. How do businesses evolve through mutual interactions with the territory where they operate? How do these mutual interactions affect their ecological and social impacts?

To explore these questions, we study the global industry of vicuña (*Vicugna vicugna*)² fiber (see section 3 for details). The vicuña case represents a “best-in-class” example of the current sustainability approaches by private firms under public regulation. First, the vicuña market is regulated internationally, enforced with relatively strong political will at the national and local scale. It is supervised by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Second, vicuña fiber is predominantly used in the luxury sector, meaning there are fewer cost constraints to invest in sustainable practices. Third, different types of organizations produce fiber exhibiting enough variations to study. Therefore, we use this case study to explore how local contexts have shaped the evolution of three different business models, presenting various social, ecological, and economic outcomes.

The article outlines the theoretical approach, methodology, and data in section 2, followed by a presentation of the vicuña industry in Latin America in section 3. It delves into the history of the three studied businesses in section 4 and analyzes their ecological, social, and economic effects in section 5.

¹ We here designate a business model as what any trading organization, regardless of its legal status, does, how, and with whom.

² Vicuñas are small camelids from South America. They belong to the same family as llamas.

Section 6 examines the underlying mechanisms and coevolution driving these impacts. The article concludes in section 7 by discussing implications for policy-making and practitioners.

2. THEORETICAL APPROACH, MATERIAL, AND METHOD

2.1. Theoretical approach

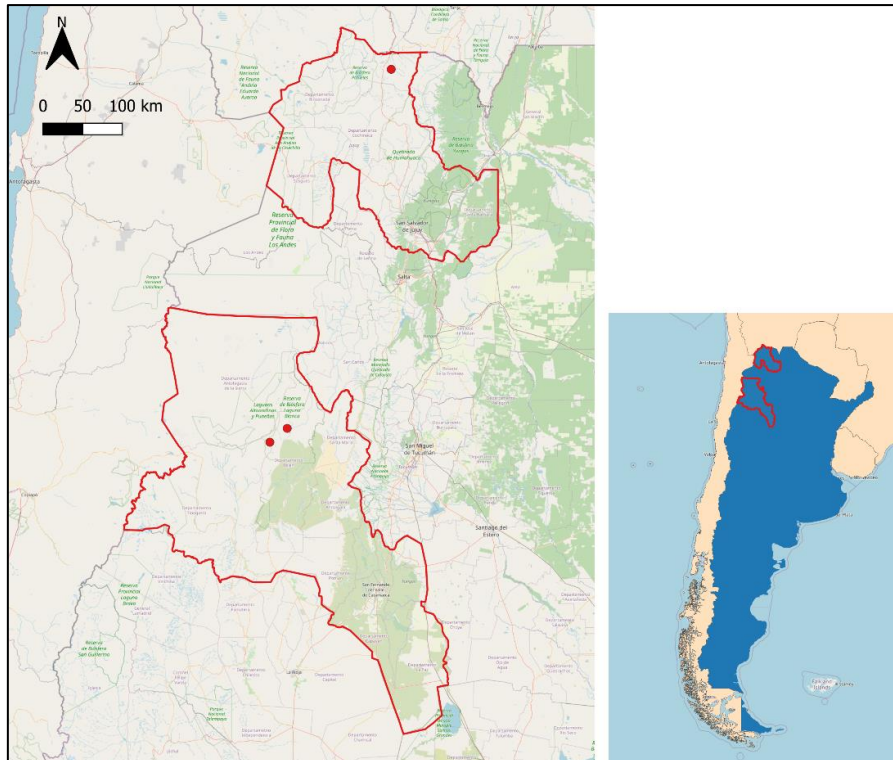
Drawing on coevolutionary ecological economics (Kallis & Norgaard, 2010), we investigate how businesses evolve toward sustainable models. The coevolutionary framework is suitable to investigate complex systems where various forms of mutual adaptation emerge. It acknowledges the reciprocal influences of various socio-ecosystems' components on the evolution of systems. The coevolutionary analysis considers changes in the ecosystem as well as technical, values, social organization, and institutional evolutions. An ecosystem is « a dynamic complex of plant, animal, and micro-organism communities and their non-living environment interacting as a functional unit » (United Nations Convention on Biological Diversity, 1992, p.3). Institutions refer to the “rules of the game in a society” (North, 1990, p.3), which only evolve in the long run while organizations are the players, i.e., “group of individuals bound by a common purpose” (North, 1990, p.3). Technical and knowledge changes designate specific competencies acquired, while values belong to the ethical realm and differentiate what is socially appropriate and what is not. Coevolutionary interactions lead to variation, selection, and retention dynamics.

We analyze the coevolutionary dynamics supporting the variation of business models by first identifying fundamental changes in each model's evolution. We distinguish three stages in this evolution, aligning with Folke et al.'s (2021) framework: preparation, where the capacity for change is built; transition, marked by emergent opportunities for change; and consolidation, where new situations stabilize. We investigate how key changes during one stage influence the next. We use inductive reasoning to trace factors that lead to this change while applying deductive thinking to determine elements of the socio-ecosystem impacted by these changes.

2.2. Material and Method

We collect materials from 18 interviews (Appendix C), documents from the grey literature, academic papers, and regulatory files. The materials used are based on a documentary review and three-week fieldwork from 26th July 2023 to 14th August 2023 in Catamarca and Jujuy Provinces, Argentina (Figure 2.1).

Figure 2.1 - Location of the case studies: Catamarca Province for the cooperative and the private firm (southern-most province) and Jujuy Province for the hybrid group (northern-most province)



During this field trip, we met different actors involved in the businesses we study (see Appendix C for details of the list of interviewees). The documentary review gathered 143 documents composed of academic articles, grey literature, archives, and 35 regulatory documents. The 18 semi-directed interviews were conducted on the field and online. We asked about the role of the interviewees in the business, what activities they carried out, how and why, the decision-making process, and what consequences it had. We also asked what changed since the trade organization's creation, what they think about it, and what they would like to change. Based on this material, we build narratives that we synthesize in section 4, while the following section justifies why we consider the Argentinian case. Our study focuses on three types of businesses: a hybrid group gathering experts and Andean communities, a cooperative, and a private firm.

We analyze each of these businesses in two steps. First, based on the data collected, we trace the history of each trade organization and describe its outcomes. We then relate the identified outcome to coevolutionary dynamics between each business and its broader environment.

3. VICUÑA FIBER TRADE IN ARGENTINA AND PERU: HOW TO QUESTION SUSTAINABILITY

The CITES strictly forbade the economic use of vicuña fiber until the mid-1990s, when the species faced extinction. Since then, trading activities of its fiber have steadily increased with different systems.

3.1. Description of the market

Vicuñas produce one of the finest fibers in the world, making it a high-priced commodity traded globally with many producers and a few buyers. Loro Piana, the leading company in the market, sells a scarf between USD 3,900 and USD 4,200³. Vicuña fiber is produced in Chile, Argentina, Bolivia, and Peru. The production process involves harvesting, sorting, and classifying the fiber. Collecting and selling fiber happens only once a year, and the periodic sales allow for annual negotiations between buyers and sellers.

The vicuña fiber industry is internationally regulated by the Convention for the Conservation and Management of the Vicuña (1979), stating that its economic use should be to "the benefit of the Andean people" (art. 1) who bore the burden of the conservation era. We focus solely on comparing Peruvian and Argentinian models as they account for 96% of global trade volumes (Cowan Ros et al., 2020).

Table 2-1 - Main differences between Argentinian and Peruvian systems of vicuña fiber production

	Peru	Argentina
Ownership	Government	<i>Res nullius</i>
Management systems	Captive and wild management	Wild management
Investments required	From USD 2,800 to USD 3,600	USD 13,200
Trading national organization	Formerly negotiated nationally, but now communities directly trade with buying companies	Direct trade
Ecological impacts	Diseases spreading, risk of in-breeding, high stress	Lower disease spreading and lower stress

³ On Loro Piana's website, accessed on 04th July 2023

3.2. Ownership of the resource

In Peru, vicuñas are the property of the national government, while in Argentina, vicuñas are *res nullius*, meaning nobody owns them. However, in both countries, the usufruct is granted to Andean communities and extended to private companies.

3.3. Management systems

Initially, Peruvian vicuña management mimicked the capture-and-release traditional Inca *chaku* method, using flags to gather and shear the vicuñas. Today, *chakus* include mechanical shearing, which is quicker and reduces stress. Motorcycles can also be used even though their noise also stresses the vicuñas. In the 1990s, Peru shifted towards a breeding and productive approach. Despite economic and ecological issues, the government actively implemented this management approach throughout Peru (Sahley et al., 2004).

Argentina also tested captive breeding via a national program. Breeders could seek financial loans from an exporting company, repaying 50% of yearly production until debts were settled. Repayment took 7 to 10 years (Vilà & Lichtenstein, 2006). Yet, captive breeding disrupted vicuñas' ecological dynamics (Vilà, 2002) and caused stress while failing to transmit conservation values (Fish and Wildlife Services, 2002). Therefore, captive breeding ceased, leaving only wild management in Argentina.

3.4. Need for investment

Captive management in Peru requires an investment ranging from USD 2,800 to USD 3,600 (Renaudeau d'Arc & Lichtenstein, 2003), while in Argentina, it takes around USD 13,290, according to Rigalt et al. (2006).

3.5. Trading scheme

Until 2004, Peru's vicuña industry was controlled by the National Vicuña Society (SNV), which represented the only channel for small communities to sell their fiber. However, after the SNV dismantling, communities negotiated individually with intermediaries, causing selling price variations (Lichtenstein, 2009). In Argentina, local producers directly negotiate with exporting companies.

3.6. Argentina as a success story of sustainable use of biodiversity

The Peruvian model faces social and ecological concerns as smaller communities obtain lower prices than larger producers, and ecological concerns have arisen from the consequences of captive management (Angulo-Tisoc et al., 2021; Vilá, 2002). In summary, the Peruvian captive management system

continues even though it has encountered economic and ecological challenges, while in Argentina, it has ended. We, therefore, focus on three distinct Argentinian types of businesses.

4. COEXISTENCE OF THREE TYPES OF TRADE ORGANIZATIONS IN THE SAME SUPPLY CHAIN

4.1. Social and ecological context

We investigate three forms of businesses located in the Puna ecosystem, the natural habitat of vicuñas at 3,000 to 5,000 meters altitude, characterized by natural resource scarcity with low rainfall, drastic temperature fluctuations, and strong winds, hosting limited vegetation and water.

Socially, Argentinian indigenous communities are marginalized with an inability to meet basic needs four times higher than the national average (37.4% vs. 9.1%), according to the National Statistics and Census Institute (n.d.). They rely on pastoral and agricultural activities with a mix of European (sheep and goats) and local (llamas) livestock. Winter is spent in the village, while summer sees herds moved to lower pastures. Traditionally, these communities are patriarchal, with men handling crops and women overseeing livestock with children helping. Bartering is common, and a few stable jobs exist, primarily in public service and mining. Young men usually emigrate as low-skilled workers. Culturally, vicuñas have sacred importance, cared for by the Pachamama (Mother Earth) (Cowan Ros et al., 2020). Before capturing vicuñas, offerings are made to seek Pachamama's permission, following the principle of taking only what's needed to avoid angering her. Thus, overexploitation risks divine consequences.

4.2. Description of the case studies

4.2.1. The hybrid group

In 2012, Andean communities in Jujuy Province sought advice from an *extensionista*⁴ - who had been working with them for several years - to manage vicuñas as they threatened their livestock but could not be killed. Following this request, the *extensionista* gathered a group of biologists, veterinarians, and agronomists. Some of these experts participated in the captive management experiences described in section 3. First, the experts focused on changing the perception of vicuñas from harmful to endangered species. Some training sessions were conducted within the communities' territory, allowing them to meet all members, including those not interested in vicuña-related activities. Meeting

⁴ *Extensionistas* are fieldworkers closely collaborating with communities in the implementation of development projects.

with the whole community contributed to securing the community's formal agreement to participate in the project through what the *extensionista* called "actas de aceptación social."⁵ Economic and market aspects were discussed only in 2014.

The hybrid group organizes the production processes using the communities' social organizations. For example, they trained two shepherds from each community to assess vicuñas' health and observe population dynamics. They suggest locations for the *chakus* accordingly. The intertwining of the commercial organization and the social structure is also evident in the decision-making process, which relies on the communities' assemblies. All members are invited to discuss any communal subject at these assemblies, including vicuña-related matters. A representative of each community is appointed to attend inter-community assemblies where decisions are taken through the same deliberative process based on consensus and the adoption of formal "actas."

Furthermore, instead of a cooperative, the experts and communities formed an informal entity, which later became the CAMVI (Comunidad Andina de Manejadores de Vicuñas). They decided to pool equipment and human resources. The inaugural *chaku* took place in 2014, while the first sale occurred in 2018, six years after the project's initiation. In 2022, the hybrid group had the opportunity to sell fiber directly to Loro Piana, the industry leader. However, it required an organizational change as the company required managing a single contract rather than one contract per community. Consequently, as a temporary solution, a single community invoiced and redistributed the revenues to others. In April 2022, efforts were underway to get the legal status of a cooperative.

4.2.2. The cooperative

La Cooperativa La Mesa Local de Laguna Blanca Ltd., located in the Catamarca Province, was established in 2008 as part of an international development project called PRODERNOA. Initially, the PRODERNOA agents set up an informal community assembly called la mesa de desarrollo local to encourage local participation and empowerment. Over time, the assembly expanded its discussions beyond vicuña fiber to encompass broader topics like education and healthcare. Later, the informal assembly officially became the Cooperativa La Mesa Local de Laguna Blanca Ltd.

In parallel, the PRODERNOA agents conducted training workshops less frequently than the hybrid

⁵ The name of the formal documents synthesizing the decisions of the *community assemblies* according to the *extensionista* who initially helped the communities (interview dated 06/07/2022)

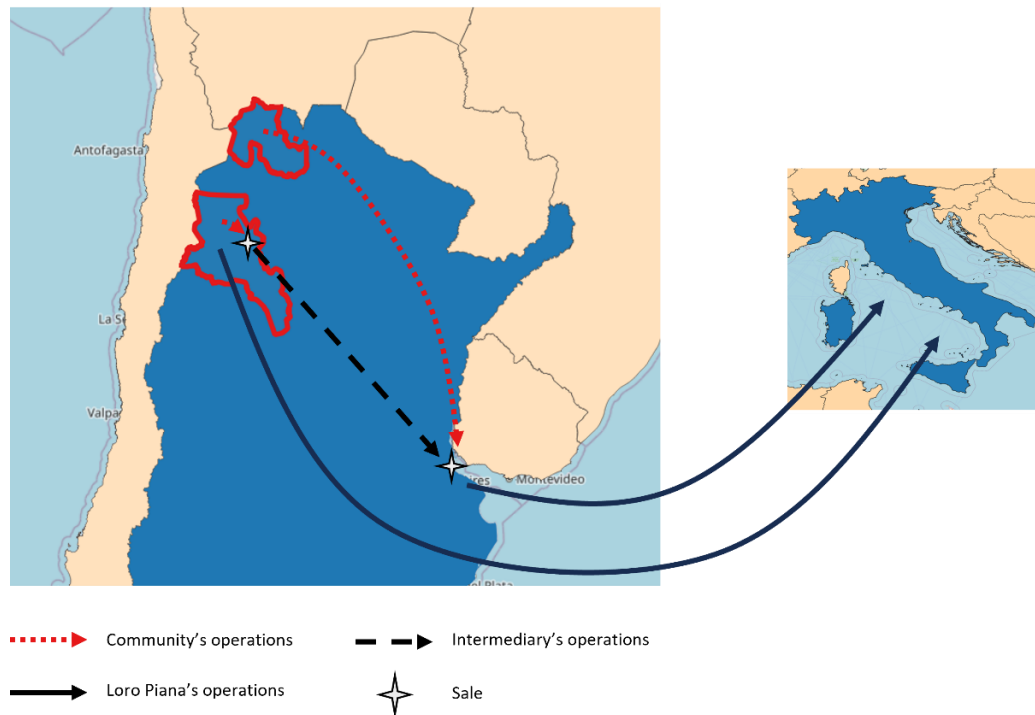
group (5 workshops versus 19 workshops). However, despite these training sessions, administrative management and compliance were neglected for four years, and in 2011, the cooperative had mounting debts near bankruptcy. Two associates were trained to manage the administrative situation. In 2013, when the administrative situation recovered, the cooperative's remuneration model was changed to provide funds for daily operations. Recently, the cooperative has expanded its revenue streams by offering tours to tourists interested in witnessing *chakus*. It also assists local communities that need support in organizing *chakus*. Currently, the cooperative is the only community in the province using the ancestral knowledge of weaving vicuña fiber. Other communities sell raw fiber.

4.2.3. The private firm

The third model is a privately owned company, with 80% ownership by Loro Piana. It bought 108,000 hectares of land in the Catamarca province in 2008. Initially, the company brought equipment and workforce from the South of Argentina, where the company operates capture-and-shearing activities. Later, the firm created jobs locally, following a regulation that reduced taxes for firms generating local employment. The private firm carries out ecological monitoring through four annual censuses and fodder provisions. It has recently formed strategic partnerships with neighboring communities willing to access the vicuña fiber market, providing monetary or technical assistance. Most of these communities are the ones of its employees who replicated the company's shearing techniques designed to minimize noise and human activity.

Figure 2.2 sums up the role of Loro Piana in each case study: either a subsidiary of Loro Piana (the case of the private firm), a producer selling to an international exporter (the cooperative and the hybrid group for its first sale), a producer selling directly to Loro Piana (the hybrid group for the 2022-sale).

Figure 2.2 - Illustration of the different types of supply chains studied and their articulation with the leading firm, Loro Piana.



In the following sections, we explain how each model adapted – or not - to its broader environment. Section 5 outlines social, ecological, and economic impacts, while Part VI delves into coevolutionary dynamics that lead to these outcomes.

5. DIFFERING SOCIAL, ECOLOGICAL, AND ECONOMIC IMPACTS

Authorizing vicuña fiber use primarily aimed at curbing extinction risk. Results indicate positive results in that matter. In the Laguna Blanca biosphere reserve, near the cooperative and the private firm's area, vicuña numbers surged from 1,300 to 13,000 (Rigalt et al., 2006) between 1982 and 2005. In Jujuy, where the hybrid group is based, they grew from 55,353 to 90,000⁶ between 2006 and 2013.

In the following paragraphs, we qualify for each case study the ecological impacts, in terms of the proportion of vicuñas shorn, respect for animal welfare, and control of poaching; the social impacts, in terms of number of individuals or communities involved and change in their living conditions; and economic impacts - in terms of revenues (Table 2-2). Appendix D, Appendix E and Appendix F detail

⁶ According to Jujuy Ministry of Environment and Climate Change: <https://www.ambientejujuy.gob.ar/chakus-y-vicunas/> (accessed on 15th July 2023)

the ecological consequences of each case study.

5.1. The hybrid group

5.1.1. Ecological impacts

Between 2014 and 2021, an average of 335 kg of fiber was harvested annually, with a notable increase since 2017, when the first sale took place. While in 2014, 213 vicuñas were shorn, producing 40 kg of fiber, in 2021, these numbers were multiplied by 16, reaching 3,392 individuals for 784kg of fiber. Based on the most recent national census (Baigún et al., 2008) and hypothesizing a natural growth rate of 13%⁷, the proportion of vicuñas shorn represents between 0.02% and 0.18% of the total population, with a recapture rate below 3% (Cowan Ros et al., 2020). Despite the low proportion of vicuñas shorn, the volume of fiber collected rapidly increases, with an average annual growth rate of 53%. If this trend continues, it could lead to overexploitation in the long run.

Concerning animal welfare practices, communities follow the protocol on animal welfare practices drawn up by the International Union for Conservation of Nature (2016) South American Camelid Specialist Group (GECS). To our knowledge, these are the strictest welfare guidelines that have been formulated so far⁸ concerning vicuñas' management. The time dedicated to training reflects the importance of animal welfare issues: 110 workshops were organized between 2012 and 2019 (Segovia, 2019), focusing on changing communities' perceptions of vicuñas. These workshops aimed to increase local community awareness and promote vicuña-friendly territory management, such as setting aside exclusive spaces for vicuñas.

Moreover, the focus on species conservation led the hybrid group to implement processes allowing for early detection of ecological disturbances through shepherds' continuous observation of the vicuña population. Local communities' involvement in ecological monitoring raises community awareness while empowering them as actors in conserving an emblematic species of the ecosystem they live in.

One of the main issues is controlling poaching despite a decrease in reported cases. In 2012, approximately a hundred vicuñas were poached, but by 2019, this number dropped to around twenty (IUCN, 2016). The hybrid group's primary anti-poaching strategy involves engaging more communities

⁷ Estimated based on the study of Arzamendia and Vilà (2012)

⁸ This group is pushing these practices to serve as a benchmark for all producer countries (Kasterine & Lichtenstein, 2018).

in conducting *chakus* to encourage them to monitor and observe vicuña populations. However, this approach may increase human pressure on the resource, and tracking the ecological consequences of an increased number of *chakus* involves dedicated financial and human resources.

5.1.2. Economic impacts

Since 2014, each family of the hybrid group received an average of 1.4kg, corresponding to an additional USD 577. Assuming a 40% tax on the last sale, this lowers the amount to USD 525 annually, representing between 1 month and 1.5 months of the average salary for each family⁹.

5.1.3. Social impacts

The additional income has improved material living conditions at the household level. It helped buy cooking equipment, finance children's education, or even a car. None of our interviewees mentioned reinvestment in additional livestock, which is in line with the practices described by Forni (1986), who observed that people rarely bought livestock in the Puna.

At the community level, the decision-making process based on consensus-building between communities has strengthened their mutual trust, enabling them to anticipate conflicts. For example, it was decided not to capture vicuñas in areas bordering each community territory to avoid debates about how to redistribute the fiber.

Finally, experts from the hybrid group are involved in every fiber production and sale stage, including *chakus* organization, training, and price negotiation. This reliance on experts raises concerns about the model's sustainability as there is no permanent structure nor budget to ensure ongoing support of these experts.

5.2. The cooperative

5.2.1. Ecological impacts

From 2007 to 2021, the cooperative collected, on average, 76kg of fiber annually. We distinguish two periods: first, from 2007 to 2013, with an average of 28kg per year, equivalent to shearing around 112 vicuñas, and second, since 2013, when the annual amount of production rose sharply to an average of

⁹ According to Cowan Ros *et al.* (2020), household annual earnings range between USD 4,210 and USD 5,895 monthly.

133kg, equivalent to shearing 532 individuals. While in the first period, there was a negative average annual growth rate in resource extraction of approximately -5% per year, it increased to +16% per year in the second period. Following the same methodology as in the case of the hybrid group, we estimate that the number of individuals shorn annually represents between 0.13% and 0.60% of the provincial vicuña population.

In terms of animal welfare, the agents of the Secretariat of Agricultural and Livestock Policies control three elements for all *chakus* in the province of Catamarca: the general condition of the individuals captured, i.e., weight, the fact that the animal does not seem weak nor ill, and in the case of females, the fact that it is not pregnant; their dentition to determine their age; and whether there are any wounds following shearing. Initially, blood samples were collected to assess the health of the vicuña population, but this has stopped.

In the province of Catamarca, fighting poaching is challenging. The area to be controlled is vast, and enforcing regulation is complicated. The region's topography, which is steeper than Jujuy Puna, makes poaching areas very difficult to control. Besides, it is impossible to quantitatively evaluate the extent of poaching as there is no provincial registry or systematic recording of catches.

Finally, the diversification of the cooperative's activities towards tourism limits the pressure on vicuñas as it decouples income from the volume of resources extracted. However, tourism can also be a source of deterioration in the vicuñas' population welfare; for example, if too many people attend the *chakus*, vicuñas could be under too much stress.

5.2.2. Economic impacts

In 2022, the cooperative gathered 102 associates, each receiving between 1.4 and 1.6 kg¹⁰ of fiber. Income generated from this resource varies depending on whether the fiber is sold raw or used to weave handicrafts.

If the fiber is sold raw, the amount of fiber yields between USD 532 (for 1.4 kg) and USD 608 (for 1.6 kg)¹¹, representing between 15 and 18 months' salary. If a piece of handicraft is made, the amount of fiber collected allows to produce a poncho that can be sold for up to USD 1,200. On this sale, the

¹⁰ Under the assumption that the cooperative sells 20% of the harvest to finance its current activities - the approximate proportion that a member of the cooperative's direction gave us.

¹¹ Taking the 2022 selling price: USD 380/kg

associate receives USD 1,140¹², representing around 2.5 years' salary. Most of the cooperative members chose to weave handicrafts. Targeting this market segment leverages the heritage discourse that had been developed and on the cooperative's national reputation.

5.2.3. Social impacts

Beyond the monetary aspect, weaving handicrafts is compatible with traditional economic activities as it can be done while looking after livestock, making it an activity especially suitable for women who usually look after livestock. In addition, entry barriers in terms of skills are low as most inhabitants already know how to weave or are eager to learn this aspect of their heritage. Finally, some consider weaving relaxing, indicating that time spent weaving has a positive value even though the preliminary step of sorting the fine fibers is physically exhausting.

Besides "showing the world"—as expressed by a former cooperative member—aspects of Andean traditional culture are a source of pride, particularly for the cooperative's young people, who have won prizes in national and international craft fairs. Making a living using an ancestral heritage is all the more significant as it contrasts with the historical marginalization of these communities.

In Laguna Blanca, the additional income also improved the daily lives of the cooperative members. Additionally, it provided investment in entrepreneurial activities. A communal canteen, at least two grocery stores, and three hostels have opened recently. At the community level, participation in the cooperative has provided administrative and accounting skills that are especially useful in integrating global markets. The cooperative's initiative to sell its products under a unique brand reflects an understanding of international markets' mechanisms.

Finally, the cooperative's economic power has reached political arenas as provincial authorities consider granting the village the status of a municipality with a representative of the indigenous population. The president of the cooperative is currently being considered for this position.

5.3. The private firm

5.3.1. Ecological impacts

The private company shears between 2,110 and 3,164 vicuñas per year, i.e., between 1.90% and

¹² As there is a 5% fee on the selling price from the cooperative

15.90% of the vicuñas of its territory.

