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China's environmental journey: the role of the Green BRI, circular economy and waste management in sustainable development

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前言

“一带一路” 是 “丝绸之路经济带” 和 “21 世纪海上丝绸之路” 的简称，该倡议于

2013 年正式出台，旨在借用古代丝绸之路的历史符号，充分依靠中国与有关国家既有的双多边机制，借助既有的、行之有效的区域合作平台，积极发展与沿线国家的经济合作伙伴关系。

据官方统计，2016 年，中国对“一带一路”沿线 53 个国家直接投资 145.3 亿美元. 现在“一带一路”的简称包括七十一国家; 这就是说“一带一路”倡议目前涵盖 44 亿人口，相当于全球人口的 62.3%，覆盖全球 GDP 的 30%。

“一带一路” 倡议以基础设施建设为基础，旨在促进成员国之间更快速、更便捷的经济与文化交流。鉴于该倡议能刺激外国投资、促进经济增长并增加能源消耗， “一带一路” 倡议开始引发人们对其可能造成的环境破坏的担忧。这是因为中国政府 2015 年决定了启动所谓的 “绿色带路” 倡议。更具体地说，中国国家国防和改革委员会 2015 年发布的《 “一带一路” 行动计划》指出： “应着力推进绿色低碳的基础设施建设与运营管理，充分考虑气候变化对建设的影响” 。

“绿色带路” 的最重要原因就是:

- 可持续发展与声誉维护. 这就是中国政府希望回应国际舆论的指责与关切，并确认中国作为全球最强商业力量之一的地位，捍卫其国际声誉;
- 认知与正当性:中国决定在“绿色带路”中纳入可持续发展目标 (SDGs) 就是因为这些目标更容易被国际舆论所认可;
- 民族认同: 这个倡议给中国政府提供传播中国思想和宣传中国意识形态的机会，在全世界强化中国民族认同感;
- “处理事情”: 中国政府明白了国际社会的疑虑与担忧可能阻碍国际投资流动和政治合作。

中国共产党还利用“一带一路”倡议传播生态文明理念。该理念将人类与自然视为同一系统的组成部分，认为自然具有价值，而非可供开发的资源。

这为实现从化石能源经济向可再生能源经济的转型提供了契机，正如《一带一路倡议白皮书》所指出的，该项目还致力于加强国际合作，共同开发水能、风能和太阳能，

从而获得低碳排放的能源来源。二零二一年，习近平提出了“无煤承诺”，这为使用可再生能源的企业带来了巨大机遇。在中国的经济转型背景下，该国正从以煤炭为基础的线性经济转向循环经济。

此外“一带一路”正在使用中国的最新技术为提高联系很远的国家的方法。

绿色发展的理念在于，既能改善环境，又能促进经济发展和基础设施建设。

“绿色带路” 的项目在具体层面是怎样推进的？这个倡议包括三个范围：绿色金融、绿色能源、绿色合作。

第一个是绿色金融。在绿色证券的发行和贷款政策的制定方面，中国处于国际领先地位。绝大多数绿色债券绝大多数绿色债券旨在服务于国内市场和证券交易所，为低碳交通项目或防污染系统提供资金。中国也发行离岸债券， 为国内和海外基础设施项目提供融资。

中国银行业监督管理委员会还颁布了绿色信贷指引，其中具体条款要求金融机构遵守当地环境法规、采用国际最佳实践，并利用第三方社会与环境影响评估。这些指引被用于为基础设施建设提供融资。然而，绿色信贷准则的实施存在一些问题；这些准则往往被忽视。此外，中国贷款机构与东道国非政府利益相关方的沟通与合作甚少。

第二个是绿色能源。中国无疑是绿色可再生能源制造与推广领域的全球领导者。例如，2009 年至 2018 年间，该国新增国内可再生能源装机容量达 497 吉瓦。

谈及中国政府颁布的实际法律，2006 年颁布了首部《能源法》，并于 2009 年 12 月 26 日进行了修订。可是，正如中国政府后来承认的那样，水电能源并非人们所认为的那样环保，我们所能做的只是减轻其环境危害，而非将其视为绿色能源。2025 年 1 月 1 日，《中华人民共和国能源法》新修订版正式颁布。这项新法规是对近期可再生能源领域工作的更新，其重点更侧重于二氧化碳排放而非能源消耗管控。此外，该法律着眼于市场动态，致力于构建统一的能源市场体系。

第三个就是绿色合作极制。绿色合作机制涵盖从政策层面的协作到技术转让等多种形式，但都基于一个核心理念：中国机构能够也应当与“一带一路”沿线国家共享环境知识与专业技术。确实，截至 2020 年 11 月，中国已与 138 个国家和 31 个国际组织签署 201 份“一带一路”合作文件。这些绿色合作机制为众多基础设施建设提供了助力，包括滇缅经济走廊、澜沧江-湄公河经济带以及中国-中亚-西亚经济走廊等各类经济走廊。

国际社会对“一带一路”倡议的提出和实施作出了怎样的反应？

在国际舆论中，既有支持“绿色一带一路”的观点，也有反对的声音。泰国，柬埔寨，另一些国家觉得可以在“一带一路”的经验中学习; 可是，西方国家和舆论针对“绿色一带一路”项目提出了各种议题。第一个是中国价值观被视为共产主义和宣传性的。所以他们觉得“绿色一带一路”就是一个口号，而没有法定执行权。 第二个问题是中国”绿色法律”在一带一路别的国家常常不适用;这是因为中国政府只在中国边界内拥有权威和政治权力。最重要的是西方国家强调一些“一带一路” 的一些项目更偏向”棕色” 而非” 绿色” ，因为环境影响报告 (EIAs Environmental Impact Assessment) 的要求常常被忽视。事实上，自 2000 年以来，中国单独或与第三国合作，已在越南、马来西亚、柬埔寨和老挝等东南亚多国启动了水坝、铁路网络及其他基础设施的建设。越南凭借其高度发达且极具吸引力的环保政策，在未来绿色投资领域展现出巨大潜力。

那么，“绿色带路”的未来会如何？新冠疫情放缓了“一带一路” 倡议的推进步伐，各国将注意力转向应对卫生和经济危机，导致全球环境治理决策出现延迟。尽管如此，BRI 仍需应对参与国绿色发展水平参差不齐的问题——这些国家多为新兴经济体，其经济增长优先级往往高于环境保护。为确保可持续未来并提升成效，建立稳定的国际框架至关重要，该框架需协调经济与环境发展，并汇聚政府、企业及公共利益相关方力量。此外，需要加强国际研究和思想交流，国际金融论坛等机构可发挥关键作用，促进亚太地区的绿色融资和创新，从而推动更公平、更有效的合作，实现“一带一路”沿线的绿色发展。

“一带一路” 倡议是迄今为止规模最大的基础设施建设项目，涉及数十个国家，动员了庞大的资金、贸易与投资流动。除了带来巨大的经济机遇，这一倡议同时也对环境产生了深远影响。基础设施和金融发展的推动直接影响二氧化碳排放以及环境质量。经济增长与环境退化之间的关系长期以来备受争议：一方面，发展往往导致能源消费和污染增加；另一方面，更高的收入水平也可能推动采用更高效、更清洁的技术。这一争论反映在环境库兹涅茨曲线理论中，该理论认为在经济发展的早期阶段污染会增加，而在收入达到某一转折点后污染会逐渐减少。然而，在“一带一路”沿线国家，

研究结果并不一致：有些国家符合这一趋势，有些国家却表现出排放量随经济增长持续上升的情况。

“一带一路” 所推动的贸易与投资还带来了 “隐含碳” 转移，即碳排放在商品生产过程中产生，但随商品出口而 “转移” 到他国消费。中国、南亚和东南亚是主要的净碳出口地区，而发达国家则通过进口消耗了这些产品，却将环境代价转嫁给新兴经济体。这一现象被称为 “碳泄漏” ，显示了全球化如何将环境压力转移到生产国，而消费国则承担较少责任。

除气候问题外，生物多样性也受到严重威胁。道路、铁路、港口、水坝和管道等大型基础设施项目往往穿越生态价值极高的地区，造成栖息地碎片化、野生动物死亡率上升、污染和外来物种扩散。同时，大量开采水泥、砂石和化石燃料等原材料，以及在地质脆弱地区建设通道，进一步加剧了环境和社会风险。

为应对这些影响，需要从法律与实践两个层面采取措施。在法律层面，环境与社会影响评估（EIA 与 SESA）至关重要，不应仅流于形式，而应真正成为预防和规划工具，并在跨国合作框架下实施，涵盖政府、金融机构、企业、非政府组织和当地社区。在实践层面，必须大力推动可再生能源投资，强化国际合作（如“一带一路”绿色发展国际联盟），并加大科研投入，包括利用卫星监测等数字技术。

循环经济也是提升“一带一路”可持续性的关键。其目标是摆脱“开采—生产—废弃”的线性模式，转向 “减少—再用—再循环”的闭环模式。近年来，中国出台了大量相关政策，建立了生态工业园区，推动技术创新，在资源效率和减排方面取得了显著成效。然而，政策在不同地区的执行效果差异较大，缺乏市场化工具，也影响了整体的协调性和力度。

总体而言，“一带一路”既是全球经济增长与合作的重要机遇，也是环境保护面临的巨大挑战。其未来能否真正实现可持续发展，取决于各方能否将绿色理念切实融入项目之中，通过严格的政策、先进的技术与广泛的国际合作，找到经济增长与环境保护之间的平衡点。

在中国这样一个经济快速增长、城市化进程加快的国家，废物管理成为最紧迫的环境挑战之一。废物管理包括收集、运输、处理、回收和处置等过程，其目标不仅是减少污染和健康风险，更是推动向循环经济转型，使废弃物成为新的资源。塑料及其衍生的微塑料问题尤为突出，因为难以降解、长期残留在环境中，这也促使中国政府出台了越来越严格的管理规定。

自 1995 年以来，中国逐步建立了较为完善的法规体系，并在 2017 年通过全面禁止进口消费后塑料废物的政策，掀起了全球性的连锁反应。此举重塑了国际塑料废物流动，迫使主要出口国（如美国和日本）寻找国内解决方案。在国内，这一禁令则推动了更加可持续的转型，与“生态文明”理念保持一致。

在政策之外，中国也大力发展废物能源化（Waste-to-Energy，简称 WTE）等创新方式，将城市固体废弃物转化为电能或热能，大幅减少进入填埋场的废弃物量。该领域得到政府强有力支持，包括财政补贴、税收优惠和巨额公共投资。在过去二十年里，WTE 设施在中国快速扩张，使其成为全球装机容量最大的国家。

在企业层面，Visottica 集团的案例展示了企业如何在实践中实现可持续管理。该集团推出了“Visible Journey” 项目，将循环经济理念应用于生产和包装，逐步替换传统材料为可回收和认证材料，提升废物追溯体系，并在能源与水资源使用方面提高效率。位于东莞的工厂严格记录和管理固体废弃物，与合格供应商合作，并推动材料再利用。同时，该工厂还投资于减少排放、循环利用工业用水以及设备翻新，以延长机器寿命。这些努力已获得当地政府认可，使企业成为中国废物管理的优秀典范。

为了更全面地了解地方实践，还在广东省开展了一项针对 15 家企业的调查。结果显示，企业对可持续发展的关注度不断提高：大多数企业采取了减少生产废料和包装废弃物的措施，并回收部分原材料，约 40%的企业表示会循环利用工业用水。然而，获得国际认证的材料（如 GRS 或 FSC）的使用仍然有限，显示未来改进空间较大。值得肯定的是，超过一半的企业已发布或正在编制可持续发展报告，反映出在透明度和责任感方面的意识正在增强。

在国际层面，中国不仅在国内推动废物管理体系改革，也通过“绿色丝绸之路”将实践和投资输出到东南亚国家，支持废物管理和能源化项目。尽管面临不同国家法规和基础设施差异的挑战，这一进程仍有助于沿“一带一路”推广更高的环境标准。

总体来看，中国的废物管理正处于经济发展、环境保护与技术创新的交汇点。国家政策、企业实践和国际合作表明，尽管挑战依然复杂，但构建更加可持续的发展模式已具备了切实的机遇。

Abstract

China's economy is now among the top three in the world in terms of nominal GDP, reflecting the country's rapid industrialization and modernization over recent decades. In 2013, the Chinese government officially launched the Belt and Road Initiative (BRI), a strategic infrastructure development project aimed at improving trade connections between China and numerous Eurasian countries through six land and maritime economic corridors. As of today, 152 nations have joined the initiative, with the goal of boosting trade, attracting foreign investment, and expanding China's export flows. However, the environmental impact of the BRI and its repercussions on local ecosystems have raised increasing international concern. This thesis aims to analyse the main strategies adopted by China to address these environmental challenges, focusing on three key areas: the launch of the Green Belt and Road Initiative in 2015, the promotion of the circular economy, and the waste management system. The analysis draws on academic literature, official documents, and websites of international organizations. Finally, a qualitative interview was conducted with a group of Chinese companies from Guangdong Province on the topics of industrial waste management and sustainable development, to integrate the research with first-hand insights. The findings provide an understanding of the challenges and opportunities related to the implementation of the Green BRI, highlighting how the circular economy and more efficient waste management can contribute to sustainable development. These insights can support policymakers and businesses in defining more responsible and innovative strategies to mitigate the environmental impact of the Green BRI.

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Chapter 1: The Green Belt and Road Initiative

1.1 The reasons why China launched the Green BRI

1.1.1 The Belt and Road Initiative

The starting point to explain and understand why China launched the Green Belt and Road Initiative (BRI) in 2015 is the definition of the BRI itself.