The private company presents ecological strengths as its production practices aim at maximizing the vicuña population on its territory by minimizing human presence and noise during captures. For example, it does not use motorcycles to facilitate the grouping of vicuñas. Therefore, the fact that neighboring communities replicate this model is favorable regarding these aspects. However, it brings in fodder from external territories without, to our knowledge, prior assessment of the ecological consequences of this practice.

5.3.2. Economic impacts

We have no data on the salaries paid to the company's full-time and part-time employees. However, regardless of the salary, access to stable employment is rare in the Puna. In this regard, the private company created about ten full-time jobs while hiring around fifty seasonal employees to help during the *chakus*. In total, this represents 22 full-time equivalent jobs. Additionally, forty women of the neighboring communities classify fiber.

Economically, the company's influence extended provincially through the redistribution fund, sourced from a 20% tax on shearing. The amount of fiber derived from community *chakus* could sustain the fund for three months, while private firms contributed the rest for the rest of the year.

5.3.3. Social impacts

We could not assess how neighboring communities used the additional income they obtained. However, to our knowledge, sales were conducted under the legal form of *comunidad indígena*, which only allows community expenses.

Finally, monetary or equipment loans offer neighboring communities market access but also create a risk of a poverty trap and dependence on the private company as communities commit to selling the harvested fiber to the company until they repay their debt. A similar monetary scheme had been implemented during the national captive management experimentation in Jujuy province, and the communities' debt had been considerable.

Table 2-2 - Synthesis of the ecological, social, and economic impacts of each case study

	The hybrid group	The cooperative	The private firm
Estimated number of individuals by the last national census in 2006^a (corresponding territory, surface)	55,353 indiv (Jujuy Province, 17,792 km ²)	24,844 indiv (Laguna Blanca Biosphere Reserve, 9,526 km ²)	2,817 indiv (Pasto Ventura, 1,080 km ²)
Estimated number of individuals in 2022^b (corresponding territory, surface)	391,198 indiv (Jujuy Province, 17,792 km ²)	175,581 indiv (Laguna Blanca Biosphere Reserve, 9,526 km ²)	19,906 indiv (Laguna Blanca Biosphere Reserve, 9,526 km ²)
Estimated number of vicuñas shorn yearly^c	1,496 indiv/year	194 indiv/year	2,326 – 3,488 indiv/year
Estimated proportion of shorn vicuñas^d (min% – max% over the organization's lifetime)	0.14% – 0.98%	0.13 – 0.60%	6% – 22%
Average quantity of fiber collected annually (kg)	335 kg	76 kg	800 kg
Average annual increase of fiber collected^d (%)	+53%	-5% until 2013, then +16%	+10%
Animal welfare practices	Fully aligned with IUCN GECS guidelines (<i>weight, hair length exceeding 3 cm, the fact that it does not seem weak nor ill, and in the case of females, the fact that it is not pregnant</i>)	Not fully aligned with IUCN GECS guidelines (<i>weight, the fact that it does not seem weak nor ill, and in the case of females, the fact that it is not pregnant</i>)	Minimized disturbances: low human presence and no use of motorcycles
Poaching	Decreasing but not controlled	Not controlled and no data	No sign of poaching for eight years
Beneficiaries	Families	Individuals	Private firm + Full-time employees + part-time employees
Nb of beneficiaries in 2022	350	102	1 + 22 + ~40
Household benefits	Equipment to improve daily living standards	Equipment to improve daily living standards	Wages
Communal benefits	Limited	Exit from socio-economic isolation	Access to vicuña fiber market for neighboring communities
Nb of shearing days	56	16	18

Total estimated revenues for 2022^d (USD)	157,500	54,264 - 116,280	400,000
Other strengths	<ul style="list-style-type: none"> - Continuous ecological observation of vicuñas - Conflict resolution facilitation between communities 	<ul style="list-style-type: none"> - Diversification toward tourism - Sufficiency approach - Promotion of indigenous culture 	<ul style="list-style-type: none"> - Replication of its capture practices by other communities
Other weaknesses	<ul style="list-style-type: none"> - Dependence of the communities on the experts 	<ul style="list-style-type: none"> - Risk of perpetuating inequalities and power relation discrepancies 	<ul style="list-style-type: none"> - Dependence on the private firm to sell the fiber - Risk of poverty trap

^a For the cooperative and the private firm, the number of individuals is computed as a linear proportion of the Catamarca's province result mentioned in Baigún et al. (2006), i.e., the latest national census

^b We estimate the overall number of vicuñas in 2022 (N_{2022}) from the last national census, applying a natural growth rate of 13% derived from the study of Arzamendia and Vilà (2012): $N_{2022} = N_{2006} * (1.13)^{16}$

^c Using an average yield of 392g/indiv for the cooperative (Rigalt, 2019); 224g/indiv for the hybrid group (Cowan Ros et al., 2020); 430g/indiv for the private firm (interview of the private firm representative)

^d See Appendix D ,Appendix E and Appendix F for further details on the computation

To sum up, the three models exert ecological pressures of varying intensity. With an average of 76kg of fiber shorn per year, the cooperative's harvesting amounts are much lower compared to the 335kg of the hybrid group and 1,000 to 1,500kg of the private company. Therefore, the risk of future overexploitation is lower, with an annual growth rate of volumes harvested of 16% compared to 53% for the hybrid group. Additionally, the hybrid group constantly monitors the vicuña population; the private company carries out four censuses per year, while the cooperative's model does not implement mechanisms preventing overexploitation in its production processes. Ultimately, for the cooperative, mitigating the pressure on the resource relies on the State that issues shearing permits.

Economically, the hybrid group provides complementary revenues while the cooperative brings significant additional revenue and the private firm a stable revenue. In the case of the cooperative and the hybrid group, both models have generated individual livelihood improvements and communal benefits: interactions with external actors that broke the trading isolation of the village in the case of the cooperative and conflict-resolution mechanisms between communities for the hybrid group. In the case of the private firm, we assume that the benefits have been reinvested at the communal scale as the regulation on indigenous communities' trade stipulates.

6. A COEVOLUTIONARY PERSPECTIVE BETWEEN BUSINESS MODELS TRANSFORMATION AND EVOLUTION OF SOCIO-ECOSYSTEMS

We use coevolutionary thinking to understand better how business model variations emerge. However, it is essential to define the specific nature of these variations:

- i. For the hybrid group: the evolution of decision-making processes based on consensus and the resource pooling decision.
- ii. For the cooperative: the diversification of activities towards tourism
- iii. For the private enterprise: the development of strategic interactions with neighboring communities

Here, we systematically compare the approaches of each trade organization, distinguishing three stages in business model evolution: preparation, transition, and consolidation. Appendix G sums up the forms of coevolution that we describe in this section. Section 6.1 presents the common dynamics emerging in the preparation phase for the three businesses studied.

6.1. Preparation stage: how trade organizations influence the socio-ecosystem

6.1.1. Building knowledge, skills, and competencies

The significant time difference and number of sessions dedicated to building knowledge and skills – 19 workshops over two years vs. 4 or 5 over a few months - reflect fundamentally different approaches between the cooperative and the hybrid group. The hybrid group approach is rooted in the experts' experience and background. Since most of them are biologists, agronomists, or veterinarians, and since some of them had been involved in the experiment of the captive management system, they prioritize conservation and animal welfare compared to marketing issues. The first sale happened in 2018, six years after the project started.

In contrast, the PRODERNOA project explicitly aimed at integrating local communities into global markets, in line with the international development paradigm of that time. The first sale took place the same year the cooperative was created. Moreover, including marketing in the training led to enhanced social interactions. For example, an elderly woman taught how to weave the vicuña fiber. Sharing knowledge between generations was crucial to overcoming the fear of using the fiber of a sacred animal while reconnecting with an ancestral heritage.

Concerning the private firm, it transferred knowledge and skills from another province, reflecting limited interactions with its operating territory, which is in line with a profit optimization approach.

In all cases, training approaches vehicle distinct perspectives on the links between biodiversity use and development. For the hybrid group, the concern and priority of conservation issues; for the cooperative, the belief that a cooperative is the adequate legal form to achieve development issues; and for the private firm, economic optimization under international regulation. The preparation stage was not only about building skills or knowledge but also about creating the values and worldviews in which each business would evolve.

6.1.2. Building trust with local communities

The hybrid group organized training sessions on the communities' territory, leveraging the existing relationship between the experts and the communities. They met all community members while strengthening trust between communities. It also secured robust foundations for communities' involvement using traditional decision-making processes that grant meaning to the *actas de aceptación social*, even though they have no official legal meaning. In fact, these "actas" are a sign of the intertwined processes between social and productive organizations. This process also ensured that all communities shared a common understanding of the organization.

Concerning the cooperative, the *mesa de desarrollo local* welcomed all community members to talk freely about *vicuña* use regardless of their condition and social status. Initially, this assembly was supposed to enhance trust between community members. Here, the medium used to build trust is also derived from the specific values the expert had on the effective ways of implementing sustainable biodiversity use. These values led them to enhance empowerment through the *mesa de desarrollo local* informal organization and to adopt the legal form of a cooperative. In contrast to the hybrid group, there is no overlap between the social organization and the production processes.

In the case of the private firm, interactions with local communities remained limited in the preparation stage. There were no mechanisms to foster trust.

6.1.3. Encouraging institutional access

A distinctive aspect of the cooperative is that it attracted other development projects on the territory, such as the United Nations Development Program, which supported equipping some houses to increase tourism carrying capacity, or the national sustainable tourism pilot project. Those projects facilitated access to external organizations, and the cooperative acted as a focal point in this dynamic.

Because these organizations already know how cooperative functions, it was, therefore, practical to deal with it. Innovative and peculiar organizational innovations, such as the ones implemented by the hybrid group, are challenging to work with as they would involve additional transaction costs¹³. In turn, the presence of these external organizations contributed to building an integrated territorial project based on tourism, which oriented the cooperative business model evolution.

To our knowledge, the experts involved in the hybrid group were already working with the communities who did not access additional organizations and the private firm only interacted with the provincial government controlling the *chakus*.

6.2. Transition stage: how, in turn, the socio-ecosystem influences business models

As distinct dynamics emerged after the preparation stage, we present the following paragraphs in an organization-by-organization order.

6.2.1. The hybrid group: institutional bricolage and pooling of resources

The hybrid group overcame administrative issues by seeking workable, though not optimized, process improvements. For instance, the experts explored various legal options to sell directly to Loro Piana. Despite lacking marketing and legal expertise, they navigated and adapted the information at hand. This modus operandi can be qualified as institutional bricolage, defined as "a process through which people [...] assemble or reshape institutional arrangements, drawing on whatever materials and resources are available" (Cleaver, 2001, p.29). Institutional bricolage allows a flexible organization in the face of unexpected events.

Pooling resources marked a notable evolution in the hybrid group's business model, supported by trust built during the preparation stage. In turn, pooling resources reinforced community interdependence. Several factors influenced this decision: provincial policies, demographics, and vicuñas' biological characteristics. Indeed, the experts that we met have been supporting the communities in their incumbent budget, with limited access to additional financial means. Second, each participating community was too small to carry out *chakus* on its own, as *chakus* require at least 70 people. Lastly,

¹³ Transaction costs are the costs incurred by an economic transaction. They can be divided into three categories: information, negotiation, and control costs. As decision-making in the hybrid group is based on consensus, an external organization would have to convince 16 representatives, while for a cooperative, only the president. This process would involve more extended discussions, translating into increased transaction costs (providing information to 16 representatives, meeting with them, and gathering the necessary legal information to contract with them, among others).

vicuñas are only shorn once every year, which also facilitates equipment pooling as communities need it interruptedly. Thus, the territory's specific social, institutional, and ecological characteristics shaped the hybrid group business model evolution.

6.2.2. The cooperative: overcoming the administrative crisis motivated by cultural factors

In contrast, in Laguna Blanca, despite a dedicated budget allocated to the PRODERNORA project, the cooperative was almost bankrupt between 2011 and 2013. The choice of the cooperative legal form and the weak practical administrative training contributed to this crisis. Successfully overcoming this was motivated by cultural factors as one of the two community members in charge of the cooperative's recovery did it to maintain ancestral knowledge. To handle the situation, she developed personal ties with every cooperative member to verify administrative information and explain the importance of their presence in the assemblies. Overcoming the crisis on its own proved to the community that it could manage a cooperative independently. It improved the esteem it had about itself and changed previous worldviews villagers had inherited from the previous disappointing cooperative experiences.

6.2.3. The private firm: strategic interactions through contingencies

Even though interactions between the private firm and its broader environment were limited, they initiated an evolution of its business model through reinforced interactions with neighboring communities. Indeed, the firm heard about difficulties the neighboring communities experienced in organizing *chakus* through the agents controlling its operations. These new forms of cooperation allow these communities to access new sources of income. However, they do not reflect a fundamental change in the firm's logic, as its main activities and how it carries them out are limitedly modified to consider local social and ecological characteristics.

6.3. Consolidation stage: the mirage of stable, sustainable models?

The last stage of the transformation process described by Folke et al. (2021) corresponds to a stable stage in which a social innovation either replaces the broader structure, incorporates it, or vanishes.

The hybrid group has implemented a stable decision-making process able to face unanticipated disturbances: decisions are taken unanimously between representatives of each community with an advisory role left to the experts. In the cooperative's case, the new fiber redistribution model constitutes a stable foundation as it secures financial stability and legal compliance. Cooperative members did not follow an optimization logic to design the new redistribution model. They instead

agreed on the amount they thought they would need – the equivalent of one poncho per year, which requires around 1kg of fiber – and the cooperative would sell the remainder to secure financial means. Adopting this approach, they apply their values – not taking too much from the Pachamama – to an external tool, the cooperative, thereby making it their own. Once economic stability was secured, the cooperative diversified its activities. The cooperative is also currently discussing the creation of its own label, *Chaku* Vicuna - Mesa Local de Laguna Blanca Coop Ltd., which would certify that production was carried out in line with the traditional *chaku* techniques, in other words, respecting the Pachamama and its natural resources.

The private firm evolved towards a win-win situation as the strategic interactions represent additional supply while contributing to helping neighboring communities enter the market. Overall, its business model marginally evolved while having ecological, social, and economic positive impacts. Therefore, coevolutionary dynamics are less pervasive than in the other two cases.

To sum up, we show that the evolution of business models and socio-ecosystems mutually influence each other. The cooperative attracted other organizations that reinforced the territory's cultural discourse and touristic facilities, which, in turn, enhanced its reputation and created a demand for its products and services. It became the focal point supporting an integrated vision of tourism, which oriented the diversification of its activities towards a non-extractive one. This coevolution led to fewer vicuñas shorn and a lower increase in extracted volumes than the other two models. Despite this lower ecological pressure, the cooperative does not rely on any mechanism to detect disturbances in the ecosystem. In contrast, the hybrid group relies on regular ecological observation. This ecological monitoring builds on communities' social organization. This peculiar organization encourages interdependencies among communities and has been facilitated by the acquaintance of experts with the cultural and social organization of local communities. In the case of the private firm, the broader social, cultural, technical, and institutional context affects its model marginally as it does not change but extends its core model.

7. DISCUSSION AND IMPLICATIONS FOR FUTURE RESEARCH AND POLICY-MAKERS

Our research findings demonstrate that MNEs operating within a specific context can generate trust and social interactions favoring the sustainable use of biodiversity. Generating positive social and ecological sustainability outcomes can be understood as a coevolutionary and adaptive process. It involves multiple elements of the ecosystem and intricate interactions between businesses and various actors in their territory. These actors not only involve suppliers but also a broader scope of partners

such as NGOs, researchers, and local government representatives. Here, the approach is not about stakeholders' consultation but continuously involving these actors in designing and monitoring the production processes. They represent allies in directing and shaping the impacts of a company.

The implication for practitioners and policy-makers is that current approaches relying primarily on suppliers to bring change appear unsatisfactory. Consequently, tools focusing only on suppliers – such as traceability certificates or labels – only use one driver, while a systemic approach could leverage positive impacts. Such an approach contrasts with studies on new sustainable business models that have predominantly investigated case studies based on circularity (Geissdoerfer et al., 2017; James et al., 2023; Jensen et al., 2021) and eco-efficiency (Chancharoonpong et al., 2021; Grassauer et al., 2022; Laso et al., 2018). These concepts consider companies as isolated entities and neglect their interactions with the external environment as drivers for their transformation. In our case studies, the evolution of business models emerged as a process rather than being driven by a proactive vision formulated behind closed doors. This finding challenges the conventional notion that changing the behaviors of corporations is a linear process starting from strategic decisions, translated into actions that lead to the expected outcomes. Focusing on changing strategic decisions at the unique corporate level might not be sufficient to observe concrete improvements in social and ecological impacts as the coevolutionary process unfolds differently in each territory. In this regard, investigating the local scale is necessary, and practitioners are increasingly encouraged to look at this scale through regulations and tools – such as the European SCRD (Sustainability Corporate Responsibility Directive) and the TNFD (Taskforce for Nature-Related Financial Disclosure).

We show that coevolution analysis can enhance our understanding of MNEs' fitness to their broader environment. Our results underline the necessity for MNEs to find flexibility at the local level for a better fit between their activities and the specificities of the socio-ecosystem in terms of ecological boundaries, social relationships, and basic human needs. They support the idea that MNEs' subsidiaries must adapt to specific territories. Granting MNEs subsidiaries sufficient autonomy to adapt contradicts the isomorphism theory developed by DiMaggio and Powell (1983). The authors suggest that organizations tend to adopt similar structures, practices, and behaviors to conform to prevailing institutional norms. Contrary to the idea of isomorphism, our findings support the conclusions of other scholars, such as Cantwell et al. (2010), who argue that enhanced sustainability necessitates greater independence for MNEs' subsidiaries.

Even though our case study focuses on a particular product and sector that is internationally regulated, with limited substitutes and high financial margins, looking at extreme case studies provides valuable

insights to understand business model transformation mechanisms better. Additionally, our study bears some limitations, including the incomplete data we got from the private company. Despite these limitations, our case studies take an original stance by broadening the conventional understanding of business transformation. We find that respecting the ecosystems and the local communities requires understanding and considering multidirectional causality, nonlinearity, feedback, and path dependency. Further research could explore the mechanisms of coevolution between businesses and their social-ecological environments involved in other commodities trade. The costs associated with managing various stakeholders could also be fruitful for future research to convince practitioners.

In conclusion, our articles first show that a different history than MNEs' social exploitation and environmental destruction is possible. MNEs can locally adapt their supply chains to account for specific characteristics of their operating territories to generate both social and ecological benefits. It involves a systemic approach, with the engagement of suppliers but also a diversity of actors. We suggest that sustainable business models are a process rather than a goal. Therefore, instead of aiming at getting straight to the right model, looking for adaptation through back-and-forth interactions with the socio-ecosystem seems a complementary approach. It involves developing interactions with local territories. CEOs could perceive this move as exposing their company to greater risks. However, in the context of unexpected significant disturbances arising from biodiversity loss, these interactions could be a source of resilience.

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Declaration of competing interests

The corresponding authors declare that they have no competing interests that could have appeared to influence the work reported in this paper.

CHAPTER 3

This chapter is in revision in *Business Strategy & the Environment*.

Contributions:

Mai-Thi Ta: conceptualization, methodology, data collection and analysis, drafting of the original version of the paper

Harold Level: conceptualization, methodology, data collection and analysis, drafting of the original version of the paper, proofreading, supervision

Michel Trommetter: reviewing

3. BARRIERS TO ADDRESSING BIODIVERSITY CONSERVATION IN MULTINATIONAL ENTERPRISES AND STRATEGIES TO OVERCOME THEM

Abstract

Corporate initiatives supporting biodiversity conservation in multinational enterprises (MNEs) face limited commitment despite biodiversity's multiple benefits. While reasons associated with MNEs' commitment are documented and include increased profits, stakeholder pressure, or reputation, those preventing it remain unclear. This study, focusing on a sample of 16 multi-sectoral MNEs, identifies common barriers and explores their underlying drivers. The analysis finds multi-level obstacles. At the company level, explicit barriers involve a lack of internal competencies, insufficient managerial support, and siloed governance, while implicit obstacles include a limited perception of biodiversity as a threat, ineffective information systems, hierarchical coordination, and a lack of motivational incentives. At the value-chain and industry levels, obstacles relate to interdependencies, power relations, and a lack of public support. Additionally, we suggest strategies to bypass these barriers which advocate for systemic change, thereby challenging prevailing views by considering biodiversity as an opportunity, notably for reshaping community engagement.

Keywords: biodiversity conservation, multinational enterprises, commitment, corporate initiatives, barriers, sustainability.

1. INTRODUCTION

Despite the rise of various corporate initiatives like Act4Nature, Taskforce for Nature-related Financial Disclosure (TNFD), One Planet Business for Biodiversity (OP2B), Science-Based Targets Network (SBTN), ORÉE, and Entreprises pour l'Environnement (EpE), corporate commitment to conserving biodiversity is still lacking as business leaders often prioritize other sustainability issues (Addison *et al.*, 2019; Adler *et al.*, 2018; Schaltegger *et al.*, 2014). Why do multinational companies not pay more attention to biodiversity conservation? How can we encourage them to consider it in their strategic decisions? Unfortunately, there is limited empirical research exploring these issues. First, most literature on sustainable business models treats sustainability as a single concept without distinguishing biodiversity conservation from other dimensions (Burritt *et al.*, 2020; Schaltegger *et al.*, 2016; Schaltegger *et al.*, 2019; Stubbs & Cocklin, 2008; Bocken *et al.*, 2019; Lüdeke-Freund & Dembek, 2017). However, recent works in the field of management and organizational studies investigate the

interactions between nature, ecosystems, and business strategies. This literature mainly focuses on two research questions: why do MNEs invest – or should be investing - in biodiversity, and what do they do to limit their impacts on biodiversity? How they actually implement these changes remains, however, underdocumented.

Investigating why companies should invest in biodiversity, authors show that it can lead to profitability gains (Naidoo & Adamowicz, 2005; Worm *et al.*, 2006; Tilman *et al.*, 2006). Additionally, empirical studies revealed what kind of businesses are more likely to consider biodiversity issues. They link corporate characteristics - such as size and industrial sector (Collaço de Carvalho *et al.*, 2023; Wagner, 2023) or the influence of stakeholder relationships (Atkins *et al.*, 2023; Quarshie *et al.*, 2021) - to biodiversity action. While these studies explain corporate involvement, they do not inform on reasons for inaction. Other studies describe what MNEs are doing for biodiversity conservation. They show that businesses mostly implement indirect actions, such as the substitution of hazardous materials (Wolff *et al.*, 2018; Wagner, 2023), rather than direct actions like restoration, conservation, or offsetting.

While these studies present an overview of actions MNEs implement to support biodiversity, how companies decide and implement such actions in practice remains unclear. How do MNEs concretely engage with biodiversity conservation? What obstacles do they encounter when trying to integrate biodiversity conservation into their strategic decisions and actions? We need a better understanding of the concrete barriers they face to promote further corporate commitment to biodiversity issues.

Here, we aim to gain a deeper understanding of how companies negotiate and integrate—or not—biodiversity conservation into their decision-making and operations. We interview representatives of 16 French MNEs, including 11 publicly listed ones, forming a significant and varied sample that is, to the best of our knowledge, the most extensive and diverse of its kind. Our research identifies common barriers these companies face and explores their drivers while suggesting potential approaches to overcome them.

The following sections of this paper provide further insights into existing literature (section 2), methodological approach, and data collection (section 3). We then outline typical approaches many companies deploy, revealing barriers to further consideration of biodiversity issues (section 4). We describe and discuss these barriers before suggesting strategies to navigate these challenges (section 5). We conclude with a discussion of our findings (section 6).

2. BACKGROUND

2.1. Reasons for involving MNEs

Several reasons support increased MNEs' involvement in biodiversity-related issues. First, they contribute to biodiversity loss both directly and indirectly. Directly, MNEs generate a significant part of international trade (OECD, 2018), which has been associated with the overexploitation of marine resources (Berkes *et al.*, 2006; Bennett & Basurto, 2018; Asche & Smith, 2010; Cinner *et al.*, 2012), of non-wood forest resources (Brown & Lassoie, 2010); deforestation (Rudel *et al.*, 2009); pasture degradation (Struelens *et al.*, 2017). Indirectly, empirical studies show that MNE activities weakened traditional bonds supporting the sustainable use of biodiversity (Lu, 2001; Bastakoti *et al.*, 2010; Becker & León, 2000) but also generated land-use change through infrastructure construction, such as roads to connect remote areas to markets (Laurance *et al.*, 2001).

Second, MNEs' financial capacity can exceed that of public administrations, and these additional resources are needed as halting biodiversity loss necessitates 850 billion dollars annually (Deutz *et al.*, 2020). For instance, LVMH Group generated 79,2 billion euros in sales revenues in 2022¹, which is close to the GDP Sri Lanka or Tanzania generated that same year (World Bank, 2022). Third, MNEs' involvement in biodiversity issues is expected to rise with intensified society pressure on this issue and increased regulation.

Despite these reasons, biodiversity still lacks corporate commitment (GRI, 2007; van Liempd & Busch, 2013), and we need to understand better how MNEs practically manage the issue to advance it.

2.2. Barriers to involving MNEs in biodiversity-related issues

While some studies provide an overview of commonly implemented actions, the nuanced decision-making processes and coordination mechanisms behind these actions are not fully comprehended. For instance, Wagner's (2023) research, based on interviews with German enterprises, reveals that businesses often take indirect actions impacting biodiversity, such as the substitution of hazardous resources, rather than employing direct measures such as conservation, restoration, or offsetting. These findings are consistent with Wolff *et al.*'s (2018) review of 34 action plans within the framework

¹ Considering the 2022 World Bank official exchange rate between EUR and USD: 1 EUR = 0.95 USD (retrieved from <https://wdi.worldbank.org/table/4.16>)

of the French National Biodiversity Strategy.

Additionally, the few academic studies investigating operational barriers in biodiversity corporate engagement (i) rely on declared barriers (Lambooy & Levashova, 2011), overlooking implicit additional barriers, and (ii) tend to focus on specific industries. Lambooy & Levashova (2011) investigate external barriers specific to forestry services and ecotourism, while Jabbour *et al.* (2018) single case study is based on a company in the botanical market while Smith *et al.* (2019) compare fisheries and forestry in Chile. These studies emphasize a lack of knowledge, capacities, and commercial opportunities, as well as senior management's distorted perception and myopia as major barriers to further consideration of biodiversity. They, however, do not provide insights into the underlying mechanisms explaining how these barriers rise. A better understanding of how businesses practically manage the issue would shed light on these mechanisms and pave the way for innovative solutions. Such insights have not been, to our knowledge, investigated among multiple cross-sectoral samples of MNEs.

3. METHODOLOGICAL APPROACH

3.1. A theoretical model of decision-making processes

To better understand how biodiversity-related issues are handled in practice, we track how decisions on this matter are taken and whether biodiversity-related information is considered. We develop a decision-making framework based on the works of Marschak & Miyasawa (1968) and Ménard (2012) and centered on information systems. The authors suggest that decision-making is supported by three key actions - investigation, transmission, and decision - which are sources of information distortions and costs (Figure 3.1). The investigation is triggered by events perceived as pertinent to a company's objectives. This investigation generates data, which is subsequently converted into codified signals, transmitted, and decoded. The efficiency of the information system relies notably on this transmission and the minimization of information distortions during coding and decoding. Ultimately, individuals make decisions by assessing gains and costs based on the message they perceive.

This model underscores the complexity of business decisions, which has been overlooked in most studies investigating corporate biodiversity management. Our analytical framework simplifies this decision-making process by grouping the mentioned steps into six main stages:

Exploration

The initial step consists of investigating the interactions between corporate activities and biodiversity. By engaging in a prospective exploration, companies build a common understanding of biodiversity-

related issues. In particular, they signal their intent to other actors in their ecosystem². This step is key as companies decide which issues are relevant to consider based on this common understanding. However, the exploration may be biased in favor of powerful stakeholders³ - such as shareholders - neglecting the interests of less influential groups like local populations and nature. Therefore, it's crucial to ensure that companies address impacts relevant to all affected stakeholders.

Measurement

In this step, companies choose how to codify information about their impacts on biodiversity. This codification can be an indicator, a dashboard, a report, etc.

Integration

This stage explores the internal flow and understanding of information within the company, detailing the routines for sharing biodiversity-related information (signaling and transmission). It describes how this information is received within the company (decoding), acknowledging that external factors such as individual experiences, beliefs, and mental models can influence this process.

Expansion

This step reports whether decision-makers actually use biodiversity-related information. When new information circulates without being considered, it suggests an inability or a reluctance to value such information.

Operational implementation

This stage assesses how effectively decision-makers implement decisions, which involves the recognition of their authority and legitimacy, along with having sufficient resources and skills.

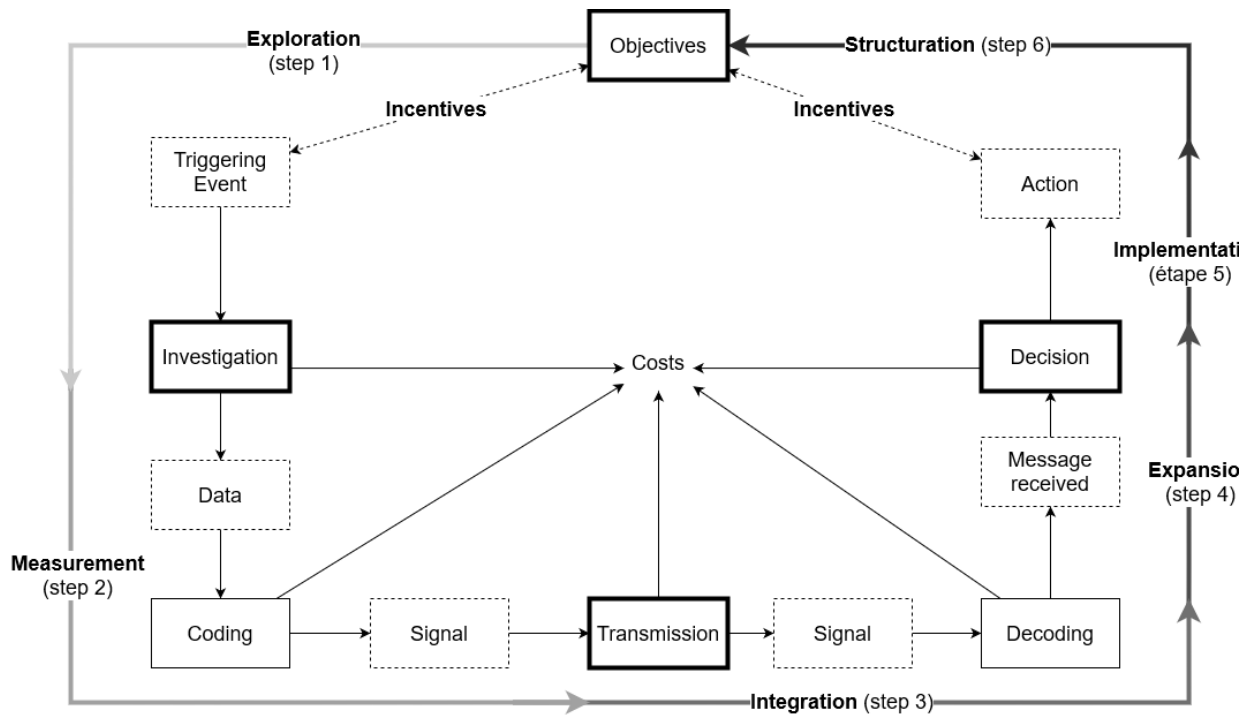
Structuration

This final stage reports the outcome of the decision-making process: whether a company's strategic objectives consider biodiversity conservation issues.

² Business ecosystems are described as "an extended system of mutually supportive organizations; communities of customers, suppliers, lead producers, and other stakeholders, financing, trade associations, standard bodies, labor unions, governmental and quasi-governmental institutions, and other interested parties" (Moore, 1998, p.168).

³ Stakeholders are individuals or groups whose interests are affected or could be affected – positively or negatively – by a [firm]'s activities and its direct and indirect business relationships across its value chain.

Figure 3.1 - Theoretical decision-making process leading to the integration of biodiversity issues into corporate decisions and the implementation of actions in favor of biodiversity. Adapted from Ménard (2012, p. 35)



Actions depicted with solid lines represent voluntary measures undertaken by companies, potentially introducing noise, whereas variables depicted with dotted lines are only partially under the company's control. Noise entails the inadvertent inclusion of incorrect, unnecessary, or undesirable information. Actions indicated by thick solid lines are predominantly sources of noise.

3.2. General method

Our research approach involves three key steps.

- 1. Synthesis of Interviews:** we synthesize the approaches described by the interviewees using the analytical framework described in section 3.1 and describe each stage of the decision-making process for every sampled company. Then, we group similar approaches together with the most commonly adopted one, termed the "typical approach," while others are labeled as "alternatives."
- 2. Obstacle Identification:** In the second step, we identify obstacles at each decision-making stage, employing inductive reasoning to analyze the drivers influencing each company's current approach, be it the typical or an alternative one. These obstacles encompass challenges explicitly mentioned by interviewees and those implicit in interview narratives.
- 3. Overcoming strategies:** Finally, we suggest strategies to overcome identified obstacles. These strategies focus on practical actions for practitioners and policymakers.

3.3. Sampling method

Our analysis is built on 41 semi-structured interviews with 16 MNEs conducted from April 25 to August 2, 2023. Within these 16 companies, 11 are publicly listed, with seven on the French CAC 40⁴. Collectively, the 2022 sales revenues generated by these 16 companies amounted to a consequential 27% of the total revenues of the 40 companies listed in the CAC 40. The representative average company we surveyed would employ 103,000 people in 72 countries.

As our objective is to uncover common challenges faced by multiple MNEs irrespective of their economic sectors, we conducted interviews across 12 economic sectors (Appendix H). These were selected using the French NAF classification of economic activities in 21 categories. Prioritization of these sectors has been done during a workshop attended by representatives from the private sector, biodiversity conservation NGOs, investors, and the press. The selection was based on three factors: participants' perceived severity of the sector's impact on biodiversity, whether some leading companies started to consider biodiversity issues, and the likelihood of finding one willing to accept a

⁴ The CAC 40 is a benchmark stock market index representing the 40 most significant companies listed on the Euronext Paris stock exchange. It reflects the performance of major French companies across various sectors.

90-minute interview with both a representative from the direction and an operational employee.

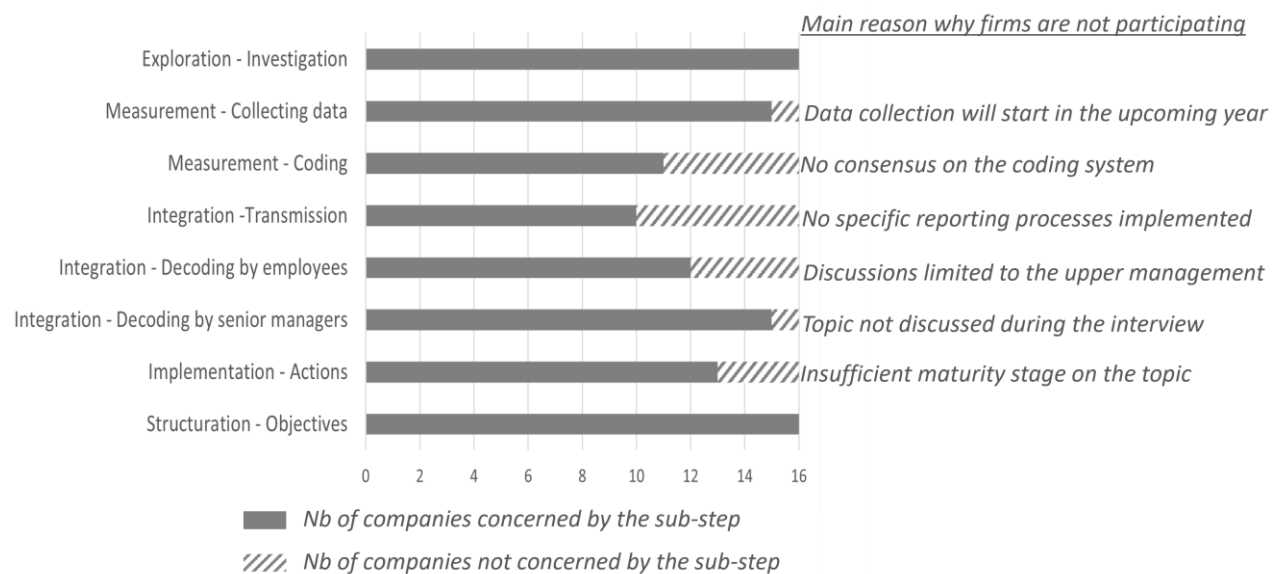
All companies in our sample have initiated discussions—at least internally—on integrating biodiversity-related issues into their activities. Five of them have not made any public commitments, but they have engaged in internal consultations. All interviews involved a representative of the direction in charge of biodiversity-related issues. For nine companies, an operational employee was also present. The interviewees were asked to describe how they dealt with the issue of biodiversity within their company and what obstacles they encountered.

4. RESULTS

4.1. Differing maturity stages

Our findings show that the surveyed companies are at different stages of maturity. Figure 3.2 displays the number of companies, out of the 16 in our sample, engaged in each step and sub-step of the decision-making process, providing a brief explanation for companies not participating.

Figure 3.2 - Number of companies involved in each stage of the decision-making process and the main reason why some are not concerned



4.2. Typical approaches result in isolated actions

In this section, we describe the typical approach and alternatives for each step of the decision-. The number of sampled companies concerned by each approach (Table 3-1) of the decision-making process is mentioned in brackets.

Table 3-1- Synthesis of typical and alternative approaches adopted by the sampled companies at each step and sub-step of the decision-making process

Step	Sub-step (<i>nb of companies concerned</i>)	Typical approach	Alternative 1	Alternative 2	Alternative 3
Exploration	Triggering event (16)	Individual motivation of senior management (6/16)	<i>Public debate (5/16)</i>	<i>Regulation (3/16)</i>	<i>Historical Anchoring (2/16)</i>
	Investigation (16)	Enhancing existing production practices (9/16)	<i>Strategic thinking at company level (5/16)</i>	<i>Commercial thinking (1/16)</i>	<i>No investigation (1/16)</i>
Measurement	Data (15)	Need for specific data (9/15)	<i>Use of data available on the market (6/15)</i>		
	Coding et signal (11)	No consensus on the choice of an indicator (6/11)	<i>Standardization of reporting process (3/11)</i>	<i>Consensus on the choice of an indicator (2/11)</i>	
	Transmission (10)	Through execution (5/10)	<i>Through accountability (3/10)</i>	<i>Through co-construction (2/10)</i>	
Integration	Message received by operational employees (12)	Confusion (6/12)	<i>Motivation (4/12)</i>	<i>Constraint (2/12)</i>	
	Message received by senior management (15)	No awareness of the issues (5/15)	<i>Leaders drive the handling of the issues (5/15)</i>	<i>Considering the issues is an obligation (4/15)</i>	<i>Others (1/15)</i>
Expansion	Decision (16)	Public engagements (11/16)	<i>No engagements (5/16)</i>		
Operational implementation	Action (13)	Sustainable supply chains (6/13)	<i>Site-level action (6/13)</i>	<i>Sub-contracting (1/13)</i>	
Structuration	Objectives (16)	No incentives (15/16)	<i>Monetary incentives (1/16)</i>		

4.2.1. Exploration

Triggering event (16 firms concerned)

Six companies started their investigation following a senior manager's motivation, five as a response to public debates like Act4nature or SBTN, three were influenced by regulations, and two were focused on biodiversity due to their historical commercial positioning.

Investigation (16 firms concerned)

Nine companies explore the topic focusing on enhancing existing production methods, five engage in broader strategic considerations, one reflects on its commercial offerings, and one tests an impact assessment methodology without developing a specific investigation.

4.2.2. Measurement

Data (15 firms concerned)

Two data types serve separate purposes. First, six concerned companies use non-company-specific data mostly for double materiality assessment⁵. These data are not specific to the company's operations, practices, or production sites but are external and often used in combination with Life Cycle Assessment (LCA). Second, nine companies use data specific to their activities and production practices for monitoring internal action plans. They mostly collect this data internally.

Coding (11 firms concerned)

In this phase, six out of the concerned companies hadn't reached a consensus on an indicator and were testing various ones. Three companies adopted an integrated approach through reporting processes at the company level. Only two companies reached a consensus on an indicator, in both cases developed internally.

4.2.3. Integration

Transmission (10 firms concerned)

⁵ Assessment of the company's impact on biodiversity and of the risks and opportunities related to biodiversity

Five companies have a top-down information flow, with operational staff executing decisions from the direction in charge of biodiversity-related issues. Three companies follow an accountability approach, allowing operational departments to set their own objectives. Two companies involve operational departments at a strategic level for co-constructing the biodiversity strategy with senior management.

Signal and decoding (12 firms concerned)

Unlike coding, which is explicitly carried out at the company level, decoding is proper to each employee and thus unreportable in interviews. However, how the interviewee perceived the signal sent at the corporate level reflects its particular decoding process. Therefore, we assess the signal and decoding sub-steps in the next paragraph based on the messages and discourses reported by our interviewees. We differentiate between messages received by operational staff and those received by senior managers.

4.2.4. Expansion

Message received by operational staff (12 companies concerned)

Six companies express that operational staff find biodiversity information confusing, four find it motivating, and only two consider it primarily constraining.

Message received by senior management (15 companies concerned)

Five companies describe supportive top management, while the same percentage sees top management as unaware of the issue. In four cases, the interviewees perceive top management as treating biodiversity conservation equally with other sustainability concerns, and one mentions managers considering it as a constraint.

Decisions (16 companies concerned)

By design, all surveyed companies have at least decided to explore how to integrate biodiversity conservation issues into their activities. For eleven companies this has taken the form of public commitments.

4.2.5. Operational implementation (13 companies concerned)

Six companies primarily emphasize the establishment of sustainable supply chains. Another six companies address sustainability at the production-site level, but these actions are not extended to

the entire supply chain or the company. A unique approach involves one company integrating sustainable supply chain initiatives with outsourcing impact management through compensation projects. This entails funding ecosystem services provided by producers, whether or not they are within the company's supply chain, thereby avoiding the need for a detailed impact assessment.

4.2.6. Structuration (16 companies concerned)

Only one company has incorporated a biodiversity impact indicator into its objectives, but it is now considering removing it.

5. FURTHER RESULTS AND DISCUSSION

5.1. Obstacles identification: barriers to corporate consideration of biodiversity issues

In this section, we explore the drivers that lead each company to its current situation, i.e., either the typical approach or an alternative (Table 3-2). Additionally, we discuss how the approaches portrayed in section 4.2 reveal mechanisms preventing the integration of biodiversity issues into decision-making processes.

Table 3-2 - Synthesis of drivers identified from the interviews leading to the typical or the alternative approaches adopted by the sampled companies

Step	Sub-step	Nb companies concerned by the sub-step	Driver	Nb companies concerned by the driver	% of companies concerned by the driver out of the number of companies concerned by the sub-step
Exploration	Triggering Event	16	Forecasting CSRD	11	69%
Exploration	Investigation	16	Doing less bad	9	56%
Exploration	Investigation	16	Biodiversity is, at best, a commercial differentiation factor	5	31%
Exploration	Investigation	16	Biodiversity is an opportunity to rethink activities	1	6%
Exploration	Investigation	16	Biodiversity should not be commoditized	1	6%
Measurement	Data	15	Need for measures adapted to businesses' specific activities	9	60%
Measurement	Coding	11	Development of internal evaluation methods	9	82%
Measurement	Coding	11	Test and reject market indicators	8	73%
Integration	Transmission	10	Transversal transmission	3	30%
Expansion	Message received by operational staff	12	Reluctance to onboard due to biodiversity perceived complexity.	11	92%
Expansion	Message received by senior management	15	Indifference to biodiversity issues	5	33%
Operational implementation	N.A	13	Issues of competition and externalities	9	69%
Operational implementation	N.A	13	Insufficient power within the supply chain	4	31%
All	N.A	16	No additional resources	14	88%
All	N.A	16	Insufficient public action	4	25%

5.1.1. At the exploration stage

A vision of biodiversity limited to a threat

In our sample, eleven companies employ double materiality assessments to identify their impacts and vulnerabilities related to biodiversity, thereby adopting a risk management approach. This approach is in line with the interests of financial investors who seek to evaluate portfolio vulnerability and who promote it externally. The logic of substitution and transformation implied by biodiversity-friendly innovations is often perceived as a threat to existing business models. This perception is linked to established routines within companies, leading to resistance. Considering biodiversity beyond risk management demands stepping out of usual routines and exploring unpredictable paths. Implementing changes, such as modifying production processes and investing in nature-based solutions, can challenge employees who feel their position and influence threatened as they are likely unfamiliar with the subject, its terminology, and its strategies. Ultimately, this unfamiliarity could undermine their ability to advocate for their annual performance results confidently.

In contrast, only one company surveyed sees biodiversity as a potential commercial opportunity, while for five companies, it is a competitive advantage. As it is complex to turn biodiversity into a marketable product or service, all sampled companies still focus on minimizing harm to biodiversity, considering it as a consequence of their activities rather than an opportunity to reimagine their business. Notably, one company believes biodiversity should not be commodified.

5.1.2. At the measurement stage

An unsuitable indicator market

None of the surveyed companies exclusively rely on market indicators to manage biodiversity-related issues. Nine out of the eleven companies involved in the coding stage consider market indicators unsuitable and are consequently developing their evaluation method. In fact, eight have rejected market indicators after testing them.

Market indicators are unsuitable because they lack sensitivity to specific company actions and provide limited information. They are generally based on Life Cycle Assessment (LCA) using similar models to link economic activities with biodiversity pressures. LCAs are effective for energy and material balances, but they rely on global averages and databases with insufficient sensitivity to capture company-specific actions, resulting in non-practical composite indicators. Consequently, these indicators do not

align with issues at individual company sites and fail to reflect local or specific efforts adequately. Therefore, users of these indicators struggle to relate them to their operational activities.

Inadequate management routines and unavailable data

The nine companies developing their coding system encounter challenges, primarily because conventional management practices are ill-suited to address biodiversity-related issues. Traditional management routines heavily rely on Key Performance Indicators (KPIs) used by both operational and management teams. The application of these KPIs to biodiversity issues results in an ongoing search for biodiversity impact indicators that are applicable to both local and international scales. However, achieving this ambition may prove challenging due to inherent tensions, as highlighted by Levelrel (2007): an indicator relevant at the international scale might be inadequate at the local scale, failing to represent local biodiversity realistically. Companies often overlook these tensions, and instead of attempting to resolve them, the focus should shift towards transparently disclosing the trade-offs involved.

Additionally, developing specific assessment methodologies necessitates adequate competencies and data, requiring dedicated time and resources, and thus, remains challenging. Data linking economic activities and biodiversity impact is scarce, leading to reliance on LCA data. Nine companies seek tailored data that align with their unique operations, collecting them internally or externally through NGOs or commercial partners.

5.1.3. At the integration stage

Coordination through hierarchy rather than cooperation

To drive changes in business models and foster biodiversity conservation efforts, transversal transmission is essential to integrate the issue across all corporate departments and support collective engagement, enhanced comprehension of the issue, and proactive foresight of operational challenges. However, only three out of ten companies concerned by this stage implement such approaches. Typically, biodiversity matters are confined to a specific direction, which relies mostly on hierarchy to enforce decisions. Thus, operational teams are involved in a top-down manner, focused on regulatory compliance and accountability, i.e., as implementers rather than empowerment. Cross-functional management encouraging co-construction with operational departments is lacking.

5.1.4. At the expansion stage

Uninformative information system

Biodiversity is a challenging topic for employees, as it is complex and abstract, encompassing various interconnected elements that are influenced by many factors. Six companies face difficulties in getting their teams onboard because of this complexity. Operational staff often find it hard to align with company-wide objectives concerning biodiversity and struggle to interpret them. This perceived complexity can overwhelm teams, hindering the development of innovative solutions for integrating biodiversity into the company's activities.

Managers also face difficulties in conveying a clear message to their teams, as some exhibit uncertainty and disregard. Five companies report indifference among some managers, who resist change and fail to proactively engage with the topic or listen to their teams, failing to recognize the urgency of addressing biodiversity loss within their company.

5.1.5. At the operational implementation stage

Interdependencies with stakeholders and the value chain

In nine cases, companies find it challenging to manage their impact on biodiversity due to external interdependencies. They express a free-rider problem where a company's efforts benefit the entire industry, potentially discouraging investments in biodiversity. For four of them, power relations within the value chain play a crucial role. They feel they lack sufficient influence in the value chain to generate successful change, especially in setting sustainability requirements. Without the most powerful actors considering biodiversity in the value chain, they believe their ability to drive significant change is limited.

5.1.6. At the structuration stage

No consensus on prioritizing objectives

One company has set explicit objectives based on its biodiversity impacts. First through its purpose, which explicitly engages the company with its stakeholders and thus guides every strategic decision; then through variable monetary incentives based on reduced biodiversity impacts. However, as a consequence of the barriers identified in previous stages of the decision-making process, no consensus was reached on how to integrate the issue at the company level, and clearer dimensions of sustainability were prioritized

5.1.7. At every stage

Lack of resources

All sampled companies face a lack of resources to address biodiversity issues. Only two companies mention allocating additional resources, with one providing funding for transitioning to more sustainable production practices and the other offering financial support for dedicated R&D projects. The majority of companies expect their teams to address biodiversity-related issues with existing resources despite the substantial uncertainty and risk associated with such investments.

Yet, investing in biodiversity-friendly practices brings significant benefits but these are not clear for managers as the impacts vary across different scales and timeframes. Even when site or business unit managers recognize these benefits, internal company decision-making processes, particularly budget allocations, often limit their consideration. Consequently, good intentions alone are insufficient. While there may be monetary incentives indirectly linked to biodiversity, they do not provide necessary resources. Given the substantial uncertainty and risk associated with biodiversity investment, it's crucial to allocate additional resources to cover these risks effectively.

Public action is insufficient to create opportunities for biodiversity-friendly activities

Seven sampled companies declare that further public policies are needed to advance the biodiversity issue within companies. According to them, public action can help “derisk” biodiversity by establishing markets and rewarding businesses that mitigate their negative impacts. These companies observe a lack of market opportunities for firms proposing solutions to reduce biodiversity impacts or restore natural environments. Worse, businesses making efforts to reduce their negative biodiversity impacts are not rewarded with a reduced risk of litigation compared to companies that have not changed their production processes. Public policies could also facilitate R&D programs, for example, by classifying chemical pollutants or agricultural practices based on their biodiversity impacts.

5.2. Solutions: overcoming strategies

5.2.1. At the exploration stage: beyond a threat, focusing on biodiversity's indirect benefits

A source of motivation for employees

While the subject of biodiversity may cause some confusion among employees, the idea of integrating

it into their work is generally well-received. In fact, for five companies, it serves as a source of motivation, fostering a sense of pride, unity, common interests, and bonds with local stakeholders. It also enhances corporate image, both internally and externally, facilitating recruitment while building loyalty among environmentally-conscious employees, and it is even used for team-building. This suggests potential virtuous circles to enhance the company's overall reputation and human resources engagement.

Sales innovations

Nature-based solutions bring multiple benefits but involve moving away from a monofunctional vision of the goods and services sold to embrace concepts such as the economy of functionality, which is rapidly gaining in popularity. Nature-based solutions should find their markets since they provide ecological answers to collective problems, typically offering a range of services such as flood protection, water filtration, pest control, and outdoor recreation spaces. The key challenge is to develop new value chains that cover both the upstream and downstream stages. Among surveyed companies, only those collaborating with local administration show an interest in nature-based solutions. It helps them communicate the public benefits resulting from their activities, thereby improving their reputation and the social acceptance of their projects. Private clients, too, could be attracted to such methods, especially as securing social acceptance becomes a growing concern.