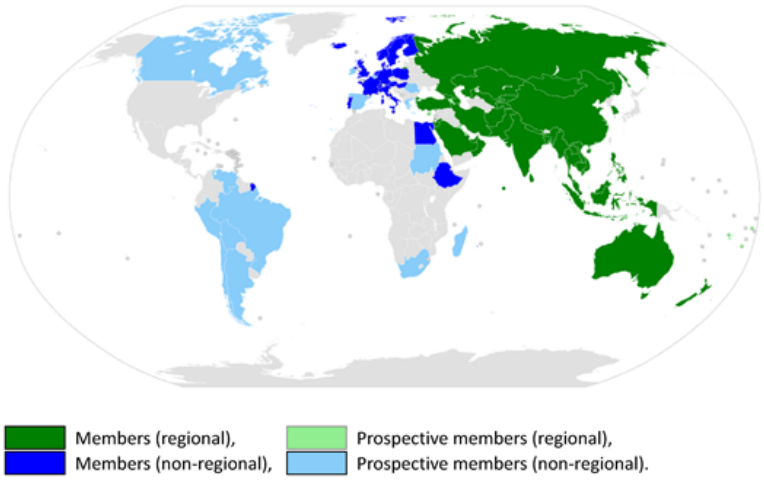
The Belt and Road Initiative, also known in China as the "One Belt One Road", is a global infrastructure development strategy, launched by the Chinese government in 2013 to invest in more than 138 countries. The project was in fact first announced in 2013 as the "Silk Road Economic Belt" through Central Asia, and "21st Century Maritime Silk Road" in South and Southeast Asia, the BRI later officially expanded to include Africa, Latin America, and the Pacific; "The BRI is composed of six urban development land corridors linked by road, rail, energy, and digital infrastructure and the Maritime Silk Road linked by the development of ports" (Harlan T. , 2020, p. 204); the BRI is both a geopolitical and geo-economic project. The endeavour has so far developed several infrastructure corridors that include 60 countries in multiple regions, mostly in Asia, Europe, Oceania, and East Africa.

"The six main economic corridors are:

- the new Eurasian Land Bridge;
- the China–Mongolia–Russia Corridor;
- the China–Central Asia–West Asia Corridor;
- the China–Indochina Peninsula Corridor;
- the China–Pakistan Economic Corridor (CPEC)".

(Cheshmehzangi, Xie, & Tan-Mullins, 2021, p. 50)

Figure 1. BRI members and prospective members as of 2020



Source: (Cheshmehzangi, Xie, & Tan-Mullins, 2021)

According to the National Development and Reform Commission (NDRC) in March 2015 the Ministry of Foreign Affairs and the Ministry of Commerce (MOFCOM), with approval from the State Council departments, jointly released the "Vision and Action", a more specific action plan for the implementation of the BRI, which stated the aim to "link Asia, Europe and Africa through five routes" (Abdul Sattar M. N., 2022).
The BRI currently encompasses 4.4 billion people, which corresponds to 62,3% of the global population and covers 30% of the global GDP (Shah Saud S. C., 2018).

1.1.2 The Green BRI

As a consequence of the overall good results achieved by the BRI project, in 2015 China launched the Green BRI project, which represents a Chinese environmental campaign aiming to support BRI's green development, to enhance China's global green leadership, to implement the Paris Agreement, and to promote United Nation's 2030 Sustainable Development Goals (SDGs). In 2017 it was formalized by China's government through a series of norms, tools, mechanisms and platforms (Cheshmehzangi, Xie, & Tan-Mullins, 2021). More specifically, the "Belt and Road Action Plan" released by China in 2015 states that "efforts should be made to promote green and low-carbon infrastructure construction and operation management, taking into full account the impact of climate change on the construction" (PRC's NDRC, 2015).

Essentially, the green BRI aims to support, serve and secure high-quality Belt and Road cooperation through green development. In other words, guided by the philosophy of ecological civilization and green development, the Green BRI will enhance the green level of policy coordination, infrastructure connectivity, unimpeded trade, financial integration and closer people-to-people ties, while it will also integrate ecological conservation and environmental protection into all aspects and throughout the whole process of the initiative. In terms of its objectives, the green BRI facilitates international cooperation in ecological conservation, environmental protection and green development, and it aims to bring global governance in line with the vision of a community with a shared future for mankind (Yu Hongyuan, 2021).

In this chapter I will investigate the reasons why China introduced the Green Belt and Road Initiative, the main policies undertaken from 2015 onwards and what are the main actors in the implementation of the project.

Noteworthy, in 2015 195 countries adopted the 2030 UN Agenda for Sustainable Development. The Agenda is also called Sustainable Development Goals (SDGs) and aims to achieve sustainability on 3 pillars: the economy, the society and the environment (Cheshmehzangi, Xie, & Tan-Mullins, 2021).
"To support developing countries in achieving the SDGs, Chinese President Xi Jinping launched a South-South Cooperation Assistance Fund in 2015, whose capital he increased at the second international BRI summit in 2017. Notably, the Chinese State promotes the Green BRI as an undertaking that incorporates the SDGs, helping to garner global legitimacy for the policy while attempting to facilitate their achievement, too" (Xiaofeng Liu, 2023, p. 238). This has the objective to integrate China into the global environmental governance system (Yu Hongyuan, 2021).

There are a series of reasons behind the promotion and introduction of the Green BRI, and for incorporating the SDGs into the Green BRI project. These mainly are:

- Sustainability and reputation: in order to avoid criticism and concern raised by negative environmental and social impacts of BRI infrastructure projects the Chinese government has launched the Green BRI project (Xiaofeng Liu, 2023). More and more

nations, in fact, are criticizing the negative effects of the massive projects carried out within the framework of the Green BRI. One employee of a MEE agency for Green BRI affairs expressed: "There are some negative environmental impacts of the BRI and some projects meet local protests and obstructions, so we are keeping an eye on the media and public opinions and reporting them to higher-level authorities" ((Gov02, May 15, 2021) (Xiaofeng Liu, 2023, p. 241)). In other words, "greening the Initiative is a response to negative Western media coverage of the environmental impacts of Chinese outbound investments, which are seen to be damaging China's reputation" (Harlan T. , 2020, p. 5);

- Awareness and legitimacy: since the Western-originated concept, namely SDGs, offers an entry point for connecting with the international community "When we are talking to foreigners, they may not know the Green BRI, but all of them know the SDGs. So, if we aim to 'go out', we need to know the SDGs more and use them to seek things in common with them" ((SemAca07, September 27, 2020) (Xiaofeng Liu, 2023, p. 242));
- National identity: the Chinese government has hosted to BRI international fora respectively in 2017 and 2019, proposing "green" rhetoric and official announcements, providing a discursive window into how the Chinese ministries interpret green development and prioritize green policies and projects launched through the BRI; this indicates how the Chinese government seeks to present the Green BRI as an alternative to a Western model of development (Harlan T. , 2020);
- *"*To fine-tune things*"*, meaning that the Chinese Government has recognized the environmental risks brought about by the BRI implementation and understood these could impede further investments and political cooperation, and has consequently taken a series of actions to improve the environmental quality of BRI's infrastructures and actions, as I will further explore in chapter 2; this is one of the reasons why the "Green BRI" has been launched in 2015 (Harlan T. , 2020).

1.1.3 The Green BRI ideological and practical opportunities

So, thanks to its connection with the SDGs, the Green BRI becomes a way to export domestic ecological norms, holding the potential for global upscaling. China considers it a means to expand its environmental governance from its sovereign territory to extraterritorial spaces

where it lacks coercive power, namely BRI partner countries. In particular, advancing the Green BRI can help share two main ideas and practices originated in China: sustainable development and eco-civilization.

Sustainable development is defined as "meeting the current generation's needs without undermining future generations' ability to meet theirs" (Brundtland, 1987).
Eco-civilization, on the other hand, is defined as "a combination of political and ideological undertakings, from intervening in the urban environment within China (Pow, 2018) to the country positioning itself as the rightful successor to industrial civilization as opposed to capitalism" (Gare, 2012).
The key difference between the two concepts is that the first considers humans and nature as separate. In contrast, the Chinese concept of eco-civilisation (生态文明 shengtai wenming), officially promoted by the Chinese Communist Party, is more holistic and ecocentric. It emphasises the harmonious unity between humans and nature, arguing that they are part of a single system and that the environment is not just a resource to be utilised but a value in itself.

In this context, there seem to be increasing opportunities for Chinese firms to shift their BRI investments from brown to green. "The World Resources Institute suggests that the Chinese government can use BRI special funds 'to quickly become a major catalyst for low-carbon development in the region'. The World Wildlife Fund proposes that Chinese firms can employ stringent domestic environmental guidelines (such as the use of Environmental Impact Assessments, or EIAs) in the process of siting, constructing, and operating BRI infrastructure in host countries. In fact, the Chinese State is mobilizing renewable energy industries to both respond to and profit from environmental concerns surrounding the BRI. The BRI white paper proposed to "advance cooperation in hydropower, nuclear power, wind power, solar power and other clean, renewable energy sources". The Chinese renewable industry has followed the Green BRI's call to invest overseas and eagerly taken up its discourses framing renewables as the key to the energy transition and carbon reduction. The proportion of China's renewable energy investments (solar, wind, hydro) out of its total overseas energy investments has risen rapidly. In addition, Chinese investment in foreign coal resources ceased in 2021 in response to Xi's 'no-coal-overseas promise'" (Xiaofeng Liu, 2023, p. 247); The declaration made by Xi Jinping himself, which came in a pre-recorded address to the UN general assembly [...], states "China will step up support for other developing countries in developing green and low-carbon

energy, and will not build new coal-fired power projects abroad". China['s] move follows similar announcements by South Korea and Japan earlier this year. Together, the three countries were responsible for more than 95% of all foreign financing for coal firepower plants (Vincent Ni, 2021). Therefore, firms in low-carbon industries have a huge potential to grow rapidly and enhance market share in BRI countries, as China is starting to move from a linear carbon economy to a circular carbon economy, as explained in chapter 3. "Green BRI is therefore seen as both a necessity and an economic opportunity" (Harlan, 2020, p. 209).

There also are some positive key points for encouraging the "Green BRI guidance":

1. the Green BRI projects and concepts can help share the idea and practices under sustainable development and eco-civilization;
2. the Green BRI endeavour can also boost intelligent transportation, taking advantage of the Chinese's innovative technologies;
3. The usefulness of the Chinese experience is also a crucial point, as many BRI countries at the moment are in the same socio-economic situation China was 20 years ago, so they can learn from China's path.

Through the means of the Green BRI, China is trying to create a green version of the Chinese model with normative values and material practices. To achieve this scope, the Chinese government is also leveraging the country's antique traditions, claiming the concepts of ecological civilization and co-governance (共同治理 gongtong zhili) as being rooted in Chinese values and wisdom (Harlan T. , 2020).

Official framings of eco civilization treat ecology as part of human civilization, marking an essential contrast to sustainable development, which views nature and humans as separate. Eco civilization also presumes that nature is something that can be used for growth but that can resist over exploitation by, for instance, compelling natural disasters. The concept appeared in the BRI whitepaper, which seeks "to promote the idea in investment and trade, increase cooperation in conserving eco-environment, protecting biodiversity, and tackling climate change, and join hands to make the Silk Road an environment-friendly one" (NDRC, 2017). Moreover, during the 2021 virtual Leaders' Climate Summit hosted by the United States, Xi Jinping highlighted two Chinese traditional values: "harmony between humans and nature" (天人合一 tianren heyi) and "follow[ing] nature's course" (道法自然 daofa ziran) (Jinping, Xinhua News, 2021).

“Yet it remains unclear whether the ‘green’ China model is actually replicable and if it could be effective beyond the country’s borders” (Xiaofeng Liu, 2023, p. 248).

“The leading idea is that green development can combine environmental improvement with economic development and infrastructure. One of the crucial reasons why China is promoting the action of ‘greening’ the BRI, in fact, is the need to address greenhouse gas emissions causing climate change, mostly in urban and industrialized areas. So, the environmental problem is framed as one of fossil-fuel dependence and energy inefficiencies that can be addressed through market-based environmental policies and green technologies like renewable energy, green building and retrofitting, and modern ‘smart’ infrastructure” (Harlan T. , 2020, p. 207).

In the next paragraph I will explore the main policies and mechanisms implemented by China and, consequently, also by the other countries along the BRI route in the context of “greening” the BRI project.

1.2 The main policies undertaken

The three main areas of development of the Green BRI project are: green finance, green energy and green cooperation mechanisms. Throughout this paragraph I will delve deep into the main policies released by China from 2015 onwards. It is important to take into consideration that the proposal for Green BRI also has a domestic policy background.

"Since the 18th National Congress of the Communist Party of China, General Secretary Xi Jinping has put forward a series of new ideas concerning the construction of an ecological civilization and the upgrading of environmental governance. He started several new initiatives to prioritize ecological conservation and follow green development pathways for a new paradigm of a harmonious human-nature relationship" (Yu Hongyuan, 2021, p. 134,135).

Let's analyse the three areas of development mentioned above.

1.2.1 Green finance

I will start from green finance. "China is an international leader in issuance of green securities and in establishment of lending policies" (Harlan T. , 2020, p. 210).
The term "green finance" refers to the two main types of financial practices implemented:

1. The first is the issuance of green financial products – such as green bonds – to raise funds for climate change solutions (typically low-carbon infrastructures). "China's green bond issuance reached USD 42.8 billion in 2018, 12% more than in 2017. The vast majority of these bonds – 77% in 2018 – are issued in the domestic interbank market and stock exchanges to finance domestic infrastructure, such as low carbon transportation (high-speed rails), clean energy, pollution prevention and control (clean coal)" (Harlan T. , 2020, p. 211). In fact, "China is now the undisputed world leader in every green technology. Last year, 82% of all solar panels and 70% of all electric batteries were produced in one country alone, China. 70% of all green high-speed trains run on Chinese tracks, and 98% of all electric buses on Chinese roads, according to Erik

Solheim, former under-secretary general of the United Nations and former executive director of the UN Environment Programme" (Tian Yuan, 2023, p. 53).