Territorial anchoring and conflict reduction

All sampled companies believe that biodiversity is a local and spatial concern, distinct from global issues like climate change. Consequently, engagement in territorial projects seems relevant as they support collaborative relationships around biodiversity, involving nature conservation groups, local communities, other businesses, and elected officials. Three of the sampled companies are selling projects explicitly including a biodiversity-related dimension. It creates spaces for local democracy, allowing a better understanding of the constraints faced by each stakeholder. Implementing this type of open negotiation process could support a better recognition of biodiversity's functions. Ultimately it reduces local conflicts but necessitates the involvement of mediators benefitting from stakeholders' trust.

5.2.2. At the measurement stage: developing internal assessment methods

Standardizing the reporting process rather than focusing on the choice of one indicator

Companies have primarily focused on innovating their internal processes for conducting biodiversity

assessments rather than introducing new commercial products or services. These organizational innovations, aiming at developing approaches tailored to the specific characteristics of each company, are the most practical and scalable. Three companies chose to standardize the process of reporting rather than using a specific indicator. This may involve standardized action plans in the form of protocols, precise reporting formats, or external audits carried out by rating agencies that have existing methodologies, such as the TNFD or the SBTN, which today seem to be the most favored methods. Some sectors developed specific frameworks, like Biodi-bat for construction or the Agrobiodiversity Index for the agro-industry.

Emerging new data-collection tools

To generate cost-effective data, companies can involve employees in participatory science initiatives like the French Muséum National d'Histoire naturelle's Vigie-Nature program. This program employs simple, time-efficient data collection protocols that can be pooled on a national or regional level. Methods are available for monitoring various species, including bats, insects, birds, and plants. Additionally, the growing sector of connected devices for automated biodiversity data collection provides opportunities to assess the interactions between a company and biodiversity at low costs. For instance, one of the companies in our sample equipped buses in Normandy to track changes in local biodiversity. These strategies can help companies establish themselves as active contributors to local communities.

5.2.3. At the integration stage: coordination methods that encourage cooperation

Leadership to support in-house initiatives

Some managers within companies have to personally take up the subject of biodiversity, advocating for optimized ecological engineering (as in two cases), shaping customer demand to create a biodiversity-related need (four cases), or enhancing in-house competencies through adequate recruitment strategies (two cases). Here, we see the key role of leadership in corporate biodiversity investments. This requires establishing a managerial environment supporting leadership on the topic, setting clear guidelines, and backing employees who drive innovative initiatives - all while respecting economic constraints. It's essential to provide safeguards within the hierarchy to mitigate the risks taken by pioneer employees. Managers play a crucial role in fostering a climate of trust in developing actions supporting biodiversity since they inherently involve risks that require internal managerial backup.

Innovative governance facilitating transversal management

It would be overly simplistic to assume that certain top-level managers are visionaries while the operational departments are slower to apprehend the necessary changes in their business models. They operate with different functions and organizational objectives. Consequently, it's crucial to track and foresee sources of organizational and operational barriers and transaction costs. To achieve this goal, two companies have introduced innovative governance structures. These governance models aim to facilitate collaboration between management and operational teams that traditionally do not work closely together but must find common ground to develop innovations that engage them in a collective effort. Notably, such governance fosters operational business units' accountability on their biodiversity impacts, avoiding leaving the subject isolated within a unique direction.

Rely on motivation and incentives to encourage cooperation

Engaging teams in biodiversity efforts can be achieved through hierarchical and motivational methods. The hierarchical approach relies on top-down relationships within the organization, but it is influenced by individual factors like supervisor-subordinate bonds. In contrast, motivational methods eliminate the need for direct supervision. Two companies motivate their teams by exploiting the emotional and intuitive aspects of biodiversity, making employees feel like valued contributors to their community. This approach is notably used in infrastructure projects in developing countries.

A fundamental source of motivation lies in salary bonuses tied to biodiversity-friendly practices and implemented across all decision-making levels. However, only one of the 16 companies has integrated such incentives. While the lack of obvious benefits can hinder biodiversity integration, linking salaries to positive impacts on biodiversity makes the benefits clearer. Without these incentives, biodiversity initiatives often rely on employee goodwill at both strategic and operational levels. Introducing monetary incentives makes biodiversity concerns structural and lasting, reducing vulnerability to contextual hazards such as changes in management.

5.2.4. At the expansion stage: simplifying biodiversity issues

Mobilizing more meaningful narratives

The majority of the companies interviewed (12 out of 16) are eager to share real-life success stories related to their biodiversity investments. These stories highlight tangible outcomes, such as agricultural practices transformations, wetland revitalization, and the resulting benefits like flood mitigation

and improved water purification. These narratives showcase both internal and external achievements and serve to inspire others while illustrating the range of changes companies can make. Sharing such success stories is a valuable tool for promoting the adoption of biodiversity initiatives within the company and for effective communication with external stakeholders, especially customers who may be unfamiliar with the topic.

Developing collective learning networks on biodiversity

Four companies established biodiversity learning collectives to enhance cooperation and promote biodiversity consideration. These networks, organized around “biodiversity correspondents,” are designed to raise awareness about biodiversity, share best practices for its integration into corporate activities, and test innovative nature-focused solutions. Whether formal or informal, they serve as valuable allies in communicating corporate biodiversity strategy and can involve hundreds of employees.

Talking about more tangible objects

A more effective approach to addressing biodiversity is to focus on specific, tangible aspects rather than treating it as a whole, abstract concept. Working with specific elements like insect populations, marine mammals, field birds, or ecosystems such as oceans and wetlands makes the topic more manageable. Six companies adopt a “pressure” approach to make the issue more concrete, targeting known sources of biodiversity erosion. By acting on them, they assume they generate positive effects on biodiversity. It also highlights that various business sectors indirectly contribute to nature conservation, often without being fully aware of it. Activities like agroecology, water treatment, eco-construction, and sustainable clothing production all indirectly aid in safeguarding biodiversity. Today's challenge is to restructure supply chains that contribute to deforestation, reduce plastic packaging to combat pollution, prioritize certified organic supply chains, use indigenous species, decrease pesticide use, promote product longevity, reduce resource consumption, and develop recycling processes, among other actions.

Working with biodiversity professionals

Thirteen companies receive support from professionals in dealing with biodiversity. Nine of them seek support from associations or scientists, the four others choosing consulting companies, to compensate for the lack of in-house expertise. Interestingly, even though the availability of in-house competencies is crucial, only seven companies explicitly identify this as a challenge.

Professionalization of biodiversity efforts is also achieved through labels and eco-certifications, which can create new job opportunities. For instance, the organic label has spurred the growth of a certification market and made professions like farm advisors and seed growers evolve. Some initiatives extend the use of labels beyond the agri-food sector, like "Biodiversity" for the construction industry.

Subcontracting

An alternative way to address biodiversity's complexity is by outsourcing actions. Notably, one company purchases biodiversity credits to fund services that reduce pressure on natural environments or restore them. This approach offers flexibility without the need to convince senior management to change their practices or commit to long-term investments. It also provides quick results, easily communicated and companies can include these credits in their CSR policies to meet regulatory requirements. While these investments can be significant and cover large areas – protection of 1 million ha of sensitive ecosystems and regeneration of 1 million ha in this case - they don't fundamentally alter companies' business model nor integrate biodiversity into their decisions. These actions rather run parallel to their activities.

5.2.5. At the operational implementation stage: working with networks

Managing interdependencies through networks and coalitions

An increasing number of companies are actively participating in collaborative networks. Ten sampled companies are engaged in inter-company working groups, enabling the consolidation of efforts within specific sectors or value chains and facilitating coordinated advocacy. These networks also serve as a platform for bringing together all stakeholders within a value chain, fostering cooperation in areas where power relations could otherwise restrain progress. Some of these coalitions, such as Paris Good Fashion and OP2B, aim to generate knowledge that benefits all sector participants and may involve collective actions to pool resources, like the test of a common waste-collection network. Others entail specific commitments, such as Act4Nature, which has been influential in encouraging executives to make commitments (in two cases). Finally, some networks seek to negotiate forms of competition that offer guarantees in terms of biodiversity protection, as is the case with the OP2B network.

5.2.6. At the structuration stage: involving stakeholders

Creating platforms for discussion among stakeholders

Initiatives like "committed consumer clubs" or "stakeholder committees" have been highlighted by

interviewees as sources of significant progress to integrate issues neglected so far. However, only four companies mentioned engaging in such consultation concerning biodiversity conservation.

5.2.7. Across all stages: policy advocacy

Companies can further collaborate with public authorities through lobbying or legal action in administrative, civil, or criminal courts. In some respects, the recommendations here should be directed towards public authorities to enhance the enforcement of biodiversity protection laws, establish transparent procedures, offer tools for compliance verification, and create favorable fiscal and institutional conditions for biodiversity-friendly markets. Since public authorities may not take these actions on their own, companies investing in this area may need to approach public administrations to demand that these elements be put in place to see their efforts rewarded.

All this may seem surprising: companies taking legal action against the State only to see the risk of sanctions increase. Yet, an interesting precedent is from the USA in the 2000s when the Ecological Restoration Business Association lobbied the government to take legal action against companies that were not complying with biodiversity protection laws. This action aimed to address insufficient business opportunities which largely depended on the strict application of the law on wetland protection. The U.S. Government Accounting Organization finally pointed out the administration's shortcomings. It gave formal notice to strengthen its procedures, leading to an explosion in the ecological restoration market in the early 2010s.

6. CONCLUSION AND IMPLICATIONS

In this study, we show that multinational enterprises are at different stages of maturity when it comes to integrating biodiversity issues into their decisions. Companies in our sample are still a long way from achieving this objective. Our contribution is three-fold. First, we confirm certain anticipated barriers within a multiple, cross-industry sample of MNEs. Second, we uncover additional, implicit ones by tracing the drivers leading to these barriers. Third, we formulate specific, concrete, and proven strategies to address these obstacles.

Typically, MNEs initially seek specific data and develop in-house methods to assess their impacts, focusing on improving their production practices based on site-specific data. Some companies are beginning to explore commercial offers with biodiversity aspects, but these efforts are often opportunistic rather than part of a company-wide strategy. Biodiversity is generally perceived as complex and threat-

ening, making it challenging to develop appropriate management methods. Business leaders see biodiversity as a risk management management issue, overlooking its indirect benefits. It is often managed through top-down methods rather than transversal, with management instructing business units to implement action plans without additional resources. This creates confusion among operational teams who struggle to comprehend the objectives and operational challenges related to biodiversity. Although most companies in the sample are deploying actions to reduce their impact on biodiversity pressures, these actions are often isolated and lack integrated strategic planning across the entire organization – which is in line with Katic et al. (2023), who find that companies use biodiversity assessment tools at the product, site, and supply-chain level.

From this typical handling of the topic, we show that MNEs face various obstacles when addressing biodiversity conservation. These obstacles manifest on two levels: the first is operational, impacting the day-to-day activities of teams, while the second is a higher, collective level, shaping the overarching rules influencing daily actions that employees perceive as unalterable.

At the operational level, the obstacles we've described were expected. These challenges include a lack of internal skills; siloed governance; unsuitable market indicators and management routines; unavailability of data; lack of resources; difficulties in getting teams to understand the issues at stake due to the complexity of the biodiversity concept; interdependencies in the value chain and lack of public support. These obstacles were identified by the interviewees and are aligned with findings from the literature. For example, the lack of suitable indicators has been highlighted by D'Amato et al. (2015), while the interdependence in the value chain by Smith et al. (2018) and Wolff et al. (2018); the lack of internal skills and by Lambooy & Levashova (2011); lack of public support by Jabbour et al. (2018). We, however, extend their validity to a broader and multi-sectoral sample of companies.

On the other hand, obstacles at the level of collective choices are not explicitly identified. These include the inefficiency of information systems, coordination based on hierarchy rather than motivation, and a vision that focuses on biodiversity as a threat. We additionally suggest that addressing these obstacles requires systemic change. Indeed, the solutions we identify involve mobilizing networks with external players, whether public or private.

Our findings have significant public policy implications Public policies can support biodiversity-friendly markets and reward companies that limit their negative impacts. Regulations already exist and are to be found in numerous legal texts, whether French laws (Climate and Resilience law, Law for the restoration of biodiversity, nature and landscapes), European directives (Natura 2000, Water Framework

Directive, Marine Strategy Framework Directive) or national strategies (French National Biodiversity Strategy). The problem is that the requirements set out in these directives, in terms of no net loss of biodiversity, zero net artificialisation, the objective of achieving good ecological status for water bodies, or species conservation, are not applied by public authorities (Weissgerber et al., 2019). Companies can also rely on external coalitions to help them overcome structural obstacles (horizontal or vertical) and to gain expertise and clarity on the subject.

We highlight a limited perspective regarding business-biodiversity interactions: biodiversity as a risk or biodiversity as a means to enhance productivity. We emphasize that alternative perspectives exist. For instance, biodiversity can be viewed as an opportunity, not necessarily for creating new products or services, but for reshaping the way a company engages with its local communities. Public policies could stimulate interest in such territorial projects.

Our results also have several implications for practitioners. The strategies to overcome barriers mobilize a variety of coordination modes within the company. A fundamental component is the implementation of an effective information system. Information and its dissemination play a central role, and it's crucial to ensure the message is conveyed in a way that limits personal opinions and tensions among decision-makers while supporting pioneer employees. This information system should enable management's capacity for prospective thinking and a clear understanding of the company's stakes. Additionally, it should pay close attention to sources of information distortion, especially in how data is communicated and understood, which refers to conveying clear objectives for operational staff. All these actions represent costs, and further studies could investigate what can be expected from the CSRD³² (Corporate Sustainability Reporting Directive) information framework.

Our study has some limitations as we rely on a sample of companies selected because they already reflect on biodiversity-related topics. Further studies could explore the challenges faced by more reticent companies, confirming or refuting our findings. Moreover, our study may be subject to the risk of omission bias, where negative information is underreported, and recall bias, as interviewees may struggle to remember negative experiences. These biases could potentially lead to a somewhat overly positive perspective in the reported approaches.

³² The European Corporate Reporting Sustainability Directive is a regulatory framework entering into application on the 1st of January 2024. It mandates certain companies to disclose non-financial and sustainability-related information in their annual reports, aiming to enhance transparency and promote corporate sustainability.

Despite these limitations, our study offers a valuable overview from which we can still identify relevant insights to both public policy and practitioners to advance the integration of biodiversity-related issues in MNEs' decisions. Additionally, a fundamental assumption underlying our work is that one of the goals of sustainable business transformation is the integration of biodiversity conservation into the decision-making process. This assumption aligns with a broad perspective on corporate social responsibility and with the CSRD³³.

In conclusion, our analysis of a diverse, cross-industry sample of MNEs has highlighted common barriers and proposed strategies to navigate them, providing promising pathways for exploration by private-sector actors, public policymakers, and researchers. One of the significant barriers we've identified relates to prevailing perceptions of the connection between biodiversity and businesses: it is too complex, there is insufficient demand, or action depends mainly on the state or competitors. While our interviews do confirm the existence of these obstacles, it's crucial not to view them as fixed constraints but rather as starting points for constructive discussions and innovation. By challenging these assumptions, we have the opportunity to create spaces where the seemingly unalterable can be questioned and pioneering and systemic approaches emerge. These efforts are critical for overcoming the prevailing inertia among MNEs and committing them to the needed transformative change the IPBES (2018) has been calling for.

³³ As stated in The European Sustainability Reporting Standards (ESRS 1), "The applicable information prescribed within a Disclosure Requirement [...] shall be disclosed when the undertaking assesses that [...] the capacity of such information meets the users' decision-making needs" (paragraph 31, p.6)

CHAPTER 4

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Contributions:

Mai-Thi Ta: data collection and analysis, drafting the original version of the paper

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4. CHARACTERIZING THE DEMAND SIDE OF URBAN GREENING TO INFORM URBAN PLANNING - A DISCRETE CHOICE EXPERIMENT IN THE PARIS METROPOLITAN REGION

Abstract

As the multiple benefits from exposure to urban green spaces (UGSs) are increasingly acknowledged, urban greening policies have become an important component of the urban political agenda. Most targeting strategies of future UGS development are based on the pursuit of an equal distribution of UGSs among residents. These strategies implicitly assume that the development of any type of UGS will have the same effect on citizens' well-being, provided that their access is guaranteed. This paper questions this assumption and addresses the demand side of urban greening policies by evaluating which UGS characteristics are sought by urban dwellers. We apply a travel time-based discrete choice experiment (DCE) to capture the trade-offs between the UGS characteristics (e.g., tree cover, size, presence of water, accessibility) and the travel time that citizens are willing to spend to reach a hypothetical UGS compared to a "stay at home" option. We discover that all the respondents have a disutility in choosing the "stay at home" option instead of a scenario of UGS development, especially when the UGS contains trees. This disutility is, however, much higher among outer suburb inhabitants living in municipalities with relatively lower urbanization levels and rent prices. Further, the global time budget dedicated to reaching a UGS is much lower for inner-city residents compared to outer-suburb inhabitants. Inhabitants living in less urbanized areas place a higher value on a large UGS (> 1.5 hectares), while residents living in city centres do not seem to be influenced by this UGS characteristic. Our results suggest that strategies based on access criteria would benefit from being differentiated according to urbanization levels of cities, as the inhabitants of city centres value nearby and multiple UGSs but not necessarily large UGSs, while the inhabitants of suburbs value larger UGSs, even when located farther away.

Keywords: Urban green spaces, recreational services, urban greening policies, preference heterogeneity, choice experiment, green infrastructures.

1. INTRODUCTION

The issue of urban green space (UGS) deprivation is becoming increasingly material in highly urbanized, extended, and populated areas. On the one hand, land is increasingly scarce in urban areas, while on

the other hand, the social demand for green space amenities has increased (Choumert & Salanié, 2008). The issue has been explicitly highlighted during the 2019 Coronavirus Disease (COVID-19) pandemic lockdowns when in cities like Paris, travel restrictions within one kilometer from a person's home prevented access to UGSs for thousands of residents. According to Picard & Tran (2021), large cities in Europe (> 1 million inhabitants) have the same profiles regarding access to UGSs (following a non-monotonic concave function of the distance to city centres in response to the high opportunity cost of land and population density). In many of these large cities, inhabitants living in the denser and more expensive inner centres are more likely to be deprived of UGSs than the inhabitants of the outer suburbs. In the case of the Paris Metropolitan area, in which UGSs represent 9.5% of the Paris intra-muros area¹, more than 50% of the residents are deprived of UGS² (Liotta et al., 2020). In the outer suburbs, this proportion decreases to 20% (Liotta et al., 2020).

UGSs are local public goods, providing multiple health and well-being benefits to urban dwellers (Hamel et al., 2021; Remme et al., 2021). They have been found to enhance physical activity, reduce exposure to air pollution, improve mental health and reduce cardiovascular morbidity, among others (World Health Organization, 2016). In France, UGSs are mainly supplied by local authorities, such as the regional council, that establish criteria to plan future UGS development. Currently, these targeting criteria are widely based on the ratio of the surface of UGS per capita, implicitly assuming that any UGS, regardless of its characteristics, is equally contributing to urban dwellers' well-being. For instance, Natural England recommends developing access to green spaces larger than 2 hectares within 300 meters of each inhabitant's residence, which is consistent with the World Health Organization's recommendations. The European Common Indicator of local public open areas defines a criterion of access to public open areas larger than 0.5 hectares and also advocates a perimeter of 300 meters from home. The Paris metropolitan area sets a goal of giving access to 10 square meters of open natural area per inhabitant (at the municipal level) by 2030.

The benefits derived from green spaces depend not only on UGS provision but also on one's preferences for different UGS characteristics. People may enjoy different types of UGSs and use them for different purposes (Swanwick, 2009). Thus, UGS provision lies not only in dedicating sufficient surface per capita but also in ensuring that its characteristics actually meet residents' needs (Hofmann et al., 2012). In this context, understanding citizens' (satisfied or unsatisfied) demand regarding UGSs'

¹ According to the World Cities Culture Forum data, available following [this link](#)

² This percentage is calculated for access to a UGS greater than 1.5 ha at 300m from each residence location

proximity and characteristics provides useful information to optimize investments and the use of available space while improving citizens' quality of life. This finding is particularly valid in a large metropolis such as the Paris metropolitan area, where land scarcity and high land prices motivate the optimal use of space (Alberti et al., 2019).

In this paper, we use a discrete-choice experiment (DCE) to provide empirical insights regarding UGS demand in a large and dense metropolitan area. To our knowledge, our study is one of few DCEs that study UGS preferences in a metropolitan area with such pronounced spatial disparities in terms of UGS supply and urban morphology between the city centre and its suburbs. Through the DCE, we specify the maximum travel time that residents of the Paris metropolitan area are willing to spend to reach a fictive UGS according to its characteristics and the residents' socio-economic profiles. We apply the travel time as an adjustment variable that local authorities can use to provide various types of UGSs and create a portfolio of UGSs that meet a differentiated demand (Swanwick, 2009).

We show that two profiles of residents stand out regarding UGS demand, even if both profiles show a clear preference for the UGS alternatives compared to the "stay at home" option presented in the DCE. First, inner-city residents living in denser environments with higher rents³ show a strong preference for having access to a UGS, regardless of its size. Their disutility for the "stay at home" option is strong but lower than that for outer city inhabitants living in less dense municipalities with lower rents. Inhabitants in outer suburbs appear to value larger UGSs (>1.5 hectares). Second, the time budget that inner city dwellers are willing to spend to reach a UGS is roughly four times lower than the time that inhabitants in outer suburbs are willing to dedicate. In terms of UGS attributes, apart from the size and proximity, the ranking is similar among the profiles. Both types of inhabitants place a high value on the presence of trees. We conclude that developing multiple small, wooded UGSs in city centres would help to improve residents' well-being, while larger UGSs, even those located farther away, would be valuable for citizens living in less densely populated areas. This finding is consistent with green investment capacities of planners regarding land prices, as the opportunity costs of developing large UGS in downtown areas, instead of alternative investments, are much higher than those in outer suburbs.

The remainder of this paper has six main sections. We briefly present in section 2 the principal literature findings regarding UGS preferences. Section 3 details the Paris metropolitan case study and

³ Rent data were sourced from UMR 1041 CESAER (AgroSup Dijon-INRAE), based on data from SeLoger, leboncoin, and PAP for the year 2018. The data are available here: <https://www.data.gouv.fr/fr/datasets/carte-des-loyers-indicateurs-de-loyers-dannonce-par-commune-en-2018/>

specifies the adopted methodological choices. The section ends with a description of the materials used for the survey design. Section 4 presents the results of our DCE and compares a mixed logit (ML) and a latent class (LC) model. In section 5, we discuss our approach and compare our results to the actual behaviors of respondents. We also outline the main limitations of our study. Section 6 synthesizes our major findings and discusses why resident-driven urban greening designs are needed to improve greening policy decisions.

2. PRINCIPAL LITERATURE FINDINGS REGARDING UGS PREFERENCES

Preferences for outdoor recreation have been previously investigated using DCEs. In France, for example, Rulleau *et al.* (2010) evaluate the management of the Gironde forest. However, few DCEs have been carried out in the specific urban context. Bullock (2008) focuses on Dubliners' preferences for small local parks and larger municipal parks. De Valck *et al.* (2017) focus on preferences for outdoor recreational destinations in Antwerp. Arnberger and Eder (2011) worked on trail preferences in Vienna, while Tu *et al.* (2016) examined recreational preferences in peri-urban forests in Nancy (France). Bertram *et al.* (2017) investigate UGS value differences between weekdays and weekends in Berlin.

From this corpus, the major findings are as follows: Bullock (2008) shows that Dublin residents' preferences vary with the size of the UGS. The quality of small, local parks is improved with play facilities and "a mix of quiet and busier areas" (p. 27), while for larger parks, natural lakes and woodlands become positive attributes. Rulleau *et al.* (2010) discover that poorer people are less likely to accept a longer travel distance to benefit from the current Gironde forest quality. Tu *et al.* (2016) reveal that living near parks is preferred by people in general, but no specific characteristics of the parks are described.

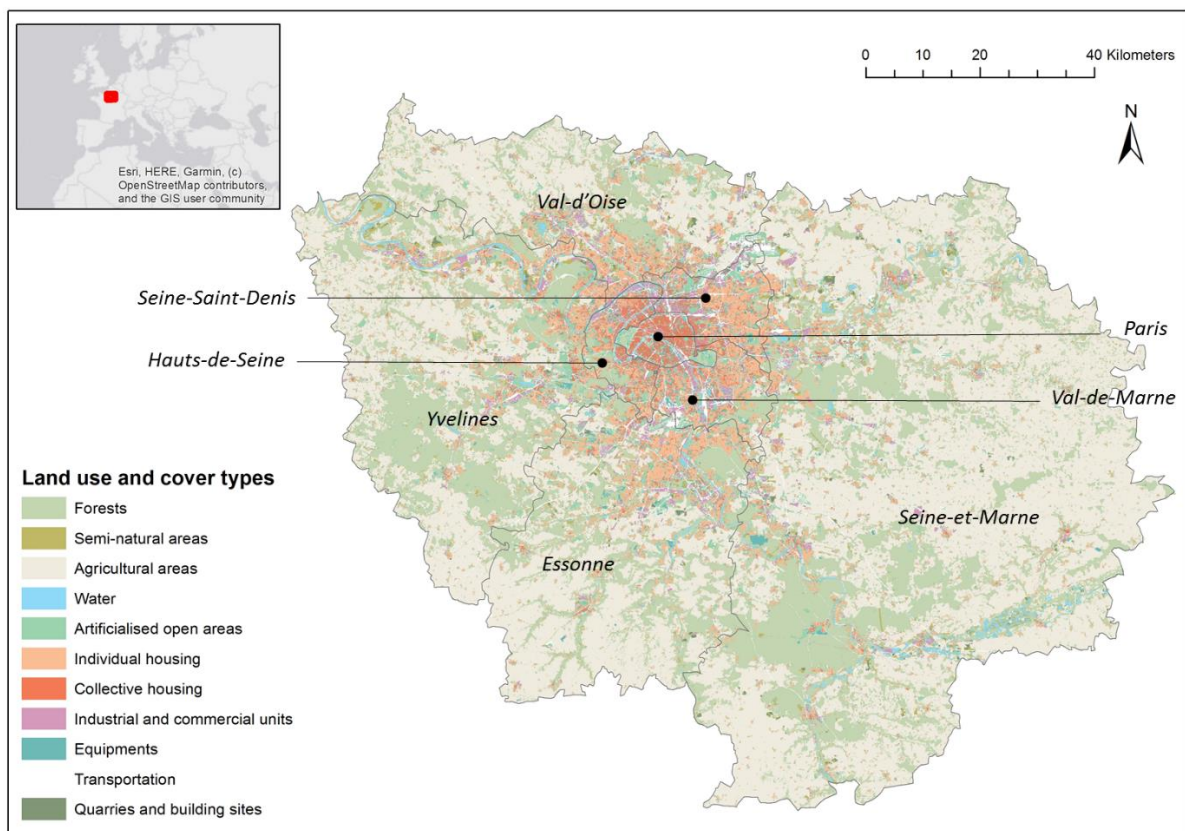
Other papers, using alternative techniques to the DCE also provide useful insights. Suárez *et al.* (2020) rely on Geographic Information System (GIS) data to identify characteristics of preferred outdoor recreational destinations in Oslo. Their results indicate that residents living in peri-urban areas prefer natural areas with vegetation and water, while residents living in city centres prefer more artificial recreational destinations with facilities. Choumert & Travers (2010) show through a hedonic pricing method that people in Angers (France) prefer to live in areas with multiple small UGSs than in areas with fewer but larger UGSs.

3. MATERIAL AND METHODS

3.1. Case study: the Paris metropolitan area

Our study focuses on the French region of Ile-de-France. The region is composed of 8 areas, which are divided into Paris *intra-muros*, the "little crown" - inner suburbs of Paris containing Hauts-de-Seine, Val de Marne and Seine-Saint-Denis, and the "big crown"- outer suburbs containing Val-d'Oise, Yvelines, Essonne and Seine-et-Marne (Figure 4.1) Despite representing only 2% of the French territory, this region accounts for 18% of the population and generates 31% of the national growth domestic product.

Figure 4.1 - Land use and land cover in the Ile-de-France region, France (based on the *Mode d'Occupation des Sols* developed by the Institut d'Aménagement Urbain, source: IDEFESE project)

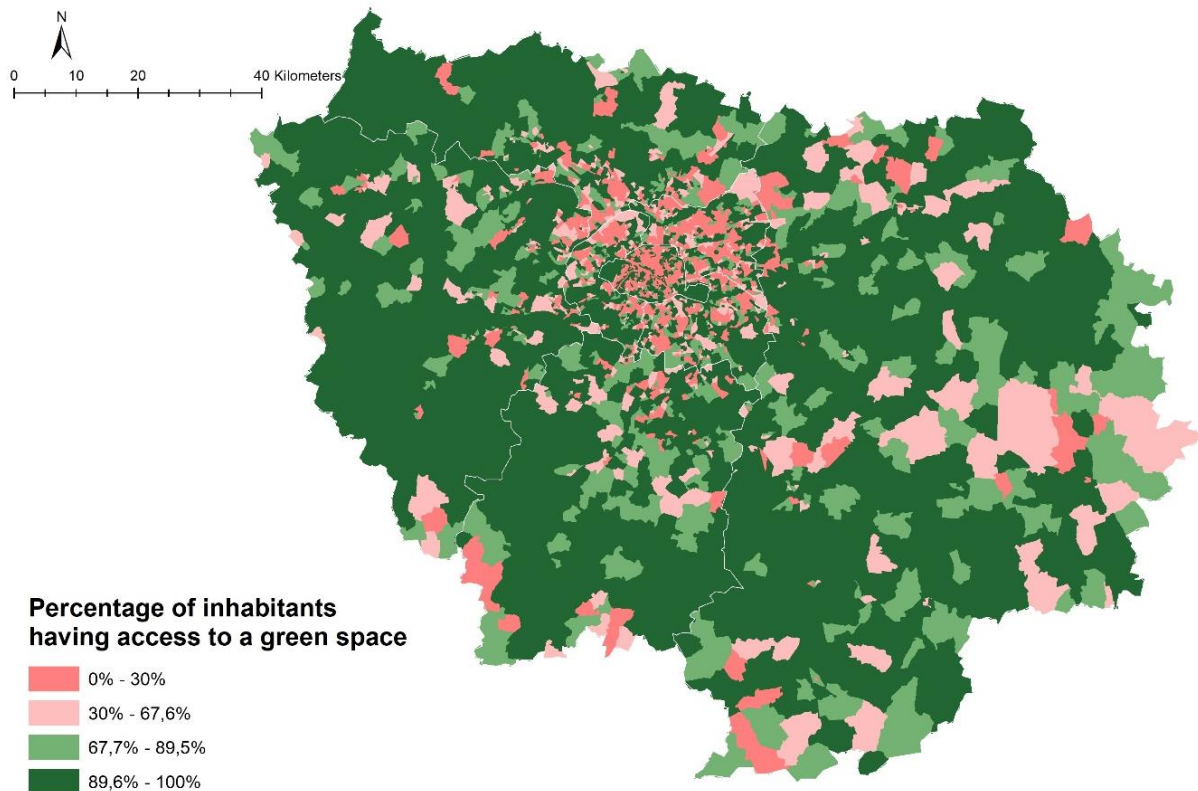


As shown in Figure 4.1, Ile-de-France is mostly covered by agricultural areas, which occupy nearly 50% of the territory (situated mainly in the big crown). The region benefits from 8,342 km of waterways, 30,000 ponds, and three national parks (Haute vallée de Chevreuse, Vexin, and Gatinais). Globally, only 66% of residents have access to a public UGS of at least 1.5 ha situated less than 300 meters from their

residence⁴ (

Figure 4.2). Even though access to green spaces increased by 2% from 1982 to 2017 in the region and in Paris's inner city, the surface area of UGS per inhabitant decreased by 24% during this period due to a net conversion of natural and open areas of roughly 40,700 hectares.

Figure 4.2 - Share of inhabitants at the census tract level having access in 2017 to a recreational green space of at least 1.5 hectares at less than 300 meters from their residence



This finding is confirmed by the diagnosis of the 2017 Green Plan of the Paris metropolitan area⁵. The Plan declared that 72% of municipalities in the region are deficient in terms of access to green spaces, and 5% of municipalities are very deficient. A municipality is considered deficient when more than 30% of inhabitants have no access to at least 10 square meters of UGS based on the master plan target. To reach the objective of 10 m² per inhabitant, 4,200 additional hectares of UGS would have to be created

⁴ All the descriptive statistics hereafter are calculated using geographical information systems based on the "Mode d'Occupation des Sols" database made available by the Institut Paris Region. Posts 1 to 4 of the "Mode d'Occupation des Sols" in 11 posts (forests, semi-natural environments, agricultural areas, and water spaces) are considered non-urban.

⁵ Conclusions of the Green Plan are available at https://www.iledefrance.fr/espace-media/applis_js/rapports_cp-cr/2017-03-09/rapportsPDF/CR2017-50.pdf

in these municipalities by 2030, but only 500 hectares are planned (Tardieu *et al.*, 2020).

3.2. Methodological options

DCEs are non-market valuation techniques that are used to appreciate preferences for different options of a good or service. Individuals are presented with several choice situations that require them to choose between hypothetical versions of a good, described by its most representative characteristics. One characteristic is usually a monetary variable that is utilized to estimate the marginal rate of substitution. An additional option, which consists of choosing neither alternative, is generally added (Hanley *et al.*, 1998). This last option can either be a status quo, i.e., the current situation where the individual keeps its consumption habits without any extra cost, or an opt-out option that expresses a default response in which a respondent opts "not to choose," i.e., the individual does not consume any of the goods proposed (Boxall *et al.*, 2009).

3.2.1. Modelling framework

DCEs rely on Lancaster's theory of value (1966) and the random utility theory (McFadden *et al.*, 1973). Lancaster's theory (1966) argues that consumers perceive a good through its different attributes, while the random utility theory considers that the utility function contains both a deterministic component derived from observable characteristics and a random component that accounts for unobserved variables that influence the choice. Therefore, the random utility $U_{i,n}$ that an individual n obtains from alternative i is:

$$U_{i,n} = V_{i,n} + \varepsilon_{i,n} \quad (1)$$

Where $V_{i,n}$ is the deterministic component and $\varepsilon_{i,n}$ is the stochastic element.

The conditional logit, which has laid the theoretical basis of DCEs' modeling, relies on two restrictive assumptions: the independence of irrelevant alternatives (IIA) and the independent and identically distributed errors. The first assumption states that the choice between any set of alternatives is not affected by the introduction of an additional alternative. The second assumption implies that unobserved variables cannot generate correlation. With these assumptions, individuals have the same utility function and consequently homogeneous preferences. Mixed Logit (ML) and Latent Class (LC) models relax the IIA hypothesis and allow for preference heterogeneity. The ML model considers individual heterogeneity through the introduction of a random coefficient distributed over individuals and alternatives. When this distribution considers a finite set of values, the model becomes an LC.

We use an ML model to explore heterogeneity at individual levels before investing it at a more macro

level. The LC model is subsequently employed for three motives. First, we assume that some unobserved heterogeneity is likely to influence residents' preferences. This heterogeneity could be related to their sense of nature or health, for example. Second, the LC model is less sensitive to the analyst's subjective assumption concerning the parameters' distribution (Tu *et al.*, 2016). Identifying preference heterogeneity according to socio-demographic classes would also be useful for public policies since they cannot address individual preferences.

3.2.2. Models specification

Mixed Logit

In ML models, the utility that individual n derives from alternative i is :

$$U_{i,n} = V_{i,n} + \varepsilon_{i,n} = \beta_n X_i + \eta_{i,n} + \varepsilon_{i,n} \quad (2)$$

Where X_i is the observed attributes vector associated with alternative i , β_n is the vector of parameters that represents an individual's preference and $\eta_{i,n}$ is a random term with zero mean that accounts for preference heterogeneity.

We assume a normal distribution of preferences among the population, except for time, which we assume to be log-normally distributed. The ML model estimates parameters through a simulated maximum likelihood. We considered 500 random draws.

Latent Class

LC models assume that there is a number of classes (C) associated with different estimated parameters $\beta_c = \{\beta_1, \dots, \beta_C\}$. The model estimates the probability that respondent n falls into class c and the probability $P_{i,n}^c(i|\beta_c)$ that respondent n chooses alternative i given his class. The unconditional logit probability is therefore the sum over all classes of the $P_{i,n}^c(i|\beta_c)$ probabilities weighted by the probability that respondent n falls into class c . We applied LC conditional logit models via the expectation-maximization algorithm developed by Pacifico & Yoo (2012), with the *llogit* package in STATA 14.

Alternative Specific Constant

For ML and LC models, an Alternative Specific Constant (ASC) is specified for the *status quo* (ASC=1 if the status quo alternative is chosen, and 0 otherwise) to capture a potential bias. When the respondents chose neither of the suggested alternatives, ASC = 1 and the selected option is to stay at

home (refer to Table 4-1). To limit possible misinterpretation of the constant variable (Bech & Gyr-Hansen, 2005), all variables are effect-coded, except for the ASC. In effects coding, a variable equals 1 if the observed qualitative level is present, 0 otherwise, and -1 for the reference level (Table 4-1). The utility of the reference level is then equal to the negative sum of the estimated parameters (Bech & Gyr-Hansen, 2005).

3.2.3. Willingness to accept additional travel-time (WTT) to reach a UGS and conversion into willingness to pay (WTP)

The compensating variation of welfare for a unit-change in one attribute k is generally given by the willingness-to-pay (WTP), which is defined as $WTP = -2 \frac{\beta_k}{\beta_m}$ with β_k and β_m the estimated parameter for attribute k and the monetary attribute, respectively. However, estimating the WTP as the marginal rate of substitution with the monetary attribute can be complicated as, depending on the assumptions for the distributions of the parameters, problems of unrealistic skewed distributions appear. This approach is referred to as estimations in "preference space". A solution to these skewed distributions is to estimate the models in the WTP space (Train & Weeks, 2005). The authors present a revised formulation of equation 2, which avoids issues of skewed distributions as it derives the distribution of parameters from the assumption of WTP distributions. Train & Weeks (2005) determine that models estimated in the preference space better fit the data, while models estimated in the WTP space provide more reasonable WTP distributions.

In our case, we run estimations in the WTP space. We replace β_m by the time parameter to estimate the willingness-to-accept a longer travel time (WTT) to a UGS for a unit increase of a given attribute. Furthermore, effects coding involves that marginal utility is multiplied by a factor 2. We thus define WTT as :

$$WTT = -2 \frac{\beta_k}{\beta_{time}} \quad (3)$$

For the LC model, the WTT is the weighted average of WTT for each class using the probability of class membership as weights. We use the STATA 14 package "*mixlogit*" with the command "*mixlogitwtp*" to estimate the ML model in WTP space. LC post-estimations are calculated with the STATA 14 *llogitml* command (with 3 iterations) and class memberships described after using the *llogitpr* command.

At least two methods of conversion can be used to convert the WTT into WTP. The first is to rely on the "reference value" of time for project evaluation in France, estimated from traffic simulation models (Quinet, 2013). The second is to rely on the opportunity cost of time (OCT), generally calculated as a ratio of hourly income. The second option is generally used in recreation studies but is still under

debate (see, for example, Feather & Shaw, 1999; Earnhart, 2003; Larson et al., 2004; Palmquist et al., 2010). Indeed, the OCT is based on the assumption of a trade-off (and therefore flexibility) in the allocation of time between work and leisure. However, time allocation between work and leisure is rarely fully flexible. Moreover, there is increasing evidence that individuals value their travel for a recreation destination. Despite this debate, a small consensus seems to have been found around a ratio equal to 1/3 of salary (see, for example, Cesario, 1976; Riera Font, 2000; Roussel et al., 2016; or Parsons, 2017).

We opted for the “reference value” of time developed in the Quinet report (2013). For the Ile-de-France region, this value is calculated from the calibration of three urban traffic simulation models and two meta-analysis grouping values estimated from revealed preferences and stated preferences. The reference value is calculated as the average of the values obtained in these papers by distinguishing four travel motives: work; home/work/study/childcare; leisure (shopping, care, visiting, recreation, tourism, etc.) and without motive details. To convert the WTT into WTP, we used the value corresponding to a leisure trip in the Ile-de-France region, i.e., a value of 8.7€/hour. This value is equivalent to the COT approach when the rate used is 1/3 of the hourly wage. Indeed, in Ile-de-France, 1/3 of the average gross hourly wage of private sector employees in Ile-de-France in 2019 corresponds to a value of 8.8€/hour (the average gross wage being 26.4€/hour). However, this value may be overestimated as there are sectoral disparities.

3.3. Survey and questionnaire description

3.3.1. Questionnaire development

The questionnaire contains three main parts (Appendix N gives a questionnaire example). The questionnaire begins with a short introduction explaining the aim of the study. The first part of the survey consists of questions regarding respondents’ socio-economic situation (place of residence, gender, socio-professional category, and household composition). Instructions concerning the DCE are then given, and choice sets are presented in a randomized order (to avoid having less attention dedicated to the same choice sets). The third part of the questionnaire asks follow-up questions regarding respondents’ habits concerning UGS, their revenue and their diploma.

Selection of attributes and definition of attribute levels

A primary selection of attributes has been conducted through a literature review on preferences regarding access to UGS. UGS public acceptability has been shown to vary depending on the distance to UGS (Choumert & Travers, 2010; De Valck et al., 2017; Kong et al., 2007; Sander & Polasky, 2009),

type of vegetation (Brun et al., 2017; Bullock, 2008; De Valck et al., 2017, Rulleau et al., 2010; Schindler et al., 2018), size (Bullock, 2008), presence of water (Ives et al., 2017; De Valck et al., 2017), type of facilities (Suarez et al., 2020; De Valck et al., 2017; Bertram et al., 2017; La Rosa et al., 2018), and cleanliness (Rulleau et al., 2010; Bertram et al., 2017). After this first selection, planning stakeholders' of the Ile-de-France region have been consulted during the IDEFESE⁶ project focus groups (Tardieu et al., 2021). Fifty-six stakeholders from the urban planning, environmental protection, non-governmental organizations (NGOs), and civil society sectors, representing more than 27 French and European institutions, have been involved during the different focus groups (stakeholders are described in Appendix I). During the focus group (held on 24 September 2018), aiming more generally at collecting suggested indicators for different ecosystem services, the attributes and levels of attributes have been discussed. The "transportation mode", for example, has been added by planning stakeholders and was not initially proposed by our team.

We ultimately chose six attributes (see Table 4-1 for an overview):

- The first attribute is *forest cover*, which represents the degree of wilderness through the density of tree cover. The attribute considers three levels: non-wooded UGS, woodland, and forest.
- The second attribute describes the *shape* of the fictional green space: either linear (as for a riverbank) or not linear.
- The third attribute describes the *size* of the fictional green space. We follow a commonly employed threshold: a green space is considered to be large if it is larger than 1.5 ha (Niemelä et al., 2010; Cabral et al., 2016; Levrel et al., 2017). Otherwise, the green space is considered to be small.
- The fourth attribute specifies the presence (or not) of a *water* body in the fictional green space.
- The Ile-de-France transportation mode considerably influences everyday choices, the fifth attribute is the *transport mode* by which the green space is accessible. The attribute considers 3 levels: walking, biking, and taking public transport or a car. To estimate the extent to which biking can be utilized as an alternative transportation mode, we isolated biking as a unique level, whereas public transport and car were combined as we considered them to be substitutes. If the respondent chose "public transport or car", we added a follow-up question asking whether the respondent would prefer the car or public transport.
- The last attribute, *transportation time*, indicates how long it takes to travel from the

⁶ Refer to <https://idefese.wordpress.com/> for more information about the IDEFESE project.

respondent's house to the fictional green space. Given the high variability of transportation time needed to travel a fixed distance in Ile-de-France (see Appendix J) we chose transportation time over distance as an indicator of accessibility. For this attribute, the lowest level is 5 min, which corresponds to a 300-meter walking trip. The highest level is 30 min, which is 5 min less than the average commuting time spent in the little crown and Paris to travel to work⁷. Between these limits, we added 2 more levels: 10 min and 20 min.

Table 4-1 - Attributes and level description

Attributes	Description	Level	Coding
Forest cover	Density of trees covering the UGS	Woodland Forest Non-wooded UGS	1 if woodland, 0 if forest 1 if forest, 0 if woodland <i>Reference (-1)</i>
Shape of the UGS	Shape of the UGS	Linear Polygonal	1 if linear <i>Reference (-1)</i>
Size of the UGS	Size of the UGS	Large (1.5 ha) Small (<1.5 ha)	1 if large <i>Reference (-1)</i>
Presence of water	Presence of water in the UGS	Presence Absence	1 if presence <i>Reference (-1)</i>
Transportation mode	Type of transportation used to travel to the fictive UGS	By bike By car or public transport By foot	1 if by bike, 0 if by car 1 if by car, 0 if by bike <i>Reference (-1)</i>
Travel time to reach the UGS	Time required to travel to the fictive UGS from home	5 min 10 min 20 min 30 min	5 10 20 30
ASC	Stay at home alternative	Fictive UGS alternative 1 or 2 Status quo alternative	0 1

We consider that for each alternative, respondents can only use the suggested transportation mode. Even if this hypothesis is implausible, it has been explained at the beginning of the DCE that attributes' levels could not be changed and that each alternative had to be considered as packages that could not be modified. This hypothesis allows us to independently interpret transportation mode from transportation time⁸.







⁷ *Les temps de déplacement entre domicile et travail*, Dares Analyses, Publication from the Directorate for Research, Studies and Statistics (Direction de l'Animation de la Recherche, des études et des Statistiques – DARES), november 2015.

⁸ As we proposed choice cards with fixed "transportation modes" and "travel time" to reach a UGS, without connecting these two attributes (e.g., we are not proposing lower travel time when the UGS is reached by car for

Experimental design and choice experiment description

The second part of the questionnaire is the DCE. Choice cards were presented, asking respondents to choose between two hypothetical green spaces described by attributes considering different levels and the stay-at-home option. Since we have 6 attributes, each taking between 2 and 4 levels, the full factorial design yielded 296 combinations. Given the large number of combinations in the full factorial design, we decided to implement a fractional factorial design, i.e., a sample of the full factorial (Hoyos, 2010). We used SAS software to select the minimum number of choice sets allowing statistically robust results. Choice sets were selected among the full factorial design using N-Gen software and a Bayesian D-optimal design with zero priors (which amounts to an orthogonal design). The 100% efficient design led to 72 or 144 choice sets, which was still excessive. We, therefore, chose to present 24 combinations with 1 violation. Gathered in pairs, this selection provided 12 choice sets. Figure 4.3 gives an example of a choice set, presenting two fictive UGS alternatives and the *status-quo* option (i.e., "stay at home").

Figure 4.3 - Example of a choice set of different UGS alternatives

Green space attributes	Alternative 1	Alternative 2	Status quo	
Forest cover				
Shape				
Presence of a water body				
Size	Large* / Long*	Small** / Short**	I choose neither of both green spaces	
Transport mode	Biking / Trotinette	By foot		
Transportation time	5 min	30 min		
Choice				2

Follow-up questions

The third part of the questionnaire is composed of several follow-up questions that are aimed at

example), we think that these two attributes have been independently considered by respondents, thereby revealing their independent preferences for a transportation mode and for a travel time to a UGS. Moreover, although transportation time and transportation mode are generally correlated, recent studies on the specific case of the Paris metropolitan area indicate that the correlation between both variables is not so clear. Traffic jams cause high variability in time spent driving, while the extended and reliable public transportation network reduces the time spent on public transportation (refer to Appendix J). This variability can also be observed when problems occur in public transport, making the "travel time" a variable with a high expectancy and variance (except for the "by foot" travel mode).

controlling different biases and collecting other socio-economic characteristics. First, a question regarding systematically omitted attributes was asked to identify the possible existence of attribute non-attendance. Second, we asked a set of questions aimed at better-characterizing respondents' profiles and at helping us interpret the results. Several follow-up questions concerned habits regarding green space attendance, ecological sensitivity, and socio-economic profile. To identify a different use of UGS, we asked about the main activities in which respondents participate when visiting a green space. We also asked about the frequency of their visits to UGSs, their most frequently visited UGS, how long it takes on average for them to travel to a UGS, and how long they usually stay in UGSs. We ended the questionnaire with two socio-economic questions about the individual's highest diploma and current income.

3.4. Survey design

The surveys were delivered to 320 people from April 15 to May 24, 2019, representing 3,840 choices. Given the short time available, we were assisted in the field by five students from Ecole des Ponts. We conducted face-to-face interviews as online surveys have lower response rates (Heerwegh & Loosveldt, 2008; Lindhjem & Navrud, 2011). Furthermore, these interviews provided a good way to reach the less-connected portion of the population (elderly or poor people, for example).

To standardize questionnaire delivery, all five interviewers met to decide on a homogeneous protocol to follow. Interviewers randomly picked respondents in the streets, not in a UGS, introducing themselves as researchers working on the recreational service provided by UGSs in the region. A brief introduction was delivered to respondents who were then asked to answer the questions on the first page (refer to Appendix N). At the beginning of the choice exercise, explanations concerning what was expected from the respondent were given, and attributes were described before allowing the respondent to answer the choice cards and follow-up questions.

We traveled to 17 representative cities of Ile-de-France to deliver the questionnaire. To select the cities, we classified the municipalities of the region regarding 3 criteria:

- Density: the ratio between the municipality's population and its surface.
- Median standard of living: the ratio between household available income and consumption unit⁹.

⁹ INSEE calculated consumption unit based on Organisation for Economic Co-operation and Development (OECD) equivalence scale: the first household adult accounts for one consumption unit (UC); all other persons aged 14 years or older account for 0.5 UC each; and children younger than 14 years account for 0.3 UC each.

- Urbanization ratio: the ratio between a municipality's urbanized surface and its total surface. Urbanized and non-urbanized surfaces were determined based on the French land use classification in 11 posts¹⁰. Following the definition given in the SDRIF, we consider urbanized areas as agricultural, forests and natural areas where urban sprawl happens. Therefore, areas considered non-urban surfaces were those classified as forest, semi-natural areas, farmlands and water¹¹. We also considered open areas with some infrastructure (such as running trails, man-made urban parks, or cemeteries) as non-urban areas (class 5 of the MOS). All other types of land-use¹²—mostly housing, lands dedicated to economic activities, equipment, transport, quarries and landfills—were considered to be urban surfaces.

Each criterion was divided into 3 classes to cluster municipalities into groups (Table 4-2). To determine the optimal cut defining classes, we utilized the Jenks classification method (refer to Appendix K). This method minimizes the variance within classes while maximizing the variance between classes. Table 4-2 describes the classes for each criterion.