2. The second is the design and implementation of green credit guidelines, which are regulations that lending institutions consider when financing all infrastructure projects. The vast majority of BRI infrastructure projects are funded through regular debt and equity finance channels. Yet loans for these projects are still subject to green financial regulations – known as green credit guidelines – set out by China's Banking and Regulatory Commission (CBRC) and individual policy and commercial banks, and containing specific articles encouraging lending institutions to abide by local environmental regulations, adopt international best practices, and make use of third party social and environmental impact assessments. More specifically, CBRC has launched the first green credit policy in 2007, and later released its Green Credit Guidelines in 2012, followed by a statistical database and key performance indicators in the following two years. This regulatory framework has been necessary since the definition of "green" used in China – which is officially set by the People's Bank of China's (PBoC) Green Bond Guidelines – does not fully align with widely used international definitions, such as the International Capital Market Association Green Bond Principles (ICMA) (Harlan T. , 2020). Fortunately, Chinese regulators announced in June 2020 that feature domestic green bond issuance will exclude fossil fuels (Leena, 2020).

"Even more relevant to Green BRI's progress are China's green bonds issued in offshore markets, which finance a mix of domestic and overseas infrastructure. For example, in 2018, $9.2 billion green bonds were issued in Hong Kong and European stock exchanges, of which $US 1. 52 billion will finance: railway lines, wind farms, and solar farms in China, Pakistan, and Scotland, with 70% purchased by European investors. These "offshore bonds" must abide by international standards, therefore do not allow clean coal, nor hydropower, and are usually subject to more stringent verifications and reports" (Harlan T. , 2020, p. 212).

There are, however, some key issues with the application of green credit guidelines. Recent analysis, in fact, reveals that their implementation is hard, and most often even
ignored. In addition, firms receiving Chinese loans still struggle to comply with local environmental regulations, not to mention international best practices. Moreover, the report argues that Chinese lending institutions do not maintain appropriate communication channels

with non-government stakeholders in host countries, especially in lower-income nations and regions (Harlan T. , 2020).
To sum up, while China's voluntary green credit guidelines are indeed welcome, in the absence of enforcement they can be easily ignored or used to "greenwash" the negative impacts of brown infrastructure, rather than actually driving investment in low-carbon infrastructure, as the "green" BRI project plan aims to do.

1.2.2 Green energy

Moving into the topic of green energy, as already stated above, China is recognized as a global leader in green energy manufacturing and the decade between 2009 and 2018 the country added 497 GW of domestic renewable energy capacity, and now owns 15% of all systems installed worldwide. There is little debate that "alternative energy" sources like solar, wind, and geothermal sources are green when compared with fossil fuels – even though the product life cycle of technologies can cause environmental damages (Harlan T. , 2020).

In September 2020, President Xi announced at the general debate of the 75th session of the United Nations General Assembly, that "China will scale up its intended nationally determined contributions by adopting more vigorous policies and measures. We aim to have CO2 emissions peak before 2030 and achieve carbon neutrality before 2060." (Jinping, 2020)
"It has become a vital channel for China to participate in global governance and reform the system, as well as an institutional platform to enhance development and cooperation. Ecological conservation is one of the main focal points in the Green BRI to enhance global governance reform and achieve economic recovery in the context of the COVID-19 pandemic" (Yu Hongyuan, 2021, p. 135,136).

From a normative point of view, China has released the "Renewable Energy Law" in 2006 for the purpose of promoting the development and utilization of renewable energy, increasing the supply of energy, improving the structure of energy, preserving the safety of energy, protecting environment and realizing a sustainable economic and social development (MOFCOM, 2013). The aforementioned Law was then amended on December 26, 2009. In the Law's body, "renewable energy" refers to non-fossil energies, such as wind energy, solar energy, hydro

energy, bioenergy, geothermal energy and ocean energy, etc., however hydropower is not considered as a green energy source, due to its major negative impacts on nearby and downstream communities and environments and the methane emissions originated by its employment.

"The Chinese government itself, in the 2006 Renewable Energy Law, only considers hydropower to be renewable on a case-by-case basis. China boasts some of the world's largest hydropower companies (namely China Power Construction, Gezhouba Group, and China Three Gorges Corporation). These State-Owned Enterprises (SOEs) have ready access to cheap credit from Chinese policy and commercial banks, enabling them to work on hydropower projects in BRI countries that might be considered 'risky'. The solar and wind industries, in contrast, are mostly private, and do not have the access to finance and political security that comes with the status of being an SOE. This difference type of financing inevitably has an impact on the kinds of green energy investments that are delivered throughout the BRI route" (Harlan T. , 2020, p. 214).

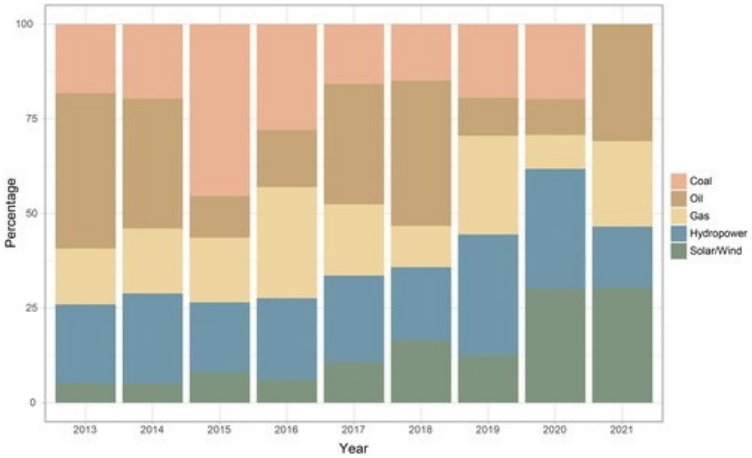
Rather than a low-carbon infrastructure, then, hydropower is better defined as a traditional energy installation aiming at driving economic development in lower-income countries and regions. In reality, then, making hydropower "green" – or "greenwashing" hydropower – is more about minimizing its environmental impacts than using it to lead low-carbon transition (Harlan T. , 2020).

More recently, on November 8, 2024 the new "Energy Law of the People's Republic of China", which came into effect on January 1, 2025 was issued. The release of this law, 18 years after the legislative process began, strengthens the legal framework governing China's energy sector, supports energy security, and facilitates the country's energy transition from a linear to a circular carbon economy, with the ultimate target of a "carbon-free economy". In particular, Article 5 marks a shift from the previous dual-control system for energy consumption to a dual-control system for carbon emissions. The Law also gives much attention to the role of the market, enshrined in Article 6, which calls for the establishment of a unified energy market system and the regulation of market order.

Renewable energy development and consumption is the central focus of this law. The text provides specific requirements for various types, including hydropower, wind, solar, biomass and more in Articles 24–26, along with the definitions in Article 73, not only for renewable energy but also for fossil energy, non-fossil energy, and hydrogen. The law supports both centralised and distributed renewable energy systems. Article 23 mandates setting and meeting minimum renewable energy consumption targets, placing responsibility on different

stakeholders, including power suppliers, electricity sales companies, consumers and captive power plants. Therefore, the Energy Law clarifies that the responsibility for renewable energy is shared by multiple parties. Article 34 advocates the Green Electricity Certificates (GECs) system to incentivise green energy consumption, thus enhancing their importance in supporting the low-carbon energy transition (Climate Cooperation, 2025).

Figure 2. China's Belt and Road Initiative energy investment, 2013–2021. Data from Green BRI Center (2022).



Source: (Xiaofeng Liu, 2023, p. 247)

1.2.3 Green cooperation mechanisms

Lastly, I shall present the system of green cooperation mechanisms. These are defined by the BRI Ecological and Environmental Cooperation Plan as "eco-environmental protection projects and people-to-people bonds" and "environmental capacity building" (MEP, 2017). "These initiatives range from policy-level cooperation to technology transfer, but are all based on the crucial idea that Chinese institutions can and should share environmental knowledge and expertise with BRI partner countries. In fact, China has signed 201 Belt and Road cooperation documents with 138 countries and 31 international organizations as of November 2020, including the United Nations Environment Program (UNEP), the United Nations Development Program (UNDP), the World Bank, the G20 and the BRICS countries Industrial Development Organization (UNIDO) and the United Nations. At the bilateral level, China has forged environmental cooperation models with France, Germany, Italy, Russia, Mongolia, Singapore and Cambodia by synergizing national strategies for ecological protection and climate change, and promoting cooperation on green infrastructure, international trade and financial services. Clearly the green cooperation projects have been both cause and consequence of the construction of multiple Belt and Road economic corridors, as already

stated above. In particular, in accordance with the China-ASEAN Environmental Cooperation Strategy (2016-2020) and the China-ASEAN Environmental Cooperation Action Plan (2016-2020), China and ASEAN countries have launched a partnership for ecology-friendly urban development and have set up an environmental information sharing platform. China has also worked with the Lancang-Mekong states in formulating and implementing the Lancang-Mekong Environmental Cooperation Strategy (2018-2022), aimed at building a sustainable Lancang-Mekong environmental cooperation network and promote a green Economic Development Belt for the area. For the China-Central Asia-West Asia Economic Corridor, the Shanghai Cooperation Organization (SCO) and other major platforms have implemented multilateral green cooperation" (Yu Hongyuan, 2021, p. 136,137).

In the cooperation between China and Central and Eastern European countries (CEECs), the China CEEC ministerial summit on environmental protection cooperation in 2018 adopted the China-CEEC Framework Document on Environmental Protection Cooperation, with the aim to strengthen policy coordination in climate change and environmental protection, and to work together on green development. In the African continent, China has cooperated with Kenya and the UN, establishing the China-Africa Environmental Cooperation Centre to strengthen the Sino-African environmental partnership. This initiative aims to increase the abilities of developing countries in environmental governance and green development, to implement the sustainable development goals (SDGs) and the African Union's Agenda 2063, and to realize green Belt and Road cooperation (Yu Hongyuan, 2021).

Apart from inter-state cooperation, various players like local governments, cities, companies and think tanks have taken part at various levels in the Green Belt and Road cooperation under the principle of extensive consultation, joint contribution and shared benefits. Companies of any dimension are using business cooperation and government-business partnerships to participate in this process and fulfil their due responsibility of environmental protection while improving their green competitiveness" (Yu Hongyuan, 2021). In other words, "China's central government's push for green cooperation has prompted the creation (or rebranding) of a network of government-affiliated research centres, institutes, and alliances for a Green BRI" (Harlan T. , 2020, p. 215).

"For example, the Belt and Road Think Tank Cooperation Alliance and the Belt and Road Studies Network have shared experience and best practices in environmental governance. They not only advise on Green Belt and Road cooperation, but also support countries along the routes and encourage more investment in green development; in terms of sharing knowledge, big data

platforms for environmental protection services and publications have been set up to offer information about policies, standards and technologies on environmental and development issues to government departments, enterprises, think tanks and the general public. In particular, The BRI International Green Development Coalition, which was jointly initiated by China and international partners during the second Belt and Road Forum for International Cooperation, published the BRI Green Development Report and the BRI Green Development Case Study Report, both offering important reference for global green development practices. Moreover, in terms of personnel training, China has launched the Green Silk Road Envoys Program, held training programs for foreign aid in environmental management, and implemented the Belt and Road South-South Cooperation Initiative on Climate Change" (Yu Hongyuan, 2021, p. 139).

To conclude this topic, since the launch of the Green BRI project, the Chinese Government has implemented many different systems, other than just written norms and policies, in order to reach the purpose of spreading "green" BRI best practices and promoting the development and utilization of renewable energy, thus realizing a sustainable economic and social development. Nevertheless, there are evidence of the fact that the proposed technological and industrial cooperation parks and demonstration sites along the BRI may simply facilitate investments in traditional industries that are not "green" at all. The issue is that Chinese green cooperation targets are nearly all about mitigating environmental risks, often neglecting the aim to promote low-carbon infrastructure investment in lower-income BRI areas. These conclusions show that BRI investments are contributing to green development in higher-income countries, but more resemble "greenwashing" in lower-income countries – and it is lower-income countries that will determine whether the world meets its emissions reductions commitments or not (Harlan T. , 2020).

1.3 International evolution of the Green BRI and the related debate

1.3.1 The international debate: a general overview

Let's start from a key question. What have been the international bodies' and organizations' responses to China's effort to promote its values and experiences through the BRI projects?

On one hand, the Chinese model for dealing with environmental issues has gained international recognition from the UN and partner countries, since it is seen as a model for other nations, namely those in Southeast Asia. This recognition has been the origin of various partnerships, such as the China–ASEAN Environmental Cooperation Centre.
Both Thailand and Cambodian officials have stated they share the Chinese view of the harmonious coexistence of humans and nature (天人合一 tianren heyi) (Xiaofeng Liu, 2023).