Table 4-2 - Jenks classification results

	Low	Medium	High
Urbanization ratio	< 0.22	[0.22, 0.56]	> 0.56
Density (inhab/km ²)	< 3, 941	[3,941; 14, 549]	> 14,549
Standard of living (€/Consumption unit)	< 9, 276	[9,276; 19, 025]	> 19,025

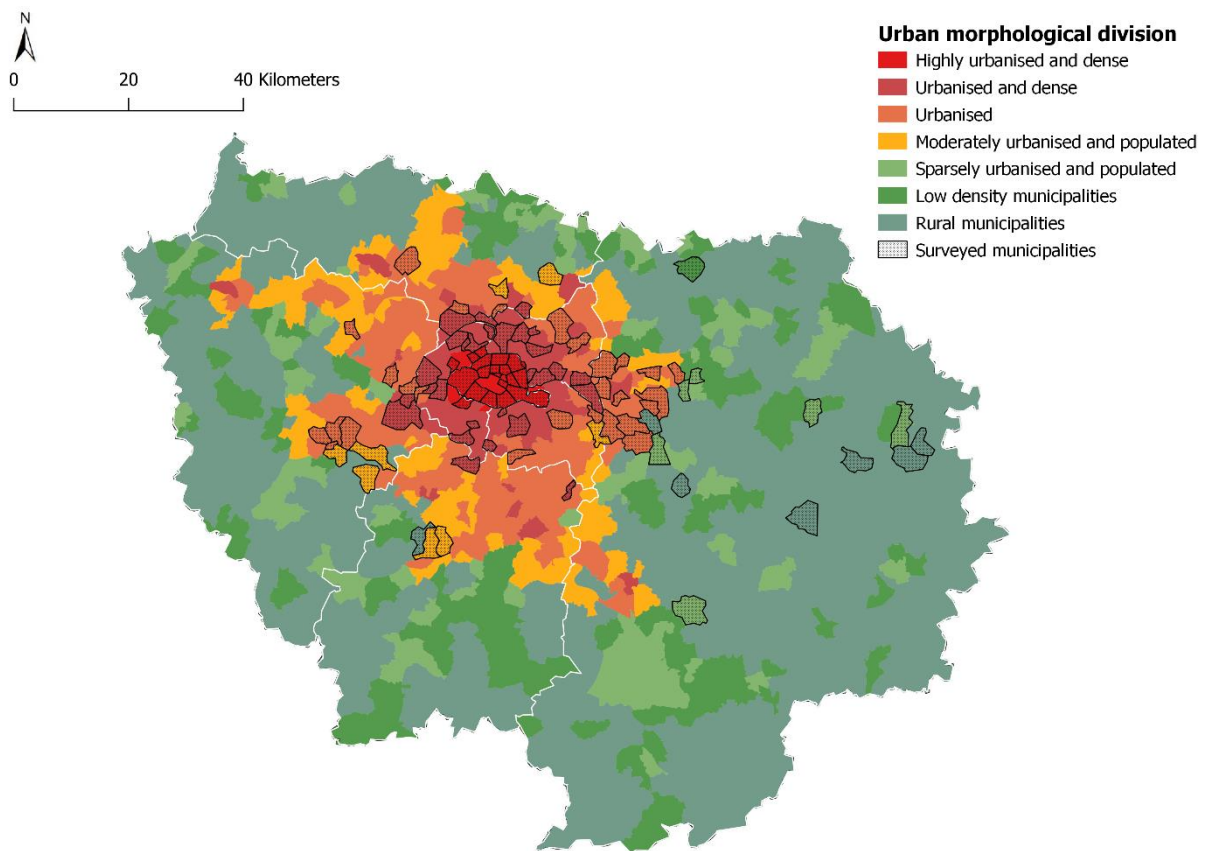
With 3 classes per criteria, we had 27 possible combinations, but only 17 combinations actually existed. For each unique combination, we randomly selected a municipality.

¹⁰ *Mode d'Occupation des Sols (MOS)* developed by the *Institut Paris Région*

¹¹ Classified from 1 to 4 in the MOS year 2017 in 11 posts available at <https://www.iau-idf.fr/fileadmin/DataStorage/iauEtVous/CartesEtDonnees/Mos/NomenclatureMOS-11-24-47-81.pdf>

¹² From number 6 to 11 of the French MOS, year 2017, 11 posts

Figure 4.4 - Geographical distribution of respondents according to the urban morphological division (Institut Paris Région)



Despite targeting the 17 selected cities, it was difficult to avoid interviewing people from other municipalities, but eventually, 66% of the respondents were from the sampled municipalities. Figure 4.4 represents all cities in which at least one individual of the survey resides.

A total of 320 respondents completed the questionnaire in full, while 13 respondents did not complete all the choice situations, leaving 307 useful responses (corresponding to 3,684 observations). We found no protest answers in the collected data, that is no respondents systematically chose the "stay at home" option. Table 4-3 presents the data on gender, age, socio-professional category, and revenue of the sample population and the region. In terms of age and income distribution, our sample is representative of the region: 52% of the respondents are women, and 60% earn less than 2,000€ monthly. The age distribution matches that of the region, although the 45- 59-year-old group is slightly under-represented, and the 18-29-year-old group is over-represented. In our sample, intermediate professions are under-represented, and employees are over-represented, possibly because we interviewed people in the streets during standard business hours when most workers are not outside. We rectified this disparity by applying a weight to the responses of the categories that are under- or

over-represented to match their proportions in the region. Our whole sample is small but sufficiently representative for drawing accurate conclusions.

Table 4-3 - Sample and population characteristics

		Proportion of respondents in the sample (%)	Proportion of the population in Ile-de-France (%)
Gender	Male	48.0	48.0
	Female	52.0	52.0
Age class	[18,29]	30.1	20.4
	[30,44]	31.4	28.0
	[45,59]	18.6	25.5
	[60,74]	15.7	17.1
	Older than 75	4.2	9
Socio-professional category	Farmer	0.1	0.1
	Craftsman, retailer, entrepreneur	6.3	3.2
	Managerial and higher-education professions	17.6	17.7
	Intermediate professions	8.5	16.1
	Employees	29.5	16.8
	Workers	4.4	8.7
	Retirees	14.2	19.7
	Other without professional activity	19.5	17.8
	Monthly disposable income	<1400€	32.5
	1400€ to 2000€	35.0	30
	2000€ to 3000€	20.0	20
	>3000€	12.5	10

Source: INSEE. Dossier complet. Région Ile-de-France at the 10th July 2021

4. RESULTS

4.1. General perception of UGS characteristics

Table 4-4 presents the results of the ML model. All attributes, except shape and forest, were found to significantly influence respondents' choices. Individuals do not take into account whether a green space is linear. This result is consistent with Choumert & Travers (2010), who report that the form of a UGS does not influence UGS preferences. People also do not seem to take into account whether a UGS is a forest, possibly because they do not distinguish the difference between woodlands and forests. Respondents also seem to favour larger UGSs. The significant negative ASC coefficient indicates that people prefer going to a UGS rather than staying at home. The standard deviation is significant for all variables influencing respondents' choice, except for size and time. This result indicates significant variation in the respondents' preferences and some potential unobserved heterogeneity.

Table 4-4 - Mixed Logit Estimates

Variables	Mean	SD
Shape	-0.909 (0.613)	-0.756 (1.244)
Water	5.969*** (0.823)	5.635*** (0.989)
Size	2.008*** (0.648)	-1.405 (1.678)
Woodland	29.84*** (3.507)	21.17*** (2.995)
Forest	-1.336 (1.666)	8.709*** (2.057)
Bike	-3.730*** (1.138)	-9.834*** (1.431)
Car or Public Transport	-5.638*** (1.209)	-13.89*** (1.537)
ASC	-76.42*** (6.562)	45.22*** (5.503)
Time	-3.284*** (0.0661)	0.0928 (0.0720)

Standard errors in parentheses

***p<0.01, ** p<0.05, * p<0.1

From equation 3, we calculate the average WTT for all significant attributes (Table 4-5) and show in Figure 4.5 the kernel densities of the distribution of the individual parameter estimates (solid line) and corresponding normal distribution (dashed line).

Table 4-5-Willingness-to-accept additional travel time (WTT) and willingness-to-pay (WTP) estimates

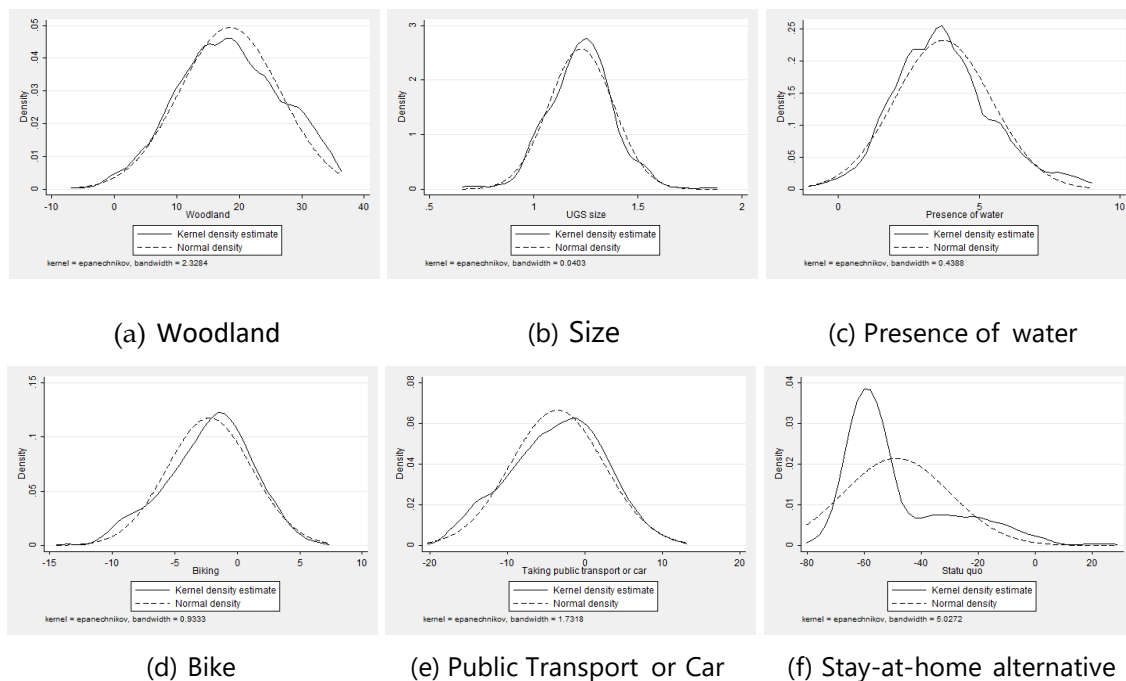
	Wood-land	Water	Size	Bike	Public transport or Car	Reach a UGS by foot	Stay at home
Average WTT	18 min	4 min	1 min	- 2 min	- 3 min 30	5 min 30	- 48 min
Average WTP	2.61€	0.58€	0.15€	- 0.29€	- 0.51€	0.80€	- 6.96€

Woodland

People are positively influenced by the presence of trees when choosing a UGS. However, they do not derive higher utility from a forest compared to a woodland. Tree coverage is nevertheless the most sought-after characteristic: on average, people are willing to spend 18 minutes to travel to a wooded

UGS compared to a non-wooded UGS. Preferences regarding woodlands are also widespread: the minimum WTT is -4.5 minutes (refer to Appendix L), while the maximum WTT is 34 minutes. These results indicate that people who dislike woodlands the most are still willing to travel to a wooded UGS rather than a non-wooded UGS if their travel time is reduced by 4.5 minutes. However, very few respondents have a negative WTT (refer to figure 4-5a), and the vast majority of people would agree to a higher travel time to visit a woodland than a non-wooded UGS.

Figure 4.5 - Individuals' WTT distribution for each significant attribute (from subfigure a to e) and the stay-at-home alternative (f)



Size

Compared with a small UGS, a large UGS (greater than 1.5 ha) positively influences respondents' choices. However, respondents are not willing to spend much time traveling to a large UGS compared to a small UGS, as the average WTT is only 1 minute. The estimated WTT is concentrated, as the maximum WTT is approximately 2 minutes, and the minimum WTT is 0.7 minutes.

Presence of water

On average, the presence of water significantly increases respondents' utility. People, on average, are willing to travel an additional 4 minutes to visit a UGS with water compared to a UGS without water. Figure 4-5c shows that very few respondents associate the presence of water with decreased utility. This could be the case of disabled or elderly persons who could associate water with increased difficulties regarding mobility. However, the large majority of people associate the presence of water with increased utility, with a maximum WTT of 8 minutes and 30 seconds (refer to

Bike

To maintain a constant utility, people are willing to ride a bike instead of walking if their journey is reduced by 2 minutes. Although the average WTT for biking is negative, 35% of respondents are willing to accept a longer travel time by bike rather than by foot (figure 4-5d). This finding indicates that more than one-third of respondents prefer going to a UGS by bike than by foot. This could mean that they enjoy the time spent traveling and value it positively if they are biking but do not value it if they are walking. In this case, the maximum accepted additional travel time is 6 minutes, which represents a distance of 1.6 km (biking at 16 km/hour).

Car or Public Transportation

The average utility derived from going to a UGS by driving or taking public transportation instead of walking is negative. On average, people are willing to drive or take public transportation if their travel time is reduced by 3 minutes and 30 seconds. However, 34% of respondents prefer to go to a UGS with motorized transportation means rather than by foot (figure 4-5e). This could be the case for families or senior residents.

Stay at home

The utility associated with staying at home is negative, indicating that people generally derive disutility from staying at home and prefer going to a UGS. This disutility is high as, on average, residents are willing to travel 48 minutes to enjoy UGS, which corresponds to 40% of the declared average recreational time spent on-site.

4.2. Preference heterogeneity

Plotted distributions in Figure 4.5 indicate potential heterogeneity for woodland, water and size preferences as WTT distributions present some inflection points. We therefore assume the existence of distinctive groups of individuals having different preferences concerning UGS characteristics. Preferences concerning transportation modes described in the previous section also indicate the potential existence of distinctive groups. Indeed, a noticeable proportion of respondents receives an increased utility biking, taking public transport or driving. Concerning the ASC, the plotted distributions distinctly reveal two groups of individuals, with the inflection point at approximately -40 minutes.

As two groups of people with distinctive WTT for the stay-at-home alternative clearly emerge, we further explore preferences for the stay-at-home alternative and run the ML model with interaction terms. We investigate the influence of diverse socio-economic variables on the probability of choosing this alternative. These variables are described as follows: living in a highly urbanized municipality (more

than 2/3 of the municipality's surface is urbanized); having a private garden; having children; benefiting from a monthly disposable income greater than 2,000€; having received higher education; and paying a high rent (greater than 19.5€ per square meter). Detailed results are presented in Appendix M. The interaction terms with the facts of living in an urbanized area with high rents are significant and positive. These results indicate that the more people live in urbanized areas with high rents, the more their disutility in staying at home reduces, even if this alternative still produces a disutility. This finding could be explained by the fact that neighbourhoods with high rents in Ile-de-France are also those with limited access to UGSs. People living in these areas may have integrated the fact that they have little access to UGS (Faburel & Gueymard, 2008; Liotta *et al.*, 2020).

4.3. Latent classes

To determine how many classes best fit our data, we obtained the log-likelihood function (LLF), Bayesian information criterion (BIC) and Akaike information criterion (AIC) for an LC model with 2, 3, 4 and 5 classes (results figure in Table 4-6) However, as the AIC seems to be biased towards an over-estimation of the number of classes (Scarpa and Thiene, 2005) and the BIC criteria seems to be biased towards an under-estimation of the number of classes for small sample sizes (Mclachlan and Peel, 2000), the choice of the appropriate number of classes should be based on not only model-quality indicators but also "the analyst's judgment on the meaningfulness of the parameter signs" (Scarpa and Thiene, 2005). Given that the larger the number of classes, the greater the possibility that the estimated parameters lose significance, we consider that 3 classes would produce an insufficient number of individuals in each class. Based on the predictive quality, we choose a 2-class model.

Table 4-6 - Model comparison indicators

Model comparison	Model comparison				Final calibration
	2	3	4	5	2
Number of latent class					
LLF	-2640.5	-2579.8	-2536.0	-2504.2	-2346.9
AIC	5318.9	5217.5	5150.0	5106.4	4749.9
BIC	5389.1	5324.6	5294.1	5287.4	4850.2
Predictive quality (%)*	96	89	88	87	96

*The predictive quality of the model measures the average probability of individuals belonging to their assigned class.

The results (Table 4-7) show that individuals living in denser areas, paying higher rents and having a private garden are more likely to belong to class 2 rather than class 1. Other socio-economic variables do not influence the probability to belong to one class or the other: having children, age, income, gender and education level. Class-2 profile tends to correspond to residents from the heart of the urban areas (Paris and inner suburbs) while class-1 profile is rather consistent with residents living in

the outer suburbs (living in less dense and less expensive areas).

Table 4-7 - Latent Class parameter and class membership results

Variables	Class 1	Class 2
Woodland	0.820*** (0.117)	1.068*** (0.233)
Forest	0.0256 (0.0659)	-0.0773 (0.131)
Shape of the UGS (linear)	-0.0243 (0.0239)	0.00842 (0.0514)
Presence of water	0.196*** (0.0252)	0.123** (0.0543)
Size of the UGS	0.144*** (0.0508)	0.125 (0.108)
Access by bike	-0.110*** (0.0357)	-0.546*** (0.0752)
Access by car of public transport	-0.193*** (0.0340)	-0.362*** (0.0678)
Travel time to reach the UGS	-0.0280*** (0.00259)	-0.0383*** (0.00599)
ASC	-3.898*** (0.326)	-0.691*** (0.211)
<i>Class membership</i>		
Urbanization ratio	-1.665** (0.835)	
Having a private garden	-0.736* (0.403)	
Rent price per square meter in the municipality	-0.0614* (0.0361)	
Constant	4.278*** (1.003)	32
<i>Class share (in %)</i>	68	

Standard errors in parentheses

***p<0.01, **p<0.05, *p<0.1

Table 4-8 presents the willingness to accept additional travel time of both classes for each attribute and its conversion in WTP. Regardless of the attribute, class-2 members accept to spend less time traveling to a UGS than residents from class-1. All residents would rather walk to wooded UGSs with water. While class-1 members could walk 23 minutes to a wooded UGS, class-2 members accept to walk 6 minutes. This represents around 1.9 km for class 1 (vs. 500m for class 2) for individuals walking at a 5km/h speed. Class-1 members could extend their travel time by 2 minutes (which represents a

walking distance of roughly 166m) if the UGS is large while this attribute does not deserve additional time for class-2 members.

Table 4-8 - Willingness to travel additional time (WTT) and willingness to pay (WTP) for class 1 and class 2

Variables	Class 1 (living in relatively lower density and lower rent areas)		Class 2 (living in relatively higher density and higher rents areas)	
	WTT	WTP	WTT	WTP
Woodland	23 min	3.34€	6 min	0.87€
Non-wooded UGS	-23 min	-3.34€	-6 min	-0.87€
Water	6 min	0.87€	1 min	0.15€
Size	2 min	0.29€	0 min	0.00€
Bike	-1 min	-0.15€	-3 min	-0.44€
Car or Public Transport	-5 min	-0.73€	-2 min	-0.30€
Reach a UGS by foot	6 min	0.87€	5 min 30	0.80€

Should be read as: people of class 1 accept an additional travel time of 29 min to go to a wooded UGS by foot and people of class 2 accept an additional travel time of 11 min.

The ASC for both classes is negative. As we coded the alternative specific constant on the "stay-at-home" alternative, this option seems to decrease the utility of individuals in both classes but not with the same amplitude. Even if all other attributes were held constant, the respondents would prefer moving from their current situation to improve UGS provision. The disutility for class 1 is, however, more important (approximately -140 min) than that estimated for class 2 (approximately -18 min).

To sum up, class-1 members who tend to live in less dense and less expensive areas prefer walking to a large wooded UGS with water, while class-2 members, who tend to live in denser and more expensive areas, prefer walking to a wooded UGS with water regardless of its size. Both classes prefer to move from the *status quo* and see an improvement in the UGS provision, even if this preference is stronger for class-1 members.

Comparison between ML and LC models

We applied the Vuong test to choose which model—between the ML and the 2-class LC—best fit our data. The results suggest that we cannot discriminate in favour of one model. Both models are equivalent, as the V-statistic equals 1.78. However, because class membership probability is linked to socio-demographic variables, the LC results would be more useful to public decision-makers. For example, a policy aimed at developing woodlands in city centres on the basis of an 18-min WTT—which

is the average WTT estimated with the ML model—would result in disregarding class 2 members, who already lack access to UGSs (as 18 minutes exceeds their acceptable travel time).

5. DISCUSSION

Our principal results suggest a high heterogeneity in preferences between city-centre dwellers living in dense and more expensive environments and outer suburb dwellers living in less dense and more inexpensive environments. The major differences lie in (1) the disutility of remaining in the *status quo* scenario, which is much lower for city-centre dwellers, (2) the global time budget that dwellers are willing to dedicate to reach a UGS, which is much lower for city centre dwellers, and (3) the size characteristic of a UGS (>1.5 hectares), which is important for suburban inhabitants but not for inhabitants of city centres.

More generally, our results provide insight to improve the quality of urban green spaces in a region experiencing densification and urban sprawl. The quantitative approach to develop UGSs (i.e., 10m²/inhabitants or 300m-distance from home) bears the risk of developing urban green spaces that do not meet residents' needs.

In a context of increased densities in many metropolitan cities in the developed and developing world, policies investing in small UGSs in highly urbanized areas can increase the welfare of city- centre dwellers. This result is consistent with Choumert and Travers (2010) who also report that developing small UGSs would be a suitable policy in Angers. Peschardt *et al.* (2012), using interviews in "pocket parks" of Copenhagen, show that these parks improve residents' everyday life. In the case of the Paris Metropolitan region, small UGSs with trees rather than grass would respond to residents' needs in the city center.

We find that residents less willing to spend time traveling to a UGS tend to live in denser and more expensive areas. One could expect, on the contrary, that residents living in denser areas have less access to urban green spaces (this corresponds to Paris *intra-muros* and the little crown) and would, therefore, be willing to spend more time to benefit from green spaces. Maat and de Vries (2006) study supports this counter-intuitive result. The authors test the compensation theory, stating that people living in less green environments would value UGS more. They show that this hypothesis is not validated in the case of the Municipality of Arnhem in the Netherlands. For the authors, a possible explanation is self-selection: when deciding on a residential location, people who value urban green spaces will choose a residential location close to UGSs. Tu *et al.* (2016) results also invalidate the compensation theory by suggesting that wealthier residents benefit from substitutes such as street

trees. They could also afford to pay to have access to private UGS or could travel to the countryside on weekends. Residents from less dense and less expensive neighborhoods could be less sensitive to this type of substitution effect. It is also worth noticing that even though residents living in areas that are more expensive are less willing to spend time reaching a UGS, they still prefer not to remain in a status quo scenario and value better access to UGS.

In less urbanized areas and municipalities with lower rents, policies could aim at developing large, wooded UGSs with water and improved walking access. This type of UGS answers better to inhabitants' needs. This is in line with the findings of Tu *et al.* (2016) showing that urban forests and parks are not substitutes. These results provide insight for resource allocation, showing that public policies can deviate from the "300m-distance from home" or $10\text{m}^2/\text{inhabitants}$ rules by providing more qualitative UGSs in outer suburbs. Indeed, dwellers seem to accept traveling longer distances to reach a qualitative UGS. Public policies can thus adapt these quantitative thresholds according to UGSs quality.

By converting the willingness to spend additional time to reach a UGS in monetary terms, we find that residents belonging to class 2 are willing to pay 0.87e to benefit from wooded UGSs while this amount reaches 3.34e for class-1 members. If we take the example of a fictive project of afforestation of the Park André Malraux in Nanterre city, we can estimate the budget that residents would be willing to support to plant trees. Nanterre is a highly populated city with a low access rate to nature (Liotta *al.*, 2020). In this example, if we make the hypothesis that all Nanterre residents belong to class 2 (as their socio-economic characteristics correspond to class 2 members), we compute that around 13,200 inhabitants¹³ would visit the wooded UGS after the reforestation project, which represents a budget of roughly 11,500e. Based on the financial figures provided by the French National Forest Office for an afforestation project in S'énart (another city located in the big crown), this could finance 2ha of afforestation¹⁴.

Although these results are useful for calibrating land-use planning in urban areas, urban greening and conservation policies cannot be measured by the sole channel of recreational services. Complementary research includes exploring other ecosystem services, such as urban heat island mitigation, natural heritage and water retention (Tardieu *et al.*, 2021). Moreover, greening policies may also consider

¹³ This is calculated based on a density of 7,941 inhabitants/km². This corresponds to the number of residents living at a maximum of 6min-walk to the park, which corresponds to a 500m-wide circle around the park, if people walk at a 5km/h speed

¹⁴ This is calculated based on the publicly available figures provided by the ONF (French Forest Organization) for the afforestation project of the S'énart Forest: 38,700 plants cost 110,000Q with a density of 2,000 plants/ha in the densest areas.

environmental justice considerations when targeting future UGS development. Liotta *et al.* (2020) show that in the case of the Paris Metropolitan area, targeting areas less endowed with UGSs, for example, in Paris *intra-muros* or in the west of the little crown, could benefit the more affluent segment of the population.

Our results should be considered within the limits of the IDEFESE project and the specific interests of its stakeholders (Hamel *et al.* 2021; Tardieu *et al.* 2021). For example, regarding the choice of attributes, the focus groups led to include both time and mode of transportation, which are considered independent variables in the analysis. Even though transportation time is highly variable in the Paris Metropolitan area, these two variables may not be entirely independent. In the present study, we consider that each respondent realized the choice experiment considering that no other transportation mode than the one suggested in each alternative was available. As the transportation mode was given, we believe that respondents evaluated transportation time independently. Since this hypothesis is based on the guidelines provided to respondents but has not been tested, it constitutes a limit to our study.

Our work also presents the limits of stated preference methods, including hypothesis bias (when respondents have difficulty envisioning fictive situations) and anchoring bias (when respondents rely too much on the first information they obtain when they make a decision). Responses might also have been influenced by the presence of the interviewer as some studies report higher WTP with face-to-face interviews than online or self-reported questionnaires (Snowball & Willis, 2011; Lindhjem & Navrud, 2011). These findings could be tested with a mixed survey (online and face-to-face) to assess if they also apply in the case of UGS choices.

Our study also disregards the spatial connection between green spaces, which may have a strong influence on individuals' preferences to practice some activities, such as running or cycling. For instance, STRAVA data show that Franciliens cover different types of green spaces when they run¹⁵. This aspect could be integrated into further research.

However, these limits can be nuanced due to the high consistency between the DCE results and the actual behaviours of residents. As the questionnaire addressed people's actual behaviour regarding UGSs, we can compare the LC results to their actual willingness to dedicate time to reach a UGS¹⁶. The

¹⁵ See <https://bit.ly/3Gouvbb>

¹⁶ In the questionnaire, respondents indicated the time spent traveling to the most visited park in the past year and their mode of transportation (walking, biking, public transportation, or car). Actual distances to the most visited UGS were calculated with the distance between the centroid of their municipality (the only data

results reveal that class 2 members, who are more urbanized dwellers and less willing to travel to reach a UGS, effectively spend less time to reach a UGS than class 1 members. The individuals in class 2 stated traveling an average of 17 min to reach a UGS, while those in class 1 declared traveling an average of 19 min, mostly by foot. When examining the most frequently traveled distances, individuals belonging to class 2 on average travel 1.02 km (approximately 17 minutes by foot for a speed of 3.6 km/h), and individuals of class 1 on average travel 2.22 km (approximately 37 minutes by foot). These answers correspond to the same orders of magnitudes of the WTTs obtained in the DCE. However, even if class 2 members are less willing to spend time reaching a UGS, individuals visit it more frequently (93 times/year on average; median of 50) compared to individuals from class 1 (74 times/year on average; median of 42).

Even if our results are foremost instructive for the Paris Metropolitan area, they might be representative of other large metropolitan areas. They are consistent with the findings of Suárez *et al.* (2020), who also find that inhabitants' residence location and, particularly whether it is situated in a central area or an outlying area, influence Oslo's residents' outdoor recreational preferences. These results indicate that an individual's place of residence, characterized by its urbanization degree, is likely to influence their preferences regarding UGS characteristics in large European cities. However, as cultural factors influence UGS use (Lo & Jim, 2010), we cannot confirm this hypothesis. Further studies in other dense and populated cities are needed to corroborate our results.

6. CONCLUSION

Urban greening has become an important component of the urban political agenda. Targeting future UGS development in highly urbanized areas is a difficult issue as land is increasingly scarce (and expensive) and the social demand for natural amenities increases. This study attempts to provide useful insights to public decision-makers for a better allocation of UGSs according to their characteristics and the socio-demographic profiles of potential users. We show with a DCE that dwellers' preferences concerning UGSs are likely to strongly differ according to the urbanization level of their residence location. While all residents value wooded UGSs, the presence of water, the ability to travel to a UGS by foot, the time budget they are willing to dedicate to reach UGSs is much lower

available from the survey) and the centroid of the most visited park. Results were double-checked using the stated travel time and travel mode indicated by the respondent by assuming a walking speed of 3.6 km/h, a cycling speed of 16 km/h, and a travel speed of 60 km/h for driving and public transportation.

for people living in denser, more urbanized and more expensive environments.

We also show that the size of a UGS is valued by inhabitants of outer areas but not necessarily by residents of central districts. This finding suggests that outer suburb inhabitants would prefer larger UGSs, even if they are located farther away, while inner centre inhabitants would prefer multiple, nearby and even smaller UGSs. Our results call for a better integration of individual preferences in the process of urban greening and suggest that the "access to UGS" criterion may be subjective.

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Conflict of Interest

The authors declare that they have no conflicts of interest.

GENERAL DISCUSSION AND CONCLUSION

This Ph.D. thesis seeks to understand better how complex organizations such as world cities and MNEs manage biodiversity issues. Through enhanced comprehension of the mechanisms leading to the successful or unsuccessful integration of biodiversity conservation, it uncovers the mediating role of organizational forms in shaping their impacts on socio-ecosystems. This Ph.D. thesis examines four key levers: the influence of regulations such as the Corporate Sustainability Reporting Directive (chapter 1), local adaptations of supply chains (chapter 2), internal decision-making processes (chapter 3), and the role of demand (chapter 4). The main objective of the Ph.D. thesis is to understand how these levers drive the evolution of complex organizations and influence their decisions and actions in support of biodiversity conservation.

More specifically, chapter 1 points to the limits of current mandatory biodiversity reporting regulation while chapter 2 sheds light on the supply side, emphasizing not only the role of local interactions but also the role of state and international cooperation. Chapter 3 identifies barriers to internal change management. Finally, based on the example of urban greening policies, chapter 4 illustrates that by characterizing demand and assessing trade-offs between product or service attributes, policies can be adapted to generate enhanced social and ecological benefits. This Ph.D. thesis presents five main contributions, which are presented in the next section. The first one is a general contribution derived from the case-study approach adopted in the last three chapters of this dissertation, while the remaining four are tied to specific chapters.

THESIS CONTRIBUTIONS

First, this work reveals the complexity of the mechanisms underlying the evolution of organizations toward increased integration of biodiversity conservation. Relying on a systemic approach to complex organizations' evolution and building on various empirical case studies, it analyses organizations' evolution processes being deployed, showing that a combination of factors contributes to these organizations' change. By closely examining the context, interactions, and dynamics of empirical case studies, it identifies the intricate processes and causal relationships at work that may be overlooked in broader, more generalized investigations.

Second, the first chapter shows that mandatory non-financial disclosure should increase information availability on biodiversity-business interactions, but this information will unlikely be useful for stakeholders advocating for biodiversity conservation. It shows that the CSRD - which has raised great

expectations among practitioners - falls short in providing qualitative information that accurately reflects MNEs' actual impacts on biodiversity. The findings question the ability of the CSRD to generate a meaningful process of change.

Third, chapter 2 provides an example of an MNE delivering positive ecological, social, and economic benefits. Our analysis uncovers how different organizations of producers evolve in practice. By tracing how adapting mechanisms emerged, take shape and are deployed on sourcing territories to generate social and ecological benefits, it provides insights into the mediating role of interactions in the evolution of organizational forms. This case study proves that developing interdependencies with socio-ecosystems can be a source of resilience where MNEs usually aim at limiting external sources of disturbances and potential dependencies.

Fourth, chapter 3 identifies concrete internal resistance and facilitation factors to organizational change associated with the integration of biodiversity conservation. To our knowledge, it is the first study based on primary data covering a wide sample of MNEs across different sectors. It opens a window onto decisions being negotiated internally at the corporate level. This chapter confirms obstacles that have been identified in the corporate integration of sustainability issues in general, although not in the integration of biodiversity conservation in particular. Additional obstacles, often overlooked by the literature, are further identified.

Fifth, chapter 4 demonstrates that considering the influence of various characteristics of the social ecosystem on demand can serve as a basis for differentiation of the offer of products or services that generate increased social and ecological benefits. By employing Discrete Choice Experiments (DCEs) to characterize the heterogeneous demand for urban green spaces, we identify different greening policies that could be implemented to enhance social and ecological benefits.

GENERAL IMPLICATIONS AND DISCUSSIONS

Our results involve developing interactions between organizations and socio-ecosystems, be it for acquiring quality information, adapting supply chains to local social and ecological contexts, deploying in-house biodiversity strategies, or characterizing the demand for ecological products and services. This finding resonates with advocates of natural resources collaborative management who argue that collaboration enhances new and diverse knowledge through increased interactions while supporting the spreading of best practices among users (Bodin, 2017; Pereira et al., 2018). Olsson et al. (2004) demonstrate how engaging in trust-building dialogues involving actors at various levels and establishing coordinating mechanisms facilitated information exchange, fostered knowledge creation and the development of a shared understanding of the challenges associated with the management of

a wetland landscape in southern Sweden. Mazé et al. (2021) show the role of social interactions in the re-appropriation of French peasants of seed varieties. It encouraged the creation of shared knowledge and competencies in seed handling and breeding, thereby empowering them to maintain seed genetic diversity. However, simply engaging with sourcing territories is insufficient for generating social and ecological benefits.

Ménard (2014) emphasizes the role of meso-institutions - defined as “socially embedded and legitimized institutions that translate the general rules of the game to specific geographies or sectors” (p.578) - as mediating the influence of institutions on organization forms. Taking the example of network services, the author shows the need to incentivize cooperation between meso-institutions. The vicuña case study illustrates how key these meso-institutions are. As seen in the vicuña case study, organizational adaptations involved the ongoing participation of local actors who were knowledgeable of local communities’ livelihoods and challenges. These actors were directly involved in the management of productive operations, which goes beyond their mere consultation. Their role has proven crucial for local adaptation of standardized and globalized corporate rules. The vicuña case study thus shows that intermediaries can be used as entry points to provide local anchorage to global supply chains.

Criticizing the “placeless” character of firms sustainability, Shrivastava & Kennelly (2013) develop the notion of place-based enterprise as businesses characterized by local ownership and control, deep connections to the physical, social, and human aspects of a particular area, as well as a strong commitment to a social mission. The authors argue that these types of enterprises present significant avenues for promoting ecological and social sustainability within local communities. As individuals gain a thorough understanding of sustainability issues specific to that place through their personal engagement, they develop a deep engagement with a specific place that leads to a stronger commitment to sustainable practices (Guthey et al., 2014; Shrivastava & Kennelly, 2013). An increased sense of place could lead managers to directly experience nature, which could, in turn, favor their environmental actions (Bögeholz, 2006; Soga & Gaston, 2016). For example, Guthey & Whiteman (2009) highlight the importance of fostering a sense of place to promote social cohesion and encourage sustainable practices within communities involved in the California wine industry. They demonstrate that actively shaping and co-creating a sense of place among stakeholders, including industry policymakers and wine producers, influenced regulations and perceptions of nature-society relationships. This ultimately led to transformative changes in community beliefs and eventually to enhanced sustainability across social, environmental, and economic dimensions.

For MNEs, reinforcing local anchorage could take the form of greater autonomy to regional or local

business units, allowing for differentiated organizational forms based on territorial differentiation. In the vicuña Argentinian supply chain, the lead firm leaves sufficient autonomy for the hybrid group and cooperative to set their rules, facilitating their alignment with the characteristics of the socio-ecosystems. The adaptation of management processes to global-local tensions when managing biodiversity-related topics is crucial. However, there is not a single way to integrate local specificities into MNE management processes. Burritt et al. (2020) recent literature review identifies three types of approaches MNEs develop to combine their global Corporate Social Responsibility (CSR) strategies with local territories. The global approach locally interprets a global strategy; the transnational strategy involves feedback loops between global standardization and local adaptation, and the regional strategy relies on regional headquarters to mediate between global and local strategies.

Without such anchorage, the involvement of local intermediaries such as NGOs or scientists may, on the contrary, overlook the social, ecological, cultural, and institutional nuances of the territory. In such instances, their role can prove detrimental, contributing to narratives that stigmatize local communities, as seen in the case of amaranth use in Mexico (Bétrisey & Boisvert, 2020). Where the use of amaranth in Mexico is framed in a built discourse based on an idealized vision of this “superfood”, the narrative framing the use of vicuña is, on the contrary, built on archeological research and emerged simultaneously with the use of vicuña fiber as a result of coevolutionary processes. Like in the case of amaranth in Mexico, the vicuña case illustrates the growing politicization of traditional ecological knowledge described by Pinton & Boisvert (2019) through the development of a discourse based on traditional Inca heritage, whether re-appropriated or original.

Another implication of our work concerns the necessary broadening of worldviews and mental models that support organizations’ ecological transformation. Adopting a co-evolutionary approach to the evolution of MNEs’ supply chain at the local scale involves acknowledging the influence of factors beyond the organization's complete control. While practitioners typically aim to minimize the influence of such factors, the vicuña case study suggests that these factors can contribute to the adaptation of global supply chains to local contexts, ultimately facilitating the creation of social, ecological, and economic benefits. For practitioners, accepting such dynamics implies distancing themselves from their operational control, which appears limited by the coevolutionary dynamics with the sourcing territories. Instead of controlling outcomes, practitioners could focus on maintaining resilience, which is overlooked in the governance of global value chains, despite the systemic risks they are exposed to (Brandon-Jones et al., 2014; Gereffi, 2020). At a corporate scale, the concept of resilience has been applied internally through “agile management”, which is an iterative and flexible approach to project management. Originating from software development, agile management has

gained popularity across industries for enhancing organizational flexibility and adaptability (Denning, 2019). Expanding agile management practices to enhance systemic resilience rather than just internal resilience could be tested.

Moreover, broadening the prevailing mental models that guide strategic decision-making and management practices is crucial to adapting mainstream management tools to biodiversity conservation. While there have been efforts to integrate biodiversity conservation into management tools and processes (Bocken et al., 2014), a reciprocal dynamic is also essential. Such a dynamic involves moving away from a coercive vision of management. In such a vision, tools are developed and used with prescriptive objectives. In a review of R. Martineau's book entitled *Anatomie des outils de gestion*, Aggeri (2024) differentiates between closed tools ("*outils fermés*" p.102), which involves limited room for users' interpretation; and open tools ("*outils ouverts*" p.102) which necessitate the cooperation of users. Our findings reveal the coexistence of "closed" and "open" tools in MNEs' current management of biodiversity-related issues. MNEs typically develop biodiversity strategic plans with limited participation of operational business units, relying on closed tools such as biodiversity indicators - expressed as a Mean Species Abundance, for example - and coercive management. However, in response to the challenges of implementing these plans effectively, internal initiatives based on the development of open tools have emerged. However, these initiatives remain mostly carried out at the strategic corporate level with limited participation of operational teams. Consequently, the developed open tools are used within a framework predetermined by decision-makers, leaving limited interpretation for the user, which hinders their adaptation to local contexts.

Because such changes involve trade-offs, the creation of experimental spaces would present arenas to test innovative management and production practices without putting at risk the organization's economic survival. By lowering the risks of using innovative approaches and tools, they could facilitate the integration of biodiversity conservation issues into complex organizations operations. Pereira et al., (2018), addressing the challenges of sustainable transition in the Global South, emphasize the role of "transformative spaces", defined as "safe-enough collaborative processes whereby actors invested in sustainability transformations can experiment with new mental models, ideas, and practices that can help shift social-ecological systems onto more desirable pathways" and the role of researchers as "transformative space-makers" (Pereira et al., 2018, abstract).

PERSONAL COMMENTS

Related to the necessary broadening of worldviews previously mentioned, competency emerges as a central aspect in advancing the integration of biodiversity conservation efforts. However, during our

interviews for Chapter 3 on internal change management, we observed a widespread lack of ecological knowledge and skills. Many interviewees were seeking market applications for biodiversity without questioning this approach, not only from a commercial standpoint but also from ethical and societal perspectives. They often assumed that generating economic profits could align with ecological and social benefits. This assumption avoids essential discussions about the trade-offs MNEs must consider. This observation echoes Maechler & Boisvert (2024), who reveal how conservation narratives centered on valuation continue to dominate while little challenged. Pursuing conservation based on such limited worldviews risks pursuing unrealistic goals where it is assumed that it is possible to conserve biodiversity, create social benefits, and increase profits simultaneously without fundamentally transforming organizational logics. Specifically, there was a latent pre-condition that managing the business-biodiversity relationship should rely on innovation and technology. However, these strategies can have adverse effects and may overlook alternative approaches such as frugal innovations (Aggeri, 2023a).

Strengthening ecological knowledge, skills and awareness at all levels of the organizations appears essential to effectively broaden the scope of business-biodiversity relationships and implement organizational dynamics that consider biodiversity conservation. MNEs and world cities need increased ecological competencies, at least to identify whether their projects are relevant to meet both their strategic objectives and broader biodiversity conservation goals. Benefitting from enhanced knowledge on ecosystems could prevent them from investing in window-dressing projects that potentially do not align with their objectives. A broader comprehension of biodiversity could benefit organizations by granting them the competencies to identify greenwashing projects. Without adequate knowledge to evaluate projects supporting biodiversity conservation, there's not only a risk of greenwashing but also inefficient resource allocation. For example, enhanced ecological knowledge could prevent MNEs from investing in projects on the basis that biodiversity conservation can seamlessly be managed through routine project management processes.

Changing mental models and raising awareness on approaches to biodiversity conservation which moves away from a vision relying on dependencies and risks, will be more likely if the tools used reflect this broader vision. Concerns have been raised on the influence of the private sector, and in particular the financial sector, on the development of corporate instruments for biodiversity conservation (Irvine-Broque & Dempsey, 2023; Kedward et al., 2022; Schreiber & Jeandon, 2020). Notably, Maechler & Boisvert (2023) study indicates that the eviction of nature, rather than its commodification, characterizes the financial perception of ecological accounting. Consequently, the priority would be to put the focus back on biodiversity on the tools firms use. Recent conceptual developments have been

suggested in this sense in ecological accounting; for example, the CARE framework relies on biophysical fluxes and the notion of ecological debt to an ecosystem (Capitals Coalition, 2020) or in the sustainable business model literature, with propositions adopting eco-systemic approaches (Bocken et al., 2019; Feger & Mermet, 2020; Upward & Jones, 2016).

If we acknowledge that improving understanding of biodiversity is crucial for driving transformative systemic changes, then the development of a new discourse on biodiversity must not only rely on individual companies but also involve public authorities. Without increased involvement from the public authorities, there is a risk that the discourse on biodiversity will be dominated by private-sector players (Petry et al., 2021; Smoleńska & Van't Klooster, 2022). Thus, particular attention needs to be paid to training content targeting corporations, which should not be limited to a compliance perspective. If intermediaries, such as consultants, advisors or auditors, possess enhanced ecological knowledge and competencies and have the time to establish relations with the involved organization, they can serve as crucial knowledge brokers. For instance, in the adoption of agricultural practices compliant with standards like "Agriculture Raisonnée", Mazé et al. (2016) show that auditors' capability to establish an open dialogue with farmers is crucial for motivating their involvement. Particularly in the early stages of the program, auditors act as translators of the codified certification scheme, explaining the requirements and underlying logic of the audit process.

The role of the State extends beyond the development of competencies and skills. It involves rewarding organizations that invest in changing their practices to integrate biodiversity while also encouraging those that have not yet engaged in such efforts. Public authorities play a crucial role in establishing the necessary institutional framework, which encompasses more than just creating a biodiversity market. They possess additional tools such as public procurement, public-private partnerships, tax systems and other macro-economic policies. For example, central banks in developing countries like Bangladesh, Brazil, China, and India have introduced macroprudential policies to ensure long-term financial market stability while framing bank investment policies to facilitate the funding of projects more respectful of biodiversity (Kedward et al., 2020). However, attention should be paid that developing private investments must not be at the expense of public spending.

LIMITS AND FUTURE RESEARCH

A first limitation of this Ph.D. is its exclusive focus on a single approach that MNEs can employ for biodiversity conservation: adapting their organizational forms to generate social and ecological benefits. However, MNEs can leverage additional strategies to support biodiversity conservation. These include financing biodiversity conservation projects as part of philanthropic or corporate social

responsibility initiatives, advocating for stricter enforcement of existing regulations, lobbying for increased standardization or derisking of regulations, financing research and development projects, initiating experiments at the sectoral or territorial levels, or resorting to market instruments.

Another limitation can be found in the study of decision-making processes. While we explore general barriers in the integration of biodiversity-related issues at the corporate level, we don't look at specific decisions, for example, concerning product development. In the vicuña case study, we don't track how the raw material used has been chosen and, consequently, why, for instance, substitutes have not been selected. However, the choice of raw material is a major choice influencing socio-ecological firms' ecological impacts, just like decisions concerning producer remuneration and administrative requirements for integrating the value chain. This is mostly explained because our requests to interview Loro Piana have been left unanswered after several attempts. Further research could explicitly explore how such choices are made and the factors that favor or impede the development of products or services more respectful of biodiversity. For example, it could investigate the adoption of circular business models. Specifically, it could explore the dynamics supporting the evolution from weak circularity - which aims at reducing waste without, however, questioning sale and revenue growths - to strong circularity, which aims at effectively decoupling resource extraction from economic benefits by transforming producing logics (Aggeri, 2023b).

Third, although we closely examine decision-making processes, their integration and implementation, our primary goal is to identify cross-sectoral barriers to the integration of biodiversity conservation issues in complex organizations. We don't delve into further details of the managerial *dispositifs*¹ mediating the strategic discourse of the organization. Such *dispositifs* are defined as "the arrangement of heterogeneous elements - discursive, cognitive, material - by managers to frame, orient and guide the conduct of subordinates towards assigned ends."² (Aggeri, 2017, p. 43). In chapter 3, the identification of common prevailing perceptions of the biodiversity-business relations among executives provides insights into the cognitive tools supporting these *dispositifs*. Yet, as the author argues, analyzing management situations and their *dispositifs* is not enough. There is a need to delve deeper into the mediating mechanisms. Thus, further studies could follow Aggeri's (2017) work and explore in detail such mediating mechanisms.

¹ As indicated in Aggeri (2017), the French word *dispositif* does not have an equivalent, so we chose not to translate it

² The original french formulation is : "l'agencement d'éléments hétérogènes – discursifs, cognitifs, matériels – par des managers visant à cadrer, orienter et guider les conduites des subordonnés vers des fins assignées. » (Aggeri, 2017, p. 43)

Fourth, the vicuña case study seems unlikely to be replicable. However, I have undertaken preliminary research to explore whether common characteristics exist in the patterns of interactions among the three studied organizations of producers. This investigation aims to identify factors within the network of interactions and its structure that either promote or hinder the generation of ecological and social benefits. As an exploratory work, I carried out a network analysis of the dynamics of the interactions developed in the vicuña case study. Based on the narratives of each producing organization, I mapped and qualified the interactions that led to the three organizational forms studied using a graphlet-based method. Graphlet-based methods are used to study the properties of networks and help understand how they function. Graphlets are small, interconnected patterns or subgraphs that structure the larger network. From the documentary and interview analysis, I divided the study into three time periods and represented the networks associated with each organization for each period, reflecting how the network of interactions changed over time. I looked at the frequency of graphlets in each network to describe its structure, with complex graphlets indicating intricate multi-actor interdependences. The representation of these networks allows to link patterns of interactions and the generation of social and ecological benefits.

Preliminary findings suggest that the hybrid group engages in both simple and complex patterns of interaction, while the private firm and cooperative mainly engage in one-to-one interactions. Complex graphlets are more prevalent in the hybrid group's network compared to the private firm and cooperative. Network analysis is still emerging in the institutional economics literature that investigates the governance of socio-ecosystems. For example, (Mazé et al., 2021b) applied such formalization to explore the role of specific actors within the broader network of French peasants exchanging seeds, as well as the influence of the network's structure on collective learning dynamics. Based on the findings from this analysis, an analytical framework could be developed to categorize additional case studies and, eventually, statistically examine the relationship between the structure of the networks of interactions and ecological and social benefits. Moving forward, such a framework could aim to systematize and generalize the analysis of interaction networks involving MNEs to identify trends between network characteristics, types of interactions, and organizations' impacts on their operating socio-ecosystems.

Fifth, limitation arises from the case study methodology and the representativity of data collected through interviews. In the vicuña case study, we have interviewed single representatives from communities, while in chapter 3, we engaged with CEOs or with CEOs and Sustainable Directors. Their perspectives may not fully and impartially represent the viewpoints of community members (in the case of the vicuña case) or employees (in the case of chapter 3). However, in the vicuña case study, we

employed data triangulation when possible. This involved integrating data from various sources, including scientifically published articles, grey literature, and interviews with different stakeholders, including representatives from communities, as well as other stakeholders such as NGOs, scientists, and government authorities. Regarding chapter 3, although our interviews were solely conducted with senior executives from each organization, it's noteworthy that our findings are based on a comparative analysis involving a wide sample of 16 MNEs, which is the largest sample found in the literature.

Finally, the costs associated with the organizational dynamics mentioned have not been addressed, nor have the related questions of trade-offs and prioritization. The focus has been on identifying and describing transformative mechanisms to understand better how organizational changes unfold rather than proving the business case of these transformative changes. Yet, the overall affordability of such practices raises questions., especially in the vicuña case, given that the lead firm operates in the luxury sector. While our work does not directly address this question, this case study serves to establish a space for reflexivity, constituting a starting point from which to explore innovative solutions, including for companies with tighter financial constraints.

In conclusion, adopting a systemic approach to supply chains allows us to analyze how complex organizations' activities interact with the specific characteristics of their operating territories and how they consider the diverse social and ecological demands that arise. This implies new ways of functioning. Recent initiatives, such as jurisdictional or landscape approaches, have emerged to address sustainability beyond individual sites or producers. Landscape approaches involve collaboration among stakeholders across a landscape, while jurisdictional approaches operate within specific administrative boundaries. By involving a broader range of stakeholders in addressing biodiversity impacts, these approaches could reduce the costs of achieving positive social and ecological outcomes. For instance, as of 2020, IDH – The Sustainable Trade Initiative declares the development of 15 landscape initiatives spanning 11 countries, covering sectors such as tea, coffee, and cocoa.

Advocating for changes in organizational forms involves acknowledging MNEs' responsibility to engage in biodiversity conservation efforts. However, this fundamental prerequisite has recently faced challenges, as seen in the United States, where the House of Representatives passed a bill prohibiting investors from considering ESG criteria in their investment decisions (Morgan, 2023). Despite such challenges, this dissertation anticipates a more positive trend. The work presented employs various methodologies, opening up potential avenues for future research. This includes exploring arbitration and prioritization of ecological, social and economic trade-offs; investigating the relationships between the structure of business-biodiversity interactions and the emergence of social and ecological benefits;

and developing a conceptual reporting framework to enhance the quality of corporate biodiversity disclosures.

Appendices

APPENDICES

APPENDICES CHAPTER 1

Appendix A – Choice of the 15 indicators included in the Multiple Component Analysis

To select the indicators for the multiple component analysis, we proceeded in two stages.

First, we identified and listed the indicators mentioned in five recent reports, specifically designed to guide companies in integrating biodiversity-related topics into their strategies and operations. As the MNEs interviewed were all French, we selected reports in French published by major organizations in this field: *CDC Biodiversité*, the *Fondation pour la Recherche sur la Biodiversité* (FRB), the European Commission's Business and Biodiversity Platform, the World Wide Fund for Nature (WWF) and the International Union for the Conservation of Nature (IUCN). These five reports are:

- Berger, J., Goedkoop, M.J., Broer, W., Nozeman, R., Grosscurt, C.D., Bertram, M., Cachia, F. (2018) Common ground in biodiversity footprint methodologies for the financial sector, Paris, France. CDC Biodiversité
- Delavaud, A., Milleret, A., Wroza, S., Soubelet, H., Deligny, A., Silvain, J-F. (2021). Indicateurs et outils de mesure – Évaluer l'impact des activités humaines sur la biodiversité ?. Coll. Expertise et synthèse. Paris, France: FRB
- Lammerant, J., Grigg, A., Leach, K., Burns, A., Dimitrijevic, J., Brooks, S., Berger, J., Houdet, J., Goedkoop, M., Van Oorschot, M., Kisielewicz, J., Müller, L. (2019) Assessment of biodiversity measurement approaches for business and financial institutions. European B@B Platform
- Ionescu, C., Gnidula, E., Le Mieux, A., Lapeyre, A., & Maudinet, A. (2019). Capital naturel et stratégie des organisations: une visite guidée des outils. Paris: WWF France.
- Stephenson, P.J. and Carbone, G. (2021). Guidelines for planning and monitoring corporate biodiversity performance. Gland, Switzerland: IUCN.