"On the other hand, Chinese values encounter significant resistance and scepticism in the West. For instance, the Five Eyes (Australia, Canada, New Zealand, the United Kingdom, and the United States) and India objected to the incorporation of "a shared future for mankind" in the UN seventy-fifth anniversary declaration, with officials from these countries claiming "the phrase is 'CCP language'" " (Xiaofeng Liu, 2023, p. 250). This is because, while the West may be willing to import technologies and innovations from China, Chinese values may be harder to accept, since they are seen as rigid and propagandistic. Indeed, current BRI investment trends are said to be in contrast with this "green claim". Some people point out that BRI projects are overwhelmingly brown, including coal-fired power, mines, oil pipelines, and heavy transportation infrastructure. Non-Governmental Organizations (NGOs) and think tank reports detail environmental abuses by Chinese firms in host countries, which include ignoring the need for Environmental Impact Assessments (EIAs) and damaging local ecology through poor construction and operation. In other words, the view that China is exporting its polluting model is more and more commonly diffused (Harlan T., 2020). Nevertheless, there are a few controversial matters in the implementation of Green BRI's policies. "China, in fact, seeks to manage extraterritorial spaces where it lacks coercive power, not only through means of governance, but also through global governmentality. However, authorities, particularly

NDRC and MOFCOM, which hold significant power over BRI decision-making, worry that more stringent mandatory regulations could increase Chinese companies' operating costs, causing them to lose international competitiveness compared to their local counterparts, who might not be beholden to such measures. Therefore, they hesitate to execute more severe environmental policies over the Green BRI and this leads to its dispersed governance. In other words, the first issue is the problem of competitiveness" (Xiaofeng Liu, 2023, p. 241).

The second major issue is the jurisdictional problem. Territorial sovereignty is normally restraint within national borders and exercised through violence, which is the instrument used to force compliance with legislation and regulations. Yet this sovereignty is usually absent beyond a State's territorial borders. As a result, the Green BRI faces a jurisdictional dilemma. As a practical example, two Chinese NGO's officers expressed a wish that Chinese enterprises should adopt Chinese standards rather than those of host countries- which tend to be lower- in order to improve the environmental performance of BRI countries. However, others argued that -due to a lack of territorial sovereignty abroad- China cannot issue compulsory regulations, but just encourage BRI members to act in an environmentally and ecologically responsible manner; so - as a consequence of both competitiveness and jurisdictional dilemma- the Green BRI is said to work as a slogan, encouraging sustainable actions, but also leaving their own interpretation of "green" to each country, as already explored before (Xiaofeng Liu, 2023).

1.3.2 The Chinese internal debate

Through the analysis of the results found on CNKI (China National Knowledge Infrastructure), which is the biggest online academic database currently existing in China, the presence, frequency and content of academic articles, academic thesis and research -fully written and prepared by Chinese authors- on the topic of the Green BRI were investigated; the objective was to verify the level of activity of the Chinese internal debate on this argument, and to investigate the specific topics of discussion.

Findings are the following:

- Number of sources= by typing *"*the Green Belt and Road Initiative*"* on CNKI a total of 23 results emerged; 3 of them were excluded, because they dealt with the international debate and/or had been published on international journals. Therefore, the analysed sources were in total 20;

- Typology of the texts: the three main categories of text which emerged are the academic thesis written by Chinese students, articles for scientific journals published by Chinese universities or scientific bodies and reports issued by Chinese sources, namely "China Ecological Civilization International Forum";
- Academic bodies involved: the Chinese Universities involved specifically are the "Guizhou University of Finance and Economics", the "Beijing Forestry University (Social Sciences)", the "Shanxi University of Finance and Economics" , the "School of Economics of the Hainan University" and the "Qingdao Agricultural University";
- Journals involved: the Journals which published the selected articles were " Resource Recycling", "China Circulation Economy", "Frontiers" and "Journal of China Executive Leadership Academy Jinggangshan";
- Date of publication: out of the 20 sources investigated, 14 were published between 2021 and 2024, while the other 6 were published between 2015 and 2019.

After analysing the sources and abstracts of all the sample articles and academic thesis we can affirm that the Chinese debate on the general topic of the Green BRI is active and shows the possibility of even more publications and debate in the near future. From the analysis of the date of publication I notice how the Chinese debate has been intensifying in the last 5 years, after a pause during the Covid pandemic in 2020. The texts issued between 2015 and 2019 are only 6, and this is probably due to fact that the Green BRI was only launched in 2015, and it was too early to discuss it in the first few years of development.
The specific topics of discussion are: the development of the Green BRI project, cooperation mechanisms employed for the construction of the Green BRI system, transports along the BRI routes, the relationship between FDI (Foreign Direct Investments) to China and the ecological performance of provinces on the BRI routes, the carbon emissions and the consequent climate change issue in the BRI, the governance system of the Green BRI and the impacts and effect of the Green BRI development, from an infrastructural side and also from an environmental and social point of view.

Lastly, the evidence that these texts have been cited and downloaded multiple times let us suppose that the internal debate among Chinese students and authors on the topic of the Green BRI project and its current and future effects on the global scenario is dynamic and is only at its starting point.

1.3.3 Exportation of BRI's "green" policies along the Belt and Road route

It's now time for a better understanding how China's "green" policies and best practices have been exported to other countries along the BRI route.

"Vietnam offers an interesting case study. Up to 2016, Chinese entities invested USD 3 billion in two coal projects in the country. Beginning in 2016, however, solar companies began to invest in Vietnam as a manufacturing hub, mainly to avoid tariffs imposed on Chinese solar panel exports in the U.S.-China trade conflict. Investment is still limited to solar panel manufacturing and one waste incineration plant (classified as alternative energy); however, solar industry players see opportunity to invest in generation due to Vietnam's preferential renewable energy policies" (Harlan T. , 2020, p. 215).

The Jakarta-Bandung High-Speed Railway, the China-Laos Railway, the Gwadar Port and a large number of other major projects have made tangible progress in recent years, thus giving rise to sustainable development in these countries, advancing the concept of a global ecological civilization and expanding green pathways for coordinating high-quality development with environmental protection.

Apart from 100% Chinese investment, some Green BRI development endeavours have been started by host countries and constructed by Chinese firms, or launched jointly by China and a third-party country (Yu Hongyuan, 2021). For example, China has been building the Laos-Yunnan Railway, a new metro in Hanoi, a railway from Bandung to Jakarta, and a lot more. Data from International Rivers, an NGO, shows Chinese involvement (including both investments or Energy Performance Contract) in 254 dams that have been planned, are now under construction, or have been completed in low-income and lower-middle income countries since 2000. An additional 25 dams in higher-middle income countries in Asia have Chinese involvement (14 of which located in Malaysia), along with 25 in higher-middle income countries in Central and South America, 25 in higher-middle income countries in the former USSR and Communist Bloc, and 9 in higher-middle income countries in North Africa. There are no Chinese investments in hydropower projects in high-income countries, except for 1 in Israel (International Rivers, 2019). Furthermore, "many probably do not know that China is now also a green leader in the protection of nature. It's by far the biggest tree planting nation

in the world. Giant pandas and snow leopards have been removed from the red lists of threatened species thanks to good conservation programs in Sichuan and western China. Kubuqi in Inner Mongolia is a global best practice for green restoration of deserts. The Chinese region of Zhejiang leads the world in rural restoration of rivers" (Tian Yuan, 2023, p. 53).

Nonetheless, the recent growth in Chinese solar investments in Vietnam show that low-carbon infrastructure can be an important part of the Initiative given the right incentives – and that China's dominance in green industries like solar and wind make it well-positioned to do so (Harlan T. , 2020).

China has also been involved in the deployment of various projects in Thailand and Malaysia, with the objective of spreading its ideas and practices for a more sustainable economic future (Hung, 2024), but I will explore this topic better in chapter 3.

1.3.4 Possible future evolution of the "green" BRI project

So, what is the future of the Green BRI, according to the international debate?
Certainly, the Covid 19 pandemic has had a negative influence on global sustainable development and -as a consequence- on "green" BRI's progress. According to the Sustainable Development Goals Report of 2020 issued by the UN Department of Economic and Social Affairs, "the unprecedented novel coronavirus crisis has severely undermined the attainability of the 17 SDGs by 2030" (International Monetary Fund, 2021). Under these circumstances, countries have been focusing their efforts and resources on epidemic response and economic recovery, rather than putting attention on green global governance consultations, decisions and policy implementation. This has produced two main outcomes. First, the consultative meetings on environmental governance are being postponed while nations are busy dealing with the pandemic. And second, the consequences of the pandemic have magnified the difficulties of global environmental governance. Moreover, economic recovery in the post-COVID era sets higher requirements and standards for global environmental governance and green development. In particular, developed countries are putting forward stricter demands for environmental protection based on their own economic, technological and standard-setting advantages, whereas the BRI may face stricter green standards and stronger competition (Yu Hongyuan, 2021).

So, what path should the Green Belt and Road Initiative follow, in order to keep up its previous achievements and improve and progress even more in the future?

Surely "one of the main challenges the Green BRI is facing are disparities in the level of green development. In fact, as most countries along Belt and Road routes are still developing countries, where the need for development overrides considerations for environmental conservation, ecological vulnerability remains high. Furthermore, green development of the BRI requires a stable international framework for development, cooperation and for the alignment of various existing national development strategies. However, governments, businesses and public stakeholders in these countries have some catching up to do in coordinating development goals for the economy, the environment and overall efficiency" (Yu Hongyuan, 2021, p. 142).

Therefore, as the BRI continues to gain global prominence, it is essential to work toward a BRI that is truly green and equitably implemented.

It will be crucial in the short-term future to enhance international research and exchange to strengthen intellectual contributions to international ecological development; intellectual support, particularly more prospective studies, is urgently needed as the BRI continues to grow. Leading and encouraging ideas and concepts also need to be developed. For example, green development concepts should be embedded in legislative principles and be given priority in legal decisions. International joint research and exchange in the process of green Belt and Road cooperation also needs to be strengthened. The discussions on innovative approaches to environmental risk prevention and governance will also help deepen our understanding of the Green BRI and build international consensus for a community of green development along the Belt and Road development pathways (Yu Hongyuan, 2021). Namely, "the International Finance Forum (IFF) could be -according to Erik Solheim, former under-secretary general of the United Nations and former executive director of the UN Environment Programme- a great candidate to serve as an intellectual powerhouse for green finance in South-East Asia region." According to him "it offers unique access to thousands of thinkers from the region and the rest of the world. Its new wonderful facilities in Nansha, right in the middle of the GBA (Greater Bay Area, the region including Guangdong-Hong Kong-Macao), will attract people to exchange ideas, business practices, knowledge of financial opportunities, and a lot more. Its award programs will inspire businesses to dive into even braver green efforts, therefore

influencing not only this region, but also other countries and the whole global economic environment more broadly" (Tian Yuan, 2023, p. 53).

Moreover, multilateral investment and financing platforms such as the Asian Infrastructure Investment Bank and the Silk Road Fund should become the entities that allow to mobilize international green investment and promote green financial systems in key countries (Yu Hongyuan, 2021).

In addition, "to tackle the challenge of Green BRI reputation and credibility, China needs to integrate higher environmental standards with broader economic and trade cooperation. While observing and improving existing green investment and trade rules, efforts should be made to promote Chinese green standards worldwide. In order to enhance international trustfulness of the BRI, China needs to set up public BRI information centres with access to project cases, data, rules and methodologies, and disclose in a timely manner the information about environmental standards and the results of environmental and social impact assessment of BRI projects" (Yu Hongyuan, 2021, p. 149).

An additional suggestion for the future of the Green BRI is prioritizing green development in people-to-people exchanges. Moving towards the future, in fact, the Green BRI needs to integrate international environmental cooperation with public diplomacy and people-to-people exchanges, and in particular establish an extensive partnership with the UNEP and the UNDP. This certainly would increase the global influence and appeal of green development partnership-programs and enable a green recovery of the world economy in the post-COVID period (Yu Hongyuan, 2021).

Chapter 2: Environmental impact of the BRI and the role of circular economy as a mitigation strategy

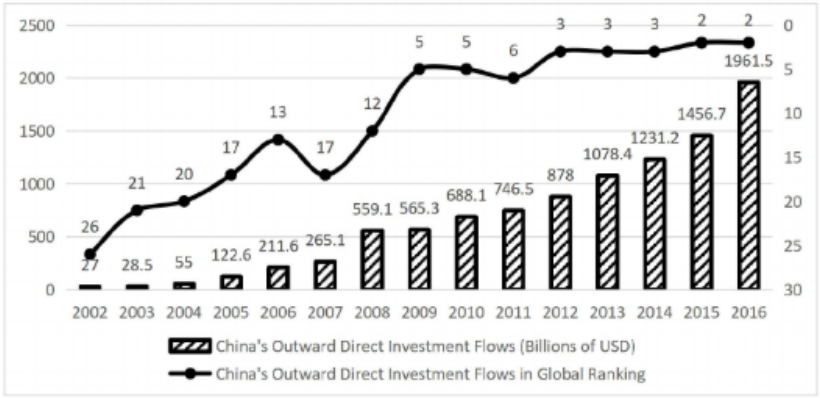
2.1 The Belt and Road Initiative: environmental impact on BRI countries

2.1.1 General overview and relationship between economic growth and environmental degradation

As already deeply investigated, both economic growth and financial development can impact on environmental functions, such as to control trade and energy consumption and to attenuate Greenhouse Gas (GHG) emissions (Farhani Sahbi, 2015).
Various research show how trade openness and financial development can impact the levels of carbon emissions on a global basis (Javid Muhammad, 2016).
It is a common perception that economic growth causes environmental degradation, and this is the key reason why awareness regarding improving environmental quality among the economists, environmental experts, and policymakers started to rise as early as the late 1960s (Shah Saud S. C., 2018).

As already stated "in late 2016, the Silk Road Fund has signed 15 projects including infrastructure construction, industrial cooperation, financial assistance and exploration of natural resources with an estimated investment worth 6 billion USD. Economic growth is known to be one of the main culprits to CO2 emissions. Moreover, investment activities are constantly required to enhance economic growth and development among the Belt and Road Initiative-participating countries, and such activities can also have an impact on the environment" (Shah Saud S. C., 2018, p. 2255). In fact, as shown in Figure 3 below, "China's Outward Foreign Direct Investment (OFDI) flows in 2016 has reached $1961.5 billion, compared with only $27 billion in 2002; in the meantime, since Asian Development Bank has reported $26 trillion required for infrastructure from 2016 to 2030 to sustain growth and strike poverty in developing Asia-Pacific, when climate change mitigation and adaptation costs are incorporated, much room is still provided for China's overseas investment persistently" (Song, 2020, p. 1).