From these reports, we identified and listed 40 tools and indicators mentioned to assess firms' impacts on biodiversity.

Second, we selected indicators based on the scope of the study. As we focus on the Driver-Pressure-State-Response conceptual framework, we discarded indicators that were not built on this framework. Indeed, the link between corporate activities and impacts seemed less obvious. This includes indicators relating to ecosystem services (- 5 indicators), accountability frameworks (-3), general guidelines such as SBTN (-3) and reporting guidelines (-1), standards (-1), databases (-1) and the local adaptation of an

indicator already selected (-1). We also discarded indicators that only assessed interdependencies, thereby overlooking impacts (-2) and those for which there were no publicly available methodologies (- 8 indicators). Last, we added the Biodiversity Intactness Index (BII) to the sample as it entered the computation of the Biodiversity Impact Metric. This gives us the list of 15 indicators included in the multiple component analysis

Appendix B - Coding variables and description of the multiple component analysis

Variable name	Level	Description
Composite	1	Interpretable composite: the metric reflects an existing concept (for example, mean species abundance relates to abundance).
	2	Non-interpretable composite: the metric does not reflect any concept
Available_data	1	Database to be entirely or mainly built
	2	Requires the supply of data external to the company
	3	Requires only data on the ingredients used by the company and the associated volumes
biodiv_dataQ	1	Biodiversity data do not correspond geographically to the site studied and/or are not recent
	2	Biodiversity data correspond geographically to the site studied and are recent (or actualized)
firm_dataQ	1	Modelled data
	2	Primary data
Link_explicitAP	1	Non-explicit link between Activities and Pressures
	2	Explicit link between Activities and Pressures
ModelPE_class	1	No model
	2	Assessment of a medium impact
	3	Assessment of a specific impact
PR	1	The methodology has not been published in a peer-reviewed journal.
	2	The methodology was published in a peer-reviewed journal
Biodiversity_explicit	1	Biodiversity is not explicitly taken into account
	2	Biodiversity is explicitly taken into account
Biodiv_level	1	The sum of "Biodiversite_explicite", "Plusieurs taxons", "Flore", "Faune", "Fonctions", "BiodivT", "BiodivM", "BiodivA", "Genetic" is less than or equal to 19
	2	The sum of "Biodiversite_explicite", "Plusieurs taxons", "Flore", "Faune", "Fonctions", "BiodivT", "BiodivM", "BiodivA", "Genetic" is equal to 20
	3	The sum of "Biodiversite_explicite", "Plusieurs taxons", "Flore", "Faune", "Fonctions", "BiodivT", "BiodivM", "BiodivA", "Genetic" is strictly greater than 20
Scale_min_ecolo	1	The lowest ecological scale possible is the local ecosystem
	2	The lowest ecological scale possible is greater than the local ecosystem

Number pressures	of	1	Nb of main pressures on biodiversity considered: less than or equal to 3
		2	Nb of main pressures on biodiversity considered: greater than 3
Scale_min_firm		1	Firms' operations lowest scale possible: site-scale
		2	Firms' operations lowest scale possible: greater than site-scale

To compute the Biodiv_level variable, we integrated the following factors :

Variable name	Level	Description
Several_taxons	1	The assessment of the state of biodiversity does not take into account several taxa
	2	The assessment of the state of biodiversity may take several taxa into account
	3	The assessment of the state of biodiversity takes into account several taxa
Flore	1	Biodiversity status assessment does not take flora into account
	2	Flora can be taken into account when assessing the state of biodiversity
	3	Biodiversity assessment takes into account flora
Fauna	1	The assessment of the state of biodiversity does not take wildlife into account
	2	The assessment of the state of biodiversity can take wildlife into account
	3	Assessing the state of biodiversity takes into account wildlife
Functions	1	Assessing the state of biodiversity does not take ecological functions into account
	2	Ecological functions can be taken into account when assessing the state of biodiversity
	3	Assessing the state of biodiversity takes account of ecological functions
BiodivT	1	The assessment of the state of biodiversity does not take terrestrial biodiversity into account
	2	The assessment of the state of biodiversity can take terrestrial biodiversity into account
	3	Assessing the state of biodiversity takes terrestrial biodiversity into account
BiodivA	1	The assessment of the state of biodiversity does not take account of aquatic biodiversity
	2	The assessment of the state of biodiversity may take account of aquatic biodiversity
	3	Assessing the state of biodiversity takes aquatic biodiversity into account
BiodivM	1	The assessment of the state of biodiversity does not take marine biodiversity into account
	2	The assessment of the state of biodiversity can take marine biodiversity into account
	3	Assessing the state of biodiversity takes marine biodiversity into account
Genetic	1	Assessing the state of biodiversity does not take genetic diversity into account
	2	Assessing the state of biodiversity takes genetic diversity into account

APPENDICES CHAPTER 2

Appendix C: List of the interviews carried out

N° interview	N° interviewee	Trade organization	Relation with the trade organization
1, 2	1	The cooperative	Monitors camelid agricultural production in Catamarca for INTA
3	2	The cooperative	Drafted the report to ask CITES to change the status of Argentinian vicuñas working for the Catamarca province
4	3	The cooperative	Manages the cooperative as a member of its comisión (elected members of the cooperative with management duties)
5	4	The cooperative	Supervises all the province's <i>chakus</i> as Secretary of Agricultural and Livestock Policies
6, 7	5	The cooperative and the private firm	Attended all <i>chakus</i> , private or communal, from 2012 to 2016
8	6	The hybrid group	Contributed to the 2006 National Census of Wild Camelids in Jujuy Province and acted as an expert for the hybrid group
9	7	The hybrid group	President of the local committee of the Suripujio community, which participates in the hybrid group
10	8	The cooperative	Member of the cooperative and manager of a hostel in Laguna Blanca
11	9	The cooperative	President of the cooperative
12	10	The cooperative	Ph.D. student in anthropology studying the community since 2014
13	11	The cooperative	Master student in archeology coming on and off to the community since 2015
14, 15	12	The hybrid group	Extensionista to whom the communities asked for support to manage vicuñas
16	13	The private company	Representative of Loro Piana in Latin America
17	14	The private company	Representative of the private company in Argentina
18	15	The hybrid group	Field research coordinator at INTA in Jujuy, expert involved in the hybrid group on the commercialization of vicuña fiber

Appendix D - Evolution in the number of shearing operations, sheared vicuñas, and volumes of fiber collected by the hybrid group since 2014.

Year	2014	2015	2016	2017	2018	2019	2021
Estimated number of vicuñas (thousands of indiv)	147	166	188	212	240	271	346
Number of participating communities	4	5	5	9	9	12	16
Number of <i>chakus</i>	3	5	9	24	19	21	28
Number of captured vicuñas	556	765	810	1813	2530	3600	4426
Number of vicuñas shorn	213	488	546	1404	1729	2475	3392
Kg of collected fiber annually	40	116	139	316	394	554	784
Estimated proportion of vicuñas shorn (%)	0.14	0.29	0.29	0.66	0.72	0.91	0.98

Source : Cowan Ros et al. (2020)

Appendix E: Evolution in the number of chakus and volume of fiber collected by the Cooperativa La Mesa Local Ltd. since 2008

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2021
Estimated number of vicuñas (millions of indiv)	32	36	41	46	52	58	66	75	84	155
Number of <i>chakus</i>	1	1	1	2	2	2	5	5	3	8
Kg of collected fiber	16.1	30.8	24.6	27.6	30.3	80.5	69.7	174.3	82.8	260.0
Estimated number of vicuñas shorn ¹	41	79	63	70	77	205	178	445	211	663
Estimated proportion of vicuñas shorn	0.13	0.22	0.16	0.15	0.15	0.35	0.27	0.6	0.25	0.43

Source : Castilla et al. (2021) ; Member of the cooperative comisión (interview 29/07/2022)

¹ With an average of fiber collected per vicuña of 0,392 kg (Rigalt, 2019)

Appendix F: Estimated evolution in the number of chakus and volume of fiber collected by the private firm since 2008

	<u>The private firm</u>														
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Estimated number of vicunas in the company's territory	3 597	4 065	4 593	5 190	5 865	6 627	7 489	8 462	9 562	10 806	12 210	13 798	15 591	17 618	19 909
Estimated amount of fiber collected	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
Estimated number of vicuñas shorn	233	465	698	930	1163	1395	1628	1860	2093	2326	2558	2791	3023	3256	3488
Estimated proportion of vicunas shorn	6%	11%	15%	18%	20%	21%	22%	22%	22%	22%	21%	20%	19%	18%	18%

Assuming an increase in amounts of fiber collected of 100kg per year, 1500g of collected fiber for 2022, and an average of 0.430kg of fiber collected per vicuña (interview of the representative of the private firm, 08/07/2022)

Appendix G - Synthesis of the forms of coevolution for each case study

	<i>The hybrid group</i>			<i>The cooperative</i>			<i>The private firm</i>		
	Preparation stage	Transition stage	Consolidation stage	Preparation stage	Transition stage	Consolidation stage	Preparation stage	Transition stage	Consolidation stage
Ecological change	Vicuña is no longer a harmful species but an endangered species	Vicuña is an endangered species and an economic opportunity		Vicuña is a harmful species competing with domestic livestock	Vicuña can be an opportunity to improve livelihoods	Vicuña is an opportunity to show the world the indigenous culture	Vicuña is an endangered species and an economic opportunity		
	Continuous observation of the vicuña population						Continuous control of the territory to limit poaching and regular control of Vicuña's health		
Technical/ Knowledge change	Raising awareness on vicuña's status and putting priority to ecological conservation	Acquisition of business skills such as negotiation	Handling a wider scope of activities, such as export logistics and export administration	Organizing training on marketing, technical handling, and conservation issues	Learning the practical necessary administrative skills to be legally compliant with the requirements linked to cooperative status	Developing managerial competencies to launch new projects and activities' diversification proactively	Optimizing capture and shearing processes from their existing activities in Patagonia	Transferring the optimized processes to the local employees	Copying the optimized processes by the local employees for the <i>chakus</i> they organize with their communities

Values	Following self-governance principles after disappointing cooperative experiences	Experiencing limits of self-governance with communities demanding the presence of experts in support of negotiations	Keeping enough flexibility to seize unexpected opportunities, such as direct sales to Loro Piana	Discouragement following disappointing cooperative experiences that didn't last	Mobilizing a collective approach involving every associate	Overcoming the former worldview that the community cannot manage cooperative in the long run	Optimizing profits without limiting the freedom of movement of the animals	Optimizing profits without limiting the freedom of movement of the animals	Optimizing profits without limiting the freedom of movement of the animals
Institutional change	Mobilizing a team of experts affiliated with public institutions but without a dedicated budget line	Limited connections with external institutions, mostly relying on the experts' existing network	Expanding interactions with external organizations and involvement in collective choice rules	Increasing access to external institutions	Mobilizing individual interactions between the direction of the cooperative and community members	Involvement in institutions through political representation	Limiting interactions with external actors to compliance	Seizing tax reduction opportunity to create local jobs	Developing interactions with local communities beyond job creation but limited to equipment or monetary loans
Social organization	Engaging the whole community through formal "actas de aceptación social"	Securing the possibility of a dialogue between the community and the trade organization	Limit direct interactions with the <i>vicuñeros</i> members of the communities	Stimulating participation and collective discussions	Emergence of few trained leaders who take on the cooperative administrative recovery	Opening of diversified activities, collective empowerment limiting competition of	Disconnecting the private firm from the social organization	Interactions with the communities through job creation	Providing access to the industry through equipment and monetary

	Appointing mediators between the trade organization and the rest of the community			Attracting development projects		the touristic facilities offer			loans
Productive organization	Facilitating the decision-making process through intertwined social and productive organization	Interdependencies between communities are limited to the capture and shearing of vicuñas	Widening the scope of interdependencies to the redistribution of revenues	Production starts in parallel with training	Production is stopped	Production is decorrelated from extraction	Optimized processes with ecological monitoring but isolated from the social territory	Optimized processes with ecological monitoring	Finding additional but marginal sources of fiber supply through strategic associations with local communities
	Pooling resources	Using the legal form of the indigenous community to market fiber	Engaging in institutional bricolage to adapt the legal form of the trade organization						

APPENDICES CHAPTER 3

Appendix H - Brief description of MNEs surveyed

Firm	Sales revenues (billion euros)	Industrial sector	Number of employees	Number of operating countries
A	3.6	Pharmaceutical	13000	150
B	37.7	Food	321000	30
C	38.2	Banking	145000	90
D	27.7	Food	100000	120
E	143	Energy	165000	17
F	0.3	Fashion	6178	55
G	0.6	Real Estate	498	1
H	20.4	Luxury	47227	N.A.
I	29	Automobile	132000	175
J	9.5	Automobile	32000	131
K	94	Energy	9586	50
L	19.7	Investment banking	3500	30
N	7.7	Transportations	83000	20
O	2.4	Cosmetics	16000	114
P	30.7	Environmental services	174000	77
Q	5	Energy	96454	31

APPENDICES CHAPTER 4

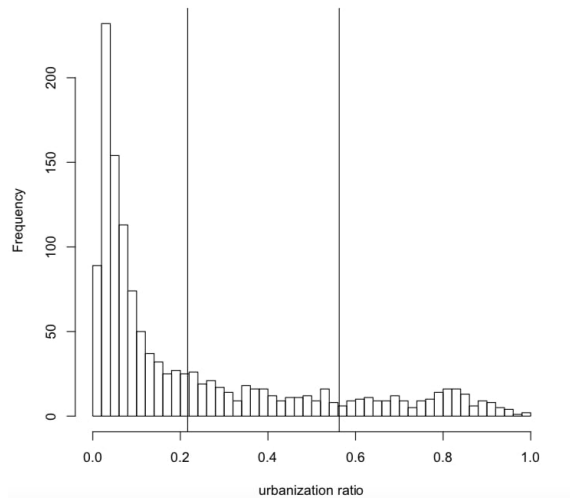
Appendix I - Composition of IDEFESE focus groups

Institution type	Institution	Department (number of interviewees)
<i>Administration</i>		
Ministry	French ministry of the environment	General commission of the sustainable development (3) General direction of planning, housing and nature (2) Urban planning, construction, development (1)
Decentralized state services	Interdepartmental regional directorate for equipment and planning (DRIEA)	Development and land planning department (2) Urban planning documents office (1) Service of knowledge and prospective studies (1)
	Interdepartmental regional directorate of food agriculture and forest (DRIAAF)	Commission of preservation of natural, agricultural and forest areas (1) Regional service of forest, wood and biomass (2)
	Departmental directorate of territories (DDT)	Planning department (2) Urban planning and regulations department (1)
Local authorities	Region Metropolis Municipality	Region Ile de France advisor (1) "Grand Paris" advisor (2) Paris city advisor (1) City council (2) Urban planning department (1)
Regional assembly	Social and environmental economic advice (CESER)	Committee on Spatial Planning and Employment (2)
<i>Agencies</i>	Institute of urban planning	Department of Urban and Rural Environment (1) Planning Mission (1) Project managers (2)
	Natural park office	Director (1)
	National forest office Environment and Energy Management Agency Regional agency of biodiversity National agency for biodiversity French agency for development	Project manager (1) Project manager (1) Project managers (2) Project managers (1) Project managers (1)
<i>Groups</i>	Chambers of agriculture Public interest group for forests	Project manager (1) Director (1)
<i>Developers</i>	Local planning and development authority Consulting agency	General directorate (1) Parisian agency (1)
<i>NGOs</i>	France Nature Environnement Terres de liens European river network	Departmental federations (8) Project manager (2) Project manager (1)
<i>Think tanks and scientific institutions</i>	AgroParisTech Météo-France IDDRI	Ecology (1) Urban climatology (2) Political sciences (1)

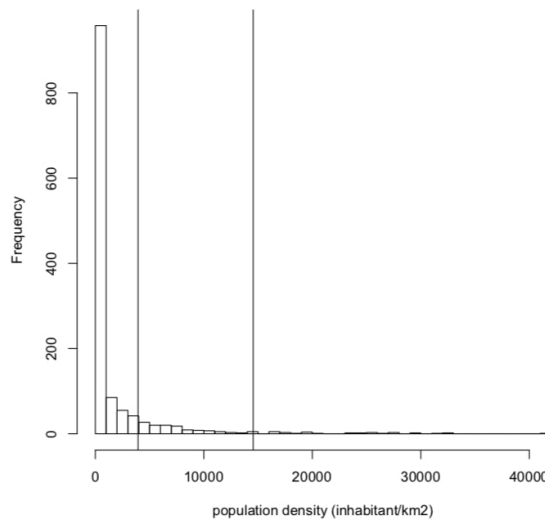
Appendix J - Transportation time depending on transportation mode to travel a fixed distance

Distance trip (km)	Trip departure/Trip destination	Travel-time by car (min without traffic jam - min with traffic jam)	Travel time by public transport (min)	Travel time by bike (min)	Travel time by foot (min)
2.6	Paris/Paris	10 - 15	20	15	30
10	Paris/Little crown	30 - 70	25	35	120
15	Paris/Little crown	35 - 70	40	45	N.A.
20	Paris/Big crown	35 - 60	30	50 (with electric assistance)	N.A.
30	Paris/Big crown	40 - 90	45	90 (with electric assistance)	N.A.
50	Paris/Big crown	40- 110	30	N.A.	N.A.

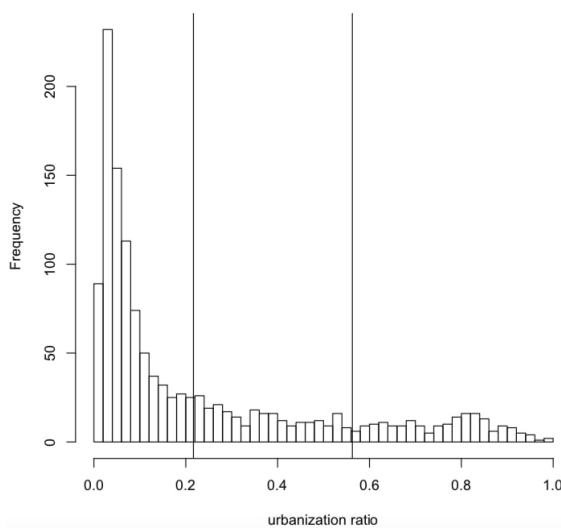
Appendix K - Jenks class results for clustering municipalities



(a) Clusters of municipalities according to their urbanization ratio



(b) Clusters of municipalities according to their population density



(c) Clusters of municipalities according to their urbanization ratio

Appendix L - Mixed logit results with minimum and maximum WTA

	Woodland	Water	Size	Bike	Public transport or Car	Reach a UGS by foot	Stay at home
Average WTT	18 min	4 min	1 min 20	- 2 min	- 3 min 30	5 min 30	- 48 min
Minimum WTT	4 min 30	- 1 min	1 min	- 13 min	- 18 min	-31 min	- 75 min
Maximum WTT	34 min	8 min 30	2 min	6 min	11 min	17 min	24 min

Appendix M - Mixed logit results with interactions

Variables	Mean	SD
Shape	-0.851 (0.607)	1.236 (1.107)
Water	5.873*** (0.815)	-5.949*** (1.017)
Size	1.871*** (0.633)	-0.127 (1.597)
Woodland	31.39*** (3.604)	23.85*** (2.486)
Forest	-1.965 (1.581)	3.144 (2.096)
Bike	-3.470*** (1.108)	8.822*** (1.537)
Car or Public Transport	-6.784*** (1.260)	-15.40*** (1.578)
ASC	-83.78*** (7.949)	-22.40*** (4.697)
ASC*urb_high	12.11** (6.038)	-13.46* (7.302)
ASC*garden	9.544** (4.312)	-18.04*** (6.483)
ASC*children	-4.699 (3.657)	27.14*** (8.183)
ASC*income_sup2000	8.889 (6.021)	-40.02*** (6.085)
ASC*higher_education	-8.080 (6.151)	-12.91* (6.780)
ASC*rent_high	11.08* (6.129)	-9.947* (5.941)
time	-3.268*** (0.0665)	0.0667 (0.0959)

Standard errors in parentheses

*** p0.01, ** p0.05, * p0.1

Appendix N - Questionnaire exemple

Questionnaire on green spaces in Ile-de-France

Hello,

We are conducting a survey in Ile-de-France to better understand people’s preferences concerning green spaces (parks, forests, riverbanks, etc.) in Ile-de-France.

Would you please have a few minutes to answer the questionnaire? (10 minutes maximum)

The questionnaire is **anonymous**.

Only persons over 18 years-old are allowed to answer

Profile

1) What is your place of residence?

CITY	POSTAL CODE
_____	_____

2) Are you a man or a woman?

- Man Woman

3) How old are you?

- 18 – 29 years-old
 45 – 59 years-old
 75 years-old and older
 30 – 44 years-old
 60 – 74 years-old

4) What is your socio-professional category?

- Farmer
- Craftsman, Retailer, Entrepreneur
- Managerial and higher-education profession
- Intermediate profession
- Employee
- Worker
- Retiree
- Other without professional activity







5) How many adults and children (without age limit) constitute your household ?







ADULT(S)	CHILD/CHILDREN (if any)
_____	_____

Choice experiment

For your next visit, what would be your favourite green space among the 3 alternatives suggested?







If your answer involves « Car or Public Transport », circle which one you would rather take.







Green space attributes	Alternative 1	Alternative 2	Status quo
Forest cover			I choose neither of both green spaces
Shape			
Presence of a water body			
Size	Large* / Long*	Small** / Short**	
Transport mode	Biking / Trotinette	By foot	
Transportation time	5 min	30 min	
Choice			







Green space attributes	Alternative 1	Alternative 2	Status quo
Forest cover			I choose neither of both green spaces
Shape			
Presence of a water body			
Size	Small** / Short**	Large* / Long*	
Transport mode	Biking / Trotinette	Public Transport/Car	
Transportation time	5 min	30 min	
Choice			







***Large/Long**: corresponds to a green space larger than 1.5ha (100x150m) or longer than 1.5 km







****Small/Short** : corresponds to a green space smaller than 1.5ha (100x150m) or shorter than 1.5 km







Green space attributes	Alternative 1	Alternative 2	Status quo	
Forest cover				
Shape				
Presence of a water body			I choose neither of both green spaces	
Size	Large* / Long*	Small** / Short**		
Transport mode	By foot	Biking / Trotinette		
Transportation time	10 min	20 min		
Choice				3







Green space attributes	Alternative 1	Alternative 2	Status quo	
Forest cover				
Shape			I choose neither of both green spaces	
Presence of a water body				
Size	Small** / Short**	Large* / Long*		
Transport mode	By foot	Public Transport/Car		
Transportation time	20 min	10 min		
Choice				4







Green space attributes	Alternative 1	Alternative 2	Status quo	
Forest cover				
Shape			I choose neither of both green spaces	
Presence of a water body				
Size	Small** / Short**	Large* / Long*		
Transport mode	Public Transport/Car	Biking / Trotinette		
Transportation time	30 min	5 min		
Choice				5







Green space attributes	Alternative 1	Alternative 2	Status quo
Forest cover			
Shape			
Presence of a water body			
Size	Small** / Short**	Large* / Long*	I choose neither of both green spaces
Transport mode	By foot	Biking / Trotinette	
Transportation time	10 min	20 min	
Choice			







Green space attributes	Alternative 1	Alternative 2	Status quo
Forest cover			
Shape			
Presence of a water body			
Size	Small** / Short**	Large* / Long*	I choose neither of both green spaces
Transport mode	Public Transport/Car	By foot	
Transportation time	10 min	20 min	
Choice			

Green space attributes	Alternative 1	Alternative 2	Status quo
Forest cover			
Shape			
Presence of a water body			
Size	Large* / Long*	Small** / Short**	I choose neither of both green spaces
Transport mode	Public Transport/Car	Biking / Trotinette	
Transportation time	5 min	30 min	
Choice			

Green space attributes	Alternative 1	Alternative 2	Status quo
Forest cover			
Shape			
Presence of a water body			
Size	Large* / Long*	Small** / Short**	I choose neither of both green spaces
Transport mode	Biking / Trotinette	Public Transport/Car	
Transportation time	30 min	5 min	
Choice			

Green space attributes	Alternative 1	Alternative 2	Status quo
Forest cover			
Shape			
Presence of a water body			
Size	Large* / Long*	Small** / Short**	I choose neither of both green spaces
Transport mode	By foot	Public Transport/Car	
Transportation time	20 min	10 min	
Choice			

Green space attributes	Alternative 1	Alternative 2	Status quo
Forest cover			
Shape			
Presence of a water body			
Size	Small** / Short**	Large* / Long*	I choose neither of both green spaces
Transport mode	Biking / Trotinette	By foot	
Transportation time	20 min	10 min	
Choice			

Green space attributes	Alternative 1	Alternative 2	Status quo
Forest cover			
Shape			
Presence of a water body			
Size	Large* / Long*	Small** / Short**	I choose neither of both green spaces
Transport mode	Public Transport/Car	By foot	
Transportation time	30 min	5 min	
Choice			12

Have you systematically omitted one or several attribute(s) in the choices you had to make? If yes, which one?

Respondent's type

1) **How many times have you been to a green space (park, forest, riverbank, garden...) last year (March 2018 to March 2019)?**

-
-

2) **What is the name of the green space you visited the most last year (March 2018 to March 2019)?**

3) **What activities do you usually do when going to a green space? (Rank from 1 to 3)**

- | | |
|---|--|
| <input type="checkbox"/> Walk the dog | <input type="checkbox"/> Fishing / Hunting |
| <input type="checkbox"/> Practice sports | <input type="checkbox"/> Have a picnic |
| <input type="checkbox"/> Cool-off | <input type="checkbox"/> Relax |
| <input type="checkbox"/> Enjoy kids' facilities | <input type="checkbox"/> Walk |
| <input type="checkbox"/> Observe nature | <input type="checkbox"/> Other: |

4) **How long do you stay in average in a green space?**

5) **How long it took you to go to a green space, in average, last year (March 2018 to March 2019)?**

6) **What facilities do you prefer when going to a green space?**

7) What is the highest diploma you obtained?

- None, French Certificate of general Education
- Certificate of professional competence or Higher technical certificate
- Baccalaureate (general, technological or professional)
- Higher education diploma

Interview

Place of the interview:

Date and hour :

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