Figure 3. China's ODIF



Source: (Song, 2020, p. 2)

This naturally implies that BRI projects, and also Green BRI ones, do rise concerns among international bodies and organizations. In this chapter I will analyse the effects caused by BRI's originated economic growth, the environmental Kuznets curve hypothesis and the main strategies to mitigate the negative impact and contribute to a more sustainable development for all BRI countries in the future.

2.1.2 Carbon emissions: origins and analysis

As noted by the United Nations in 2013, globalization and the constant expansion of trade markets will lead to a significant growth in the number and dimension of linkages between developing countries in the fields of trade, investment and finance; in turn these linkages enable involved countries and regions to share experiences and commonly design institutional and policy reforms, thus contributing to sustainable and equitable economic growth (Mengyao Han, 2018).

It is also true that the rise of the Global South, through the promotion of endeavour as the BRI which promote trade and investment that alter the regional allocation of resources, is reshaping the global governance system, traditionally dominated by the Global North. In other words, the Belt and Road Initiative represents a new type of South-South Cooperation (Michael Dunford, 2016).

The exchange of resources, ideas, money and materials naturally promoted by the BRI endeavour inevitably implies incorporated carbon transfers, that need to be investigated in order to assess their effect on the environment and on human and social life. It is also relevant to suggest possible mitigation strategies.
It is indeed clear that the development of a comprehensive energy cooperation model and carbon reduction mechanisms are crucial for both BRI implementation and for tackling global warming and environmental pollution (Ning Zhang, 2017).

In fact, a World Bank Study stated that BRI transport infrastructure is estimated to increase carbon dioxide emissions by 0.3% worldwide—but by 7% percent or more in countries like Cambodia, Kyrgyz Republic, and Lao PDR as production expands in sectors with higher emissions (World Bank Group, 2019).

So, how did some scientific and academic international bodies analyse this topic?

The majority of past literature research and articles employed carbon emissions as a proxy variable to capture the environmental effects of BRI (Abdul Sattar M. N., 2022) (Song, 2020) (Shah Saud S. C., 2018) (Mengyao Han, 2018).
The main tests and indicators utilized investigate the issue from a spatial-regional point of view. In particular, Saud et al. use the country-wise long-run estimator, which analyses the long-term effects of a selection of variables, namely GDP, financial development (Foreign Direct Investments), Energy Performance Contracts (EPCs) and trade flows. This method shows results for single nations for a panel of 59 BRI countries over the period 1980-2016 and its objective is to lead policy makers to the creation of better and more focused environmental policies. The 59 countries are a sample size, selected among the 71 BRI-nations currently hosted by the State Information Centre, basing on the availability of data. The data is retrieved from the World Development Indicators, at the World Bank Website, from 1990 to 2016 (Shah Saud S. C., 2018).
Sattar et al., implement a difference-in-differences (DID) approach, examining the impact of Belt and Road Initiative on carbon emissions. They include country fixed effects and year fixed effects and the key variable is the interaction term, which captures the differences in CO2 emissions before and after the BRI launch (before and after 2013) between countries involved in the BRI and those not involved. As Saud et al. research, this study's control variables also include GDP per capita, energy consumption, financial development, trade flows and

population, which were all retrieved from the database of World Bank Indicators, apart from data of financial development that was extracted from the International Monetary Fund (Abdul Sattar M. N., 2022).

Z.G. Song used three spatial econometric models, namely the Spatial Lagged Model (SLM), the Spatial Durbin Model (SDM) and the Spatial (Autoregressive) Error Model (SEM). The first assumes that the value of the dependent variable in one location depends not only on its own predictors, but also on the values of the dependent variable in neighbouring locations; in other words, this model suggests that BRI countries along the route influence and impact each other. The Spatial Durbin Model is an extension of the previous model, assuming not only that the outcome in nearby countries matter, but also the predictors in those nearby places matter. Lastly, the Spatial Error Model assumes that the error terms (the unexplained parts) are spatially correlated; in other words, according to this last theory, unobserved factors affecting one location are related to those in neighbouring locations (James P. LeSage, 2009). The key explanatory variables employed are: China's investments and imports and economic and institutional distance with China. To be specific, "China's outward foreign direct investment stock originates from the Statistical Bulletin of China's Outward Foreign Direct Investment, in which the stock of investment indicates the reserve at the end of the previous year. Likewise, China's imports from BRI countries (IV) are referred from the UN Comrade. The absolute economic (GDPB) and institutional (WGIB) distance between BRI countries and China are respectively measured as the GDP per capita in current prices and Worldwide Governance Indicators from the IMF and World Bank. Besides, the level of economic development, industrial and trade structure, along with the infrastructure level in BRI countries are expressed as the scale, structure and technique effect on the CO2emissions within the region, which are selected as GDP per capita in current prices (GDP) of a specific BRI country from IMF, ratio of manufacturing & construction value , and trade value to GDP from World Bank, and ratio of individuals using the internet of population from International Telecommunication Union." (Song, 2020, p. 3,4)

Lastly, Mengyao et al. utilize a Multi-region input-output (MRIO) analysis to identify embodied carbon flows between major world regions, including seven regions along the Belt and Road, and the spatial distribution of production- and consumption-based carbon intensities. The MRIO is also used by many international organizations, that have built several databases using this system. In particular, this study was based on the Eora 2012 MRIO table, which is the most detailed global scale multi-regional input-output database, covering 189 individual economies and featuring a 26-sector harmonized industrial classification. The Eora table

corresponds to the 2012 input-output table from the Chinese National Bureau of Statistics, providing satellite accounts for energy consumption, carbon dioxide emissions and environmental pollution. Per capita and GDP data were all retrieved from the World Bank database and Table 1 below lists the names of and abbreviations for the 65 regions (including China) along the BRI for reference (Mengyao Han, 2018).

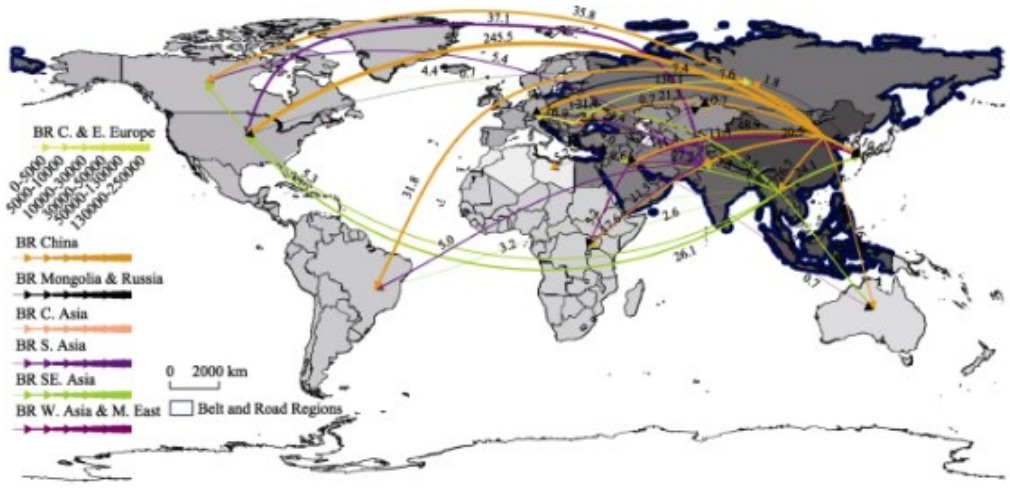
Table 1. Regional classification of 65 regions

Category	Region
China (BRI)	China (12)
Central Asia (BRI)	Kazakhstan (26), Kyrgyzstan (28), Tajikistan (56), Turkmenistan (60), Uzbekistan (63)
Mongolia & Russia (BRI)	Mongolia (37), Russia (48)
Southeast Asia (BRI)	Brunei (9), Cambodia (11), Indonesia (21), Laos (29), Malaysia (34), Myanmar (39), Philippines (44), Singapore (51), Thailand (57), Viet Nam (64)
South Asia (BRI)	Afghanistan (1), Bangladesh (6), India (20), Maldives (35), Nepal (40), Pakistan (42), Sri Lanka (54), Bhutan (58)
Central & East Europe (BRI)	Albania (2), Belarus (7), Bosnia and Herzegovina (8), Bulgaria (10), Croatia (13), Cyprus (14), Czech Republic (15), Estonia (17), Hungary (19), Latvia (30), Lithuania (32), Macedonia (33), Moldova (36), Montenegro (38), Poland (45), Romania (47), Serbia (50), Slovakia (52), Slovenia (53), Ukraine (61)
West Asia & Middle East (BRI)	Armenia (3), Azerbaijan (4), Bahrain (5), Egypt (16), Georgia (18), Iran (22), Iraq (23), Israel (24), Jordan (25), Kuwait (27), Lebanon (31), Oman (41), Palestine (43), Qatar (46), Saudi Arabia (49), Syria (55), Turkey (59), UAE (62), Yemen (65)

Source: (Mengyao Han, 2018, p. 1268)

As shown in Figure 5 “China, South Asia and Southeast Asia were major net embodied carbon exporters, with all regions outside of the BRI area importing embodied carbon from these regions. The main transfer flows included those from China to other BRI regions, from South Asia and South-east Asia to West Asia & Middle East, from Central & East Europe to Mongolia & Russia and to West Asia & Middle East, and from Mongolia & Russia to Central Asia and to West Asia & Middle East. Of these Belt and Road regions, China was the largest carbon exporter, while West Asia & Middle East was the largest carbon importer, with especially large embodied carbon emission imports for Iran, Saudi Arabia, Turkey and the UAE (United Arab Emirates)” (Mengyao Han, 2018, p. 1268).

Figure 4. Embodied carbon transfers of the Belt and Road regions



Source: (Mengyao Han, 2018, p. 1268)

2.1.3 Carbon emissions: analysis' results and Environmental Kuznets Curve hypothesis

After the overview of the main methods and variables employed to investigate and assess the origins of carbon emissions on a global basis -and the sources where the data were retrieved- it's now time to delve deeper into the findings of the above-mentioned studies and research, including the verification of the Environmental Kuznets Curve hypothesis for the BRI countries.

First of all, it is important to state that the international debate presents two main schools of thought on the nexus between economic growth and environmental degradation:

1. According to the first one, financial development alleviates the credit constraints and enhances investments in high energy consumption projects, boosting economic growth, energy consumption and CO2 emissions (Faiza Abbasi, 2016);
2. The second view states that financial development enhances investments in advance and energy-efficient technologies, thus reducing energy consumption and improving environmental quality (Shah Saud D. S., 2018).

The first view is based on a causal theory: it assumes there is a cause-effect relationship between economic growth and an increase in carbon emissions, and therefore also between economic growth and environmental degradation (Shah Saud S. C., 2018).

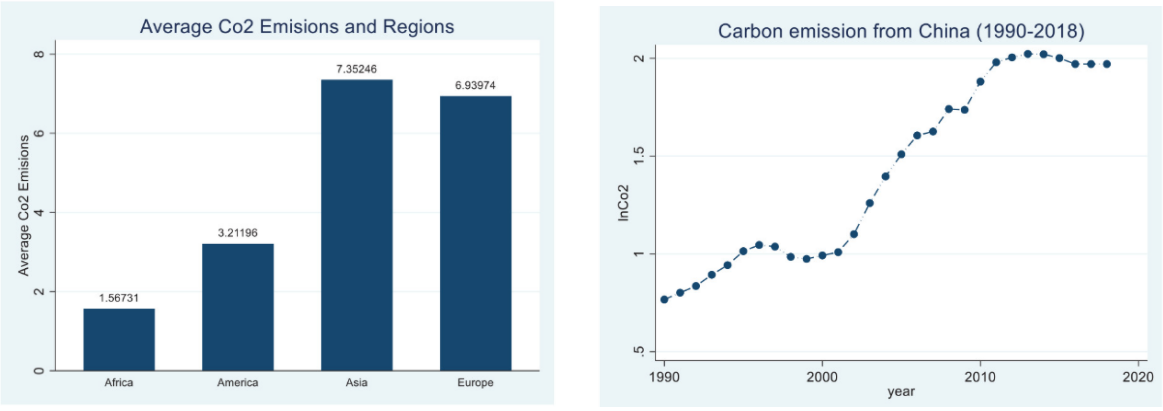
Other studies, on the other hand, support the second school of thought, by stating that environmental degradation through high industrial pollution may also be mitigated by high

financial development and investments, which can play an important role in environmental quality improvement by facilitating financing at lower costs of investment in environmental-friendly projects (Jansen, 1996).

The difference-in-differences (DID) approach revealed that, generally, outcome of carbon emission of Belt and Road Countries (BRC) exceeds that of the non-BRC group to reach a significant and positive impact of the BRI on carbon emissions to BRCs. In fact, it was found that trend in carbon emission in BRI and non-BRI countries was similar before the launch of the BRI in 2013, while the level of emissions significantly increased after 2014.
Opposite, the same method shows how the coefficient value for GDP is negatively correlated with CO2 emission; so, high economic growth can reduce CO2 emission and an upgrade in the economic structure may help to reduce carbon emissions, which is in line with the second view (Abdul Sattar M. N., 2022).

In addition, the research by Sattar et al. also verifies the impact of BRI on carbon emission in BRI economic corridor countries, as shown in Figures 5 and 6, because those are considered more closely attached to BRI. “Findings show that the impact of BRI on carbon emission is positive to BRI economic corridor countries, which confirms the results for the BRC group” (Abdul Sattar M. N., 2022, p. 12,13).

Figure 5, figure 6. Average carbon emissions by regions and China’s carbon emission from 1990 and 2018



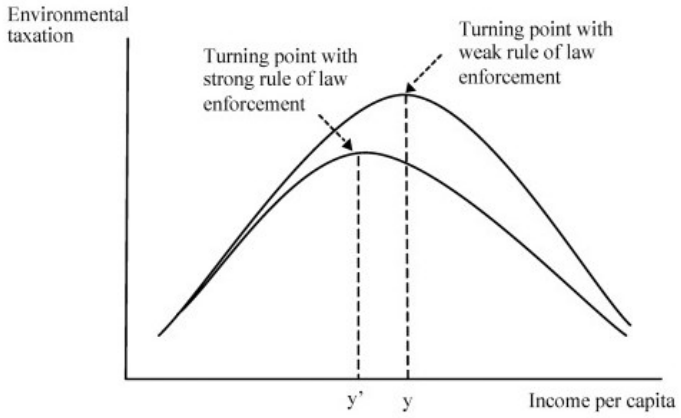
Source: (Abdul Sattar M. N., 2022, p. 2)

The theory behind the Environment Kuznets Curve originated in the 1990s, but the idea at its basis was initially presented by Simon Kuznets, an American economist, between 1950 and 1960. The EKC hypothesis states that at the early stage of economic development, environmental pollution increases, but the curve tends to reverse at the income turning point. In particular, this curve develops over three stages, as shown in Figure 7:

1. Initially economic growth (GDP increase) deteriorates the environment quality at the threshold level;
2. After reaching the maximum point the curve moves downward;
3. The carbon emission and economic growth relationship becomes negative.

(Jun Wen, 2021)

Figure 7. Graphical explanation of the Environmental Kuznets curve



Source: https://www.sciencedirect.com/topics/social-sciences/environmental-kuznets-curve

"The possible explanation behind the negative correlation of economic growth with carbon emission is that when a country is at the initial level of development there are larger possibilities that such country will be the service sector economy which contributes less to carbon emission as compared to the manufacturing sector. On the other hand, the lower GDP implies recession or depression in the country that's why people mainly focus on their basic needs and minimize their unnecessary utilizations; as a result, energy utilization is also minimized, consequently, carbon emission is reduced" (Abdul Sattar M. N., 2022, p. 13).

Saud et al., by using the country-wise long-run estimator, present empirical findings that demonstrate how Environment Kuznets Curve hypothesis is confirmed in some countries; for example, in nations like China, Egypt and Russia the data shows that as GDP increases, CO2

emissions also increase, but only up to a certain point. After a certain level of economic growth, in fact, emissions begin to decrease.
In other countries, such as India, Saudi Arabia or Turkey, both GDP and its square lead to higher emissions, which keep rising with economic growth, with no sign of turning point; therefore, the EKC does not apply to these countries (Shah Saud S. C., 2018).

The study by Sattar et al. negate the presence of the EKC, since the estimated coefficient of the square term of GDP turned out negative to positive. However, this indicates the U-shaped association between economic growth and carbon emissions, meaning that energy consumption and population shows a positive impact on CO2 emissions and financial development and trade openness reduce the carbon dioxide emissions (Abdul Sattar M. N., 2022, p. 1,13).

The study conducted by Z.G. Song empirically confirms the existence of spatial autocorrelation for the level of CO2 emission in BRI countries. Moreover, through the estimated results of the Spatial Durbin Model with spatial fixed effects, China's OFDI and imports to BRI countries do exert third-country effects or spatial spill overs effects (Song, 2020, p. 7). This brings about a series of suggestions and possible policy-level improvements that will be explored later on in this chapter.

Lastly, the research conducted by Mengyao et al. provides insightful data on embodied carbon emissions. "The percentages of embodied carbon emissions consumed within China, South Asia and West Asia & Middle East (from 77.63% to 78.73%) were relatively larger than for the other regions. Of China's embodied carbon emissions, West Europe, the United States and the rest of East Asia accounted for 5.51%, 4.90% and 4.20%, respectively. Paying attention to specific countries, most of the carbon emissions embodied in the imports of the United States, Japan, Korea, Germany, the UK, Canada, Singapore and India are from China (Figure 8b).
The consumption structure of South Asia's carbon emissions was similar to that of China, with 5.58% and 3.56% of its embodied carbon emissions associated with goods produced for export to West Europe and the United States, respectively, and 3.54% and 2.20% for goods exported to West Asia & Middle East and China, respectively (Figure 8c). The United States, China, Germany, the UAE, the UK, Japan, Italy and Singapore were identified as its major carbon importers.
In the case of the carbon emission structure of West Asia & Middle East, West Europe and

the rest of East Asia took the largest responsibility for import-generated emissions, accounting for 5.98% and 5.43% of these areas' national totals, respectively. These zones were followed by the United States, China, South Asia and Southeast Asia, with 2.07%, 1.88%,1.85% and 1.57%, respectively (Figure 8d). The largest contributors to the emissions generated by the production of goods for export from West Asia & Middle East were Japan, Korea, the United States, India, China, Germany and Italy.

In the case of Southeast Asia, 7.74% of carbon emissions were a result of goods they produced for consumption in China, while the rest of East Asia, West Europe and the United States were responsible for 6.67%, 5.86% and 4.87%, respectively. China, the United States, Japan, Korea, Germany, India, the UK and Australia were all major contributors, through their imports, to carbon generated in Southeast Asia (Figure 8e).

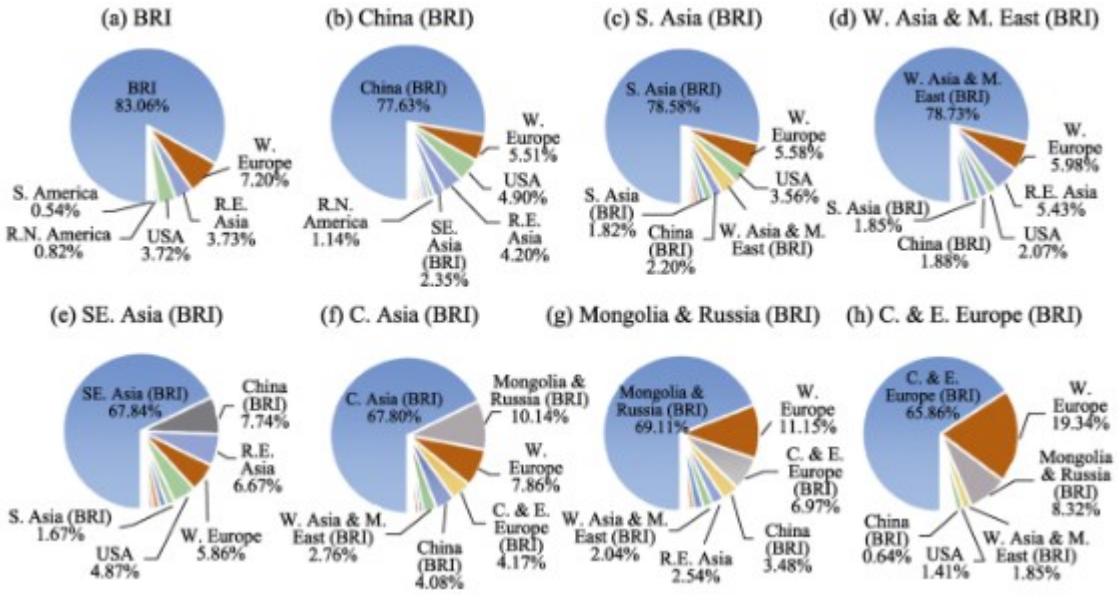
Of the carbon emissions of Central Asia, 10.14% and 7.86% were a result of production for export to Mongolia & Russia and West Europe, respectively, while 4.17% and 4.08% were due to exports produced for Central & East Europe and China, respectively. Russia, China, Germany, Ukraine, Iran, Italy, Romania, and the United States were the countries whose imports made the largest contributions to Central Asian emissions (Figure 8f).

Some 11.15% of the embodied carbon emissions of Mongolia & Russia were generated by the production of goods for export to West Europe. 6.97% derived from exports to Central & East Europe, and 3.48%, 2.54% and 2.04% from exports to China, the rest of East Asia and West Asia & Middle East, respectively. The major generators of emissions through imports were China, Germany, Japan, Ukraine, Kazakhstan, France, Turkey and Slovakia (Figure 8g).

Some 19.34% of the embodied carbon emissions of Central & East Europe were associated with exports to West Europe, and 8.32% with those to Mongolia & Russia. Overall, Germany, Russia, Italy, the United States, Austria, France, Turkey, the Netherlands and the UK were the largest causes of emissions from the production of exports in this area (Figure 8h)" (Mengyao Han, 2018, p. 1270,1271).

Figure 8 below exemplify the above-mentioned data, including figures from 8a to 8h.

Figure 8. Embodied carbon emissions by region



Source: (Mengyao Han, 2018, p. 1271)

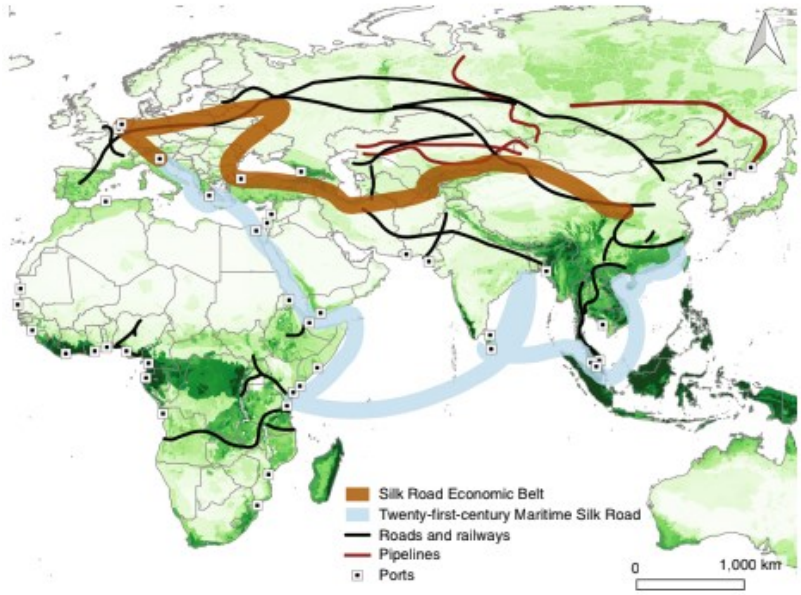
Mengyao et al. study firstly highlights how a key feature of globalization is effectively moving high-emission industries from developed countries to emerging economies, such as India or China. Noteworthy, trade-related (embodied) carbon emissions make up about one-third of global emissions, meaning it's not enough to measure emissions by production alone when assigning responsibility. This is especially relevant for Belt and Road (BR) regions, which have become major global manufacturing hubs, led by China. Most global transfers of embodied carbon go from BR regions (like China, South Asia, and Southeast Asia) to developed regions such as the U.S., Western Europe, Japan, and Korea. So, while some argue the Belt and Road Initiative (BRI) increases emissions, the real driver is rising global consumption, especially in developed countries — not the BRI itself.

Moreover, the study also highlights a clear spatial difference between production-based and consumption-based carbon intensities. “In BR regions (like Mongolia, Russia, Central Asia, and China), production-based emissions are much higher, meaning these countries bear greater environmental costs to support global economic growth.

Carbon leakage, which is defined as the shifting of emissions from developed to developing countries, is more prominent in BR regions than in wealthier or less industrialized nations. Since these areas serve as the “world’s factory”, their carbon intensities are unlikely to drop soon” (Mengyao Han, 2018, p. 1271-1273).

2.2 Other implications of the Belt and Road Initiative on the environment

Figure 9. Main trade corridors (Silk Road Economic Belt and twenty-first-century Maritime Silk Road) from and to China and some of the most important infrastructure and ports built or planned with Chinese investment in the BRI



Source: (Fernando Ascensao, 2018, p. 207)

The Belt and Road Initiative promises to be the largest infrastructure project in human history, involving 71 countries and valued over USD 8 trillion by 2049; however, this high-level development necessarily entrains significant risks for biodiversity (C.Hughes, 2019).

In fact, despite the potential economic benefits, such a large, cross-border project entailing the expansion and upgrading of huge infrastructure as roads, railways, airports, ports, power stations, and pipelines, comes with considerable risks (Zhai, 2018).

More precisely, "new roads and infrastructures -when planned and built through areas of high environmental value- may have significant impacts on biodiversity. The negative impacts of roads on biodiversity are well known and include increased wildlife mortality, restrictions of animal movement, pollution (chemicals, noise, light) and the spread of invasive species" (Fernando Ascensao, 2018, p. 206).

In particular, five main classes of possible impacts are individuated by the research conducted by Hughes:

1. Direct or resource destruction to build roads and associated infrastructure;
2. Raw material extraction for building roads or supplying resources for new human population centres (e.g., power supply);
3. Increased access to natural resources (and wildlife) due to greater accessibility along the route;
4. Habitat fragmentation due to road construction;
5. increased roadkill and increased wildlife trafficking due to increased regional connectivity; (C.Hughes, 2019)

2.2.1 BRI risks: impacts on biodiversity

The implementation of the BRI may also negatively impact biodiversity by chopping up habitats, increasing wildlife mortality, pollution, and spread of invasive species, as manifested by the preliminary spatial analysis of the World Wildlife Fund (WWF) (World Wildlife Fund, 2017).

"For what concerns the destruction and fragmentation of natural resources and biodiversity, recently, the World Wildlife Fund (WWF) carried out an initial spatial analysis of the overlap between the proposed BRI terrestrial corridors and important areas for biodiversity and natural resources. The report shows that those corridors overlap with the range of 265 threatened species, including 39 critically endangered and 81 endangered species. In addition, the corridors overlap with 1,739 Important Bird Areas or Key Biodiversity Areas and 46 biodiversity hotspots or global 200 ecoregions" (Fernando Ascensao, 2018, p. 206).

Hughes research is very insightful and more precise in describing the effects already caused by the Belt and Road Initiative implementation on natural habitats and biodiversity.
"The study overlaid the proposed road and rail routes on Key Biodiversity Areas (KBAs), Protected Areas (PAs), and predicted biodiversity hotspots for over 4138 animal and 7371 plant species, by using the most up-to-date maps of proposed routes (routes did not differ by >600 m) and carefully developed species distribution models for areas of greatest biodiversity" (C.Hughes, 2019, p. 883,886).

The data collected are the following.

- For what concerns Key Biodiversity Areas and Protected Areas:
- On average, 17% of KBAs were within 50 km of proposed roads and 60.6% were within 50 km of proposed rail routes;
- Proposed railways were especially close to KBAs (19.9% within 7 km of a proposed rail route);
- In contrast to KBAs, more PAs were near roads (13.5%within 50km) than railways (6.8%near).
- Regarding animals and plant biodiversity:
- 34% of important areas for mammals (least 25% of maximum richness) were within 50km of roads in mainland Southeast Asia with 5% within 7 km of roads;
- For areas with 50% of maximum diversity, mammals had the greatest vulnerability; up to 8.3% of these regions were within 50 km of proposed roads;
- Birds were most vulnerable to railways; almost 29% of regions with up to 25% of maximum diversity were within 50 km of railways, and 5%of maximum-diversity hotspots were within 7 km of railways, over double that of other species;
- For amphibians only, a small proportion of the most diverse areas fell within the road route, but of these 84.7% of the richest areas within the buffer area occurred in Indonesia. For railways amphibians in Lao appeared the most vulnerable; 53.2% of the most diverse areas were within the buffer;
- For reptiles 59.8% of the most diverse areas within the road buffer (17.5% of the most diverse areas) were in Thailand;
- For orchids in China, 90.7% of hotspots were within road buffer (50.2% of the total) and 85.5% of hotspots were located near railways (11% of total);
- Bats were the only group mapped for the entirety of tropical regions of the BRI; Southeast Asia appeared disproportionately vulnerable. Within road buffers, 77% of the most diverse areas were in Malaysia for bats overall;
- For rail, bats in Lao were most vulnerable; 36.9% of the most diverse areas were within the buffer.
- At a country level:

- Cambodia and Vietnam had the highest proportion of areas with the greatest diversity (75–100%highestmammal diversity) near proposed railways (46.9% and 25.6%, respectively);
- Only in Thailand and Cambodia proposed railways bisected the most diverse areas for mammals;
- For birds 16% of the most diverse areas and 38.4% of hotspots within the 50-km road buffer were in China;
- Malaysia had 9.4% of the most diverse bird areas and 22.6% of hotspot areas within the buffer;
- Vietnam had 23.8% of the most diverse areas for birds, and 51% of those areas were within the railway buffer.

(C.Hughes, 2019, p. 887,888)

Table 2 below displays the full set of data extracted, where *taxon* indicates the animal's or plant's species/category.

Table 2. Percentage of diversity hotspots for 7 *taxa* within 5 different distances (1-50 km) of proposed BRI rail and road routes

		Road					*Rail*				
Taxon	*Species richness (%)*	*1*	*7*	*14*	*30*	*50*	*1*	*7*	*14*	*30*	*50*
Reptiles	25	0.5	2.7	2.6	4.2	5.6	0.6	4.2	4.5	7.9	11.8
	50	0.1	0.4	0.4	0.7	0.9	0.1	0.7	0.8	1.5	3.2
	75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Orchids	25	0.4	1.8	1.6	2.9	4.8	0.4	2.1	2.0	4.1	7.6
	50	0.1	0.3	0.1	0.1	0.3	0.1	0.2	0.2	0.2	0.3
	75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphibians	25	0.1	0.5	1.0	2.3	4.9	0.1	0.5	1.0	2.3	4.9
	50	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.1	0.1
	75			0.0	0.0	0.0			0.0	0.0	0.0
Birds	25	0.5	3.5	6.2	10.6	17.1	0.6	4.1	7.9	14.9	28.5
	50	0.1	0.4	0.6	0.8	1.2	0.1	0.5	0.9	1.3	2.1
	75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mammals	25	0.6	4.8	9.7	18.4	34.0	0.2	1.8	3.7	7.0	13.0
	50	0.1	0.6	1.4	3.4	8.3	0.0	0.2	0.5	1.3	3.2
	75	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.1
Pteropus*	25	0.1	1.0	1.8	3.2	5.2	0.1	1.0	1.8	3.2	5.2
	50	0.0	0.1	0.1	0.3	0.4	0.0	0.1	0.1	0.3	0.4
	75		0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Bats*	25	0.2	1.2	2.3	4.2	7.1	0.2	1.2	2.3	4.2	7.1
	50	0.0	0.3	0.7	1.3	2.4	0.0	0.3	0.7	1.3	2.4
	75	0.0	0.1	0.1	0.2	0.4	0.0	0.1	0.1	0.2	0.4

Source: (C.Hughes, 2019, p. 887)

Overpasses and underpasses may be necessary to minimize roadkill in some areas. This may be especially important for routes crossing KBAs. Disturbance can significantly affect species wellbeing; thus, key regions, especially for data deficient and threatened species, should be

avoided because their degradation, even with careful implementation, may have extremely large impacts on species (C.Hughes, 2019).

There is then another crucial issue with infrastructure construction promoted by the BRI: deforestation. “Many areas around the proposed route showed expansive forest cover and high rates of deforestation. 66.4% of the area within 50 km of roads was forested, accounting for an average 21.2% of forest within countries. Overall, 1.65% of forest within buffered regions was lost from 2001 to 2017, and average forest loss for each country was 6%. For railways on average 22% of forest fell within 50 km of routes, and 24.5% of the area within this distance of railways was forested, and 5.7% of deforestation per country was within this area. On average 2.1% of the area within 50 km of railways was lost from 2001 to 2016, which was 1.41% of overall deforestation and 7.9% of deforestation in any country. Of this, 32% of deforestation within 50 km fell within 14 km of roads, despite only having 25% of the total tree coverage in the buffer. In total 36.4% of forest was lost from 2001 to 2016, although the level of deforestation varied greatly by region” (C.Hughes, 2019, p. 889).

Besides, “many BRI routes run through geodynamical active areas that are vulnerable to flooding, soil erosion, landslides, and sedimentation in rivers. Examples are the Russia– China Amur Bridge transport corridor that dissects two nature reserves with pristine forests and the Karakoram Highway that traverses one of the most geodynamic regions on earth, posing risks to earthquakes, landslides, flooding, etc” (Zhai, 2018, p. 3).

2.2.2 BRI risks: raw materials and energy for infrastructure

Additionally, another key problem is BRI infrastructures will boost the extraction and use of raw materials, such as sand and limestone for production of concrete and cement, and fossil fuels. Sand extraction has already exceeded its natural renewal rate, damaging river deltas and coastal and marine ecosystems. China is already responsible for one-third of total greenhouse gas emissions, and production of cement, mainly employed to construct roads, is a significant contributor to these emissions (Fernando Ascensao, 2018). “Many portions of the road and railway may be constructed from cement, and there is a significant probability that much of this cement will be sourced from limestone karst, an under protected ecosystem that supports high levels of endemism, which is the phenomenon of one specific species only being present in one single habitat. Southeast Asia especially, with over 800,000 km2 of karst, may be

particularly vulnerable. China alone already uses about 63% of global cement at approximately 1.5t per capita annually. Thus, highly endemic karst faunas are at great risk. The BRI expansion will increase use and demand across the region while the decreased cost of mining karst rather than underground limestone is likely to disproportionately impact these unique systems" (C.Hughes, 2019, p. 891).

Indeed, "for all BRI countries, number and density of mines decreased sharply as distance from proposed routes increased. This indicated that new roads are planned to connect areas with many mines to facilitate export. Areas along proposed routes with few mines are vulnerable to exploitation given the additional connectivity, and existing mines may be enlarged, too. Mappable roads along the BRI totalled 170,126 km; the rail and pipeline networks were 80,451 km and 343,677 km, respectively. If the entire road network were made with or underlain by, roads would require 332,906 t of cement (roughly 436,107 t of limestone). Based on average dimensions, rail networks would require 28,278,527 t of cement (37,044,896 t limestone) and pipelines 157,320 t of limestone" (C.Hughes, 2019, p. 889).

Furthermore, many of the routes proposed through Southeast Asia create significant risk to biodiversity and endemism hotspots and these routes, together with other planned infrastructure, may facilitate wildlife trafficking. Overall, routes will favour easier access and, therefore, increase the vulnerability of species and systems across the Southeast-Asian region (C.Hughes, 2019).

"The construction of roads and railways, in fact, lowers transport costs and thereby shifts markets and human populations, which may lead to illegal poaching, logging, and other economic and environmental effects" (Zhai, 2018, p. 3).

"In particular, routes tracing the Thai-Malay peninsula and the coastline railway of Vietnam potentially pose some of the greatest risks to the largest numbers of species" (C.Hughes, 2019, p. 890) .

Since BRI constantly requires the construction of new roads, rails and infrastructure to make different areas wider and faster connected, another crucial point is how power is generated; Increased use of dams has huge implications for terrestrial and fresh water ecosystems. Other forms of power are also likely to be exploited along the route because BRI countries own 58.8% of the world's oil ,79.9% of its natural gas, and 54% of its coal reserves (Fei Duan, 2018). In fact, the large investment in pipeline infrastructure will increase the rate at which oil and gas

reserves are exploited, further locking the world into fossil-fuel dependency and high greenhouse gas emissions, just as much as the increased shipping associated with the BRI, which is one of the fastest-growing sectors in terms of greenhouse gas emissions (Fernando Ascensao, 2018). To be more specific, "China has great potential for and has largely increased BRI investments in renewable energy with the latest technology, but a larger share of BRI projects are oil, gas, and coal focused. According to a report by the World Resources Institute and Boston University's Global Development Policy Centre, out of China state policy banks' loans in the energy sector for the BRI from 2014 to 2017, coal power, nuclear power, and hydropower loans combined are almost seven times more than loans to solar and wind" (Zhai, 2018, p. 4).

For all the above-mentioned reasons, there is the risk of protected areas along the BRI corridors being downgraded, downsized and deprived of legal protection, thus facilitating access to and use of natural resources (Fernando Ascensao, 2018). For example, in Cambodia many PAs downgrading, downsizing, and deprivation of legal protection events and limited PAs coverage mean remaining unprotected ecosystems may be particularly vulnerable (C.Hughes, 2019).

As a consequence, a comprehensive, coordinated sustainable approach will be necessary in the future deployment of Belt and Road Initiative projects, as I will more deeply investigate in the next paragraphs.

2.3 Possibilities for mitigation of the environmental impacts of the Belt and Road Initiative

"If not properly addressed, the negative environmental impacts of the BRI are likely to disproportionately affect the world's poor, hence putting at risk the wellbeing of the very people it aims to help, other than negatively affecting global natural environments, biodiversity and human life" (Fernando Ascensao, 2018, p. 207).

There is a variety of possible strategies to mitigate the environmental problems caused by the implementation of the BRI and the Green BRI, both from a legal point of view and from a practical one.

2.3.1 Legal mitigation tools

Starting from the legal field, "host governments' policies regulate the execution of the Green BRI scheme, and host states' laws and regulations may provide at least minimum protection against environmental risks posed by BRI projects" (Zhai, 2018, p. 4). As suggested by Ascensao et al., national governments will need employ strict manners in guiding the development to ensure its ecological and social impacts are reduced as much as possible (Fernando Ascensao, 2018).

China has already published a wide suite of approaches, tools, and policies to minimize the impact of infrastructure on the environment domestically; the challenge is now for these same policies and guidelines to be implemented in Chinese infrastructure projects along the other BRI route's countries (C.Hughes, 2019).

On 29 January 2019, the Ministry of Commerce of China officially published the Guidelines for Country-by-Country (Region-by-Region) Foreign Investment and Cooperation. In addition to introducing the political, economic, cultural, and geographical conditions of 172 countries (all BRI-participating countries included) and prioritizing the development of a Green BRI, the Guidelines also include environmental laws and regulations of BRI host states; China has promised to comply with the laws and regulations of host states for all BRI projects, so theoretically, these norms can serve as the first line of defence against environmental repercussions caused by the BRI if they are enforced with deliberations on site selection, consultation, social impact, displacement, and long-term impacts, etc.

"Compliance with host states' environmental laws and regulations ensures that BRI projects meet local environmental requirements, while China's Green BRI policies that are linked to the UN 2030 SDGs make it possible to adhere to the highest international environmental standards" (Zhai, 2018, p. 4). In fact, one of the main international concerns related to BRI's environmental effects actually is the difficulty of China and the BRI-partner nations to abide by SDG's and the Paris Agreement. As early as 2015, China has released a domestic "Ecological Civilization" reform plan, supported by a series of new environmental policies, including a more vigorous Environmental Protection Law, which I have already

discussed in chapter 1 (Zhai, 2018). In October 2017, during the 19th CPC National People's Congress, President Xi Jinping further emphasized "speeding up reform of the ecological civilization system and building a beautiful China" (Xi Jinping , 2017). "The Ecological and Environmental Cooperation Plan, released in May 2017 by China's Ministry of Ecology and Environment, states that cooperation on environmental protection is a fundamental requirement for the BRI, and that such cooperation is vital for a green transformation of the national and regional economy and a major move to fulfil the 2030 Agenda for Sustainable Development" (Fernando Ascensao, 2018, p. 207).

According to Hughes, "guidelines must be developed for safeguarding the Key Protected Areas previously investigated through either strict protection or adaptive management" (C.Hughes, 2019, p. 890).

So, since China has already implemented a wide range of tools, policies and regulation to mitigate the negative impacts of BRI deployment, what else could be done to further improve environmental quality worldwide?

Hughes and Ascensao et al. suggest the emission of Environmental Impact Assessments (EIAs) and Strategic Environmental and Social Assessments (SESAs) of the BRI as a whole and along each major economic corridor (C.Hughes, 2019), (Fernando Ascensao, 2018).

Indeed, according to the first, sourcing policies must explicitly include environmental impact assessment associated with major consumables, such as cement. This is especially important for Southeast Asia and southern China regions, where many species that inhabit karst ecosystems are endemic and little is known about most of them. This is connected with more practical suggestions I will discuss later on in this chapter. Few EIAs for any part of the route have been published up to now and if national bodies and international funding agencies, such as the Asian Development Bank, Asian Infrastructural Investment Bank, and similar financiers impose the preparation of clear EIAs with international standards and supervision, the level of conservation in the region would highly increase (C.Hughes, 2019).

"The SESAs should provide a systematic evaluation of the environmental consequences of policies, plans and programmes, ensuring that they are appropriately addressed at the earliest stage of decision-making, concurrent with the economic and social consequences. SESAs have

been regularly applied in China since the 1990s, as they are a legal requirement for major economic development activities. In addition, credible environmental impact assessments of specific projects can prevent irreparable damage and generate substantial conservation and social benefits, such as biodiversity protection, increased carbon storage and improved water quality. For such environmental assessments to effectively avoid damaging impacts of the BRI, it is fundamental that China and its partners regard the SESAs not only as a formal requirement, but also as an important step in the process to add value to the projects. There is much to gain from strategically addressing all environmental impacts before projects begin, rather than ignoring and facing them later on, when repairing the damage is either impossible or extremely costly" (Fernando Ascensao, 2018, p. 207).

Inevitably, EIAs and SESAs can become more complex when infrastructure projects are promoted by more than a country and funded by a mix of international, national and private funds. However, the BRI, like most transboundary infrastructure programmes, consists of subprojects in different areas, with varying schedules, therefore an essential point is the instauration of a dialogue among those involved in the decision making process — governments, financial institutions, developers, non-governmental organizations and local communities — and researchers investigating biodiversity conservation, human health and climate change mitigation, in order to exchange knowledge and expertise, thus raising awareness about the possible environmental and social impacts of the BRI. In other words, the SESA process should involve all key actors. Given the huge number and variety of entities and bodies involved, it will be very important to develop an effective communication plan for research results.

Considering the vast diversity of natural and socioeconomic contests characterizing the BRI route, China and all the nations involved in the BRI should act as environmental stewards by planning infrastructures only if regulated by rigorous SESA frameworks, and building it in ways that are responsive to the different scenarios. Additionally, BRI partners could also integrate local conservation initiatives, taking place within each country's borders, to promote an inclusive approach to the SESA (Fernando Ascensao, 2018).

2.3.2 Practical mitigation strategies

"The Chinese Government has also been translating those sustainable objectives into concrete actions, such as increasing green energy investment, advancing cooperation, and exchanging

reference experience with BRI-participating countries on environmental protection" (Zhai, 2018, p. 5).

Starting from the most practical solutions, to protect KBAs and PAs from degradation, and considering that complete avoidance of all key areas for biodiversity along the entire route will be difficult, appropriate and adequate conservation provisions must be developed on a case-by case basis but, as just discussed, this will only be possible if comprehensive EIAs are conducted during the planning process. Moreover, further deforestation should be prevented wherever possible; this is especially important in Southeast Asia, which is already fragmented and subject to some of the highest levels of deforestation and has the highest aggregations of species richness per unit area and of vulnerable or threatened taxa (C.Hughes, 2019).

In order to increase renewable energy's utilization, it is also crucial for China and the other countries involved in the Belt and Road projects to invest in green financing, as I have already highlighted in chapter 1. "As a world leader in renewable energy, in fact, China has a wide range of opportunities to scale up renewable energy investments through the BRI. As stated by a recent report by Natural Resources Defence Council (NRDC), from 2008 to 2017, the global average annual growth rate of wind- and solar-power installed capacity was 19 percent and 46 percent, respectively. China's average annual growth rate of wind- and solar-power installed capacity reached 44% and 191%, respectively, laying a solid foundation for China's renewable energy cooperation with BRI countries. It is estimated that the total installed capacity of renewable energy in 38 countries along the BRI route could reach 644.334 GW from 2020 to 2030, and total investment in wind and solar power could reach $644.334 billion. China has formed an international development cooperation model for renewable energy, which focused on six BRI economic corridors and China–Africa cooperation. Some examples include the Sweihan Photovoltaic Project jointly developed by China's JinkoSolar and Japan's Marubeni in Abu Dhabi, UAE and Sinomatch and General Electric's cooperation on a 102 MW wind power demonstration project in Kapedo, Kenya, and others. Therefore, China's massive potential in renewable energy investment can not only go a long way in helping BRI countries meet their domestic clean energy targets under the Paris Agreement, but it can also greatly contribute to the reduction of global carbon emissions" (Zhai, 2018, p. 5). This last point would be particularly important, given that cement production accounts for at least 15% of China's total emissions and their enormous use of cement (>100 new cement plants planned along the BRI), PRC's emissions may further increase consistently (C.Hughes, 2019).

An additional field for investments should be environmental research. The BRI is an opportunity to channel funding to support research and monitoring of the various environmental effects of such a complex initiative, during both the construction and operation phases. “An important advance is the Digital Silk Road, led by the Chinese Academy of Sciences, a project that aims to share big data from satellite imagery and other Earth observations. However, ground-based information of species likely to be sensitive to BRI impacts is also essential. Therefore, the BRI could boost environmental research, particularly in remote locations in southeast, central and western Asia, to map areas of high value for biodiversity and carbon storage; such information, coupled with a range of global change scenarios, would allow BRI planners to avoid placing infrastructure in important conservation areas, and to be used to improve the network of protected areas and wildlife ecological corridors bisected by the BRI corridors” (Fernando Ascensao, 2018, p. 208).

Moreover, “in April 2019, in order to enhance international cooperation and share international experience, China launched, in partnership with the United Nations Environment Program (UNEP), the BRI International Green Development Coalition (BRIGC)” (Zhai, 2018, p. 5). This is a partnership project, initiated by the Ministry of Ecology and Environment (MEE) of China, which governs various targets, such as Chinese companies and BRI government officials, through the aid of intermediary agencies (Xiaofeng Liu, 2023). The BRIGC develops ten thematic partnerships and already counted over 130 partners by May 2019, including private business, environmental institutions, research bodies and international organizations (Zhai, 2018).

The BRIGC showcases advanced work and provides insights in pollution treatment, the management and conservation of ecosystem, green energy, green production, green lifestyles, green finance, etc. For example, the restoration of coast in Indonesia, the Karot Hydropower project in Pakistan and the Esquel Plant in Vietnam Industrial Park. Most of the cases were from cooperative projects as well as practices by BRI-participating countries. They demonstrate the cooperative efforts within and between BRI-adhering countries as well as among stakeholders and may further enhance green consensus, boost confidence in Green BRI, and spawn more down-to-earth practices for green development (Zhai, 2018).

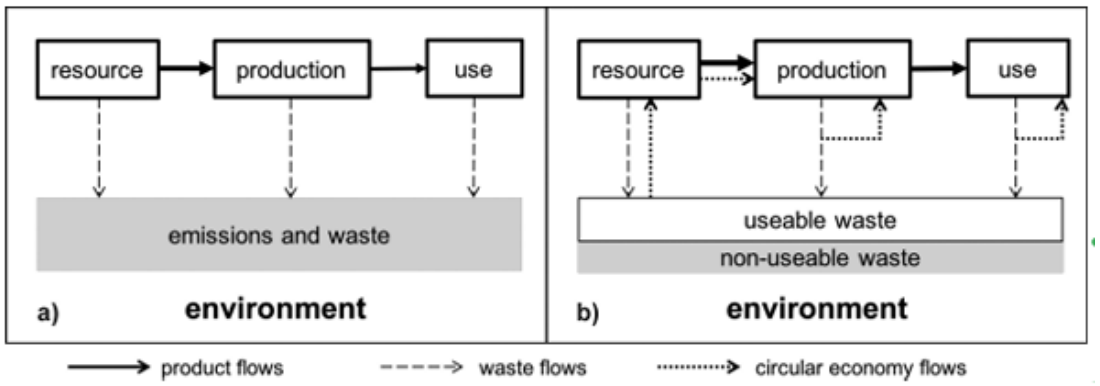
2.3.3 Circular economy

The term "circular economy" (CE) defines the efforts to develop new business models that delink economic development from resource extraction and environmental impacts, as opposed to the traditional linear model of "take, make, dispose" (Ellen MacArthur Foundation, 2013). The concept appeals to rapidly industrializing countries like China, and is widely supported by the European Commission and member States (Junming Zhu, 2018). In fact, "in 2020, China announced the target of hitting the peak of carbon emission before 2030 and reaching carbon neutrality by 2060. In doing so, China is amongst the first emerging economies announcing such target and in policy alignment with commitments made by the EU, the UK, the US, and others. The Chinese announcement came at a time when the country was seen as a large polluter of the world, certainly in terms of greenhouse gas emissions" (Raimund Bleischwitz, 2022, p. 1).

China's circular economy demonstrates how sustainability policies can be integrated into economic norms and practices to maintain the provision of key ecosystem services. Unfortunately, implementation of these policies across China varies, and they do not apply to Chinese investments overseas, at the moment (C.Hughes, 2019).

First, I will graphically and descriptively explain the difference between a linear economy and a circular economy and after that, I will delineate the history of CE policies in China, taking into consideration "China has a long tradition and wider ambitions in terms of the CE and an 'ecological civilisation'" (Raimund Bleischwitz, 2022, p. 1).

Figure 10. Graphical explanation of a typical linear economy and of a circular economy



Source: (Junming Zhu, 2018, p. 112)

"Figure a (within Figure 10 above) is a simplified representation of a conventional linear economy where resources are extracted, then converted in the production process into products, which are used and finally disposed as waste. All of the three phases—resource extraction, production, and use—are associated with generation of solid wastes and other pollution emissions that damage the atmosphere, water, or land." (Junming Zhu, 2018, p. 111), while "figure b is the representation of a circular economy. At the resource extraction phase, recyclable by-products and waste from resource extraction that were previously discharged are now treated as resources. Similarly, waste generated from other phases is also recovered from the stock of reusable waste. The result is more resource flows available to the production process without necessarily increasing natural resource extraction. The production phase uses as intermediate inputs these additional resource flows, its own by products and wastes that were previously discharged, as well as wastes from final consumption" (Junming Zhu, 2018, p. 111). To sum up, a circular economy basic characteristic is taking "reduce, reuse, recycle" (3R) as the key principles, and targeting low consumption, low emission and high efficiency as the target objectives (Yupeng Fan, 2020) (Raimund Bleischwitz, 2022).

In the general framework of CE policies, there are four main categories of policies implemented, namely resource-oriented policies, production-oriented policies, waste policies and use-oriented and life-cycle policies. However, they all are "developed and implemented through a top-down approach, from the central government to provinces, cities, and factories through setting targets, creating indicators for different industries, and experimenting with various pilots" (Raimund Bleischwitz, 2022, p. 2) (Junming Zhu, 2018).

Among policies related to the CE, the ones having the longest history are those regarding comprehensive utilization of resources (CUR), introduced first in the early period of the People's Republic of China of the 1950s, drawing on the CUR concept first originated in the Soviet Union, and responding to the conflict between China's desire for rapid industrialization and the country's limited resource availability; they were first employed for the use of water resources through construction of hydrology projects in early 1950s; after that, in the middle-1950s the concept was further developed in the use of by-products from mining and production of coal and other fossil fuels and only in the late 1950s, these policies were applied to the use

of valuables from industrial solid waste, wastewater, and waste gas and pre-emption of health impacts (Junming Zhu, 2018).

Another policy focus that closely relates to the CE is cleaner production, or the so-called "production-oriented policies". "Cleaner production calls for prevention of pollution from the source-production processes-through improvement in technologies, management, and operational systems that reduces emissions and increases efficiency. The idea originated from the 'Pollution Prevention Pays' program of 3M in the USA and cleaner production in Europe, both in the1970s. But China was more explicitly affected by the United Nations Environment Program (UNEP) and the United Nations Industrial Development Organization gradually in the 1990s" (Junming Zhu, 2018, p. 112).

Apart from cleaner production, which focuses on a single firm or production process, Eco-Industrial Parks (EIPs) rely on cooperation among separated firms to increase resource efficiency and reduce environmental implications (Junming Zhu, 2018). "Starting in the 1980s, the Chinese government began setting up industrial parks in coastal cities. China is estimated to host 2543 parks in 2019 that produce more than 60% of the national industrial output- China has also been establishing Eco-Industrial Parks (EIPs) since 2001 in collaboration with UNEP as a key tool to combine industrial innovation and development with ambitions towards what is now called an 'ecological civilization'" (Raimund Bleischwitz, 2022, p. 7). It is likely that in the near future both industrial parks and eco-industrial parks will play a crucial role in circular economy, and in a more CE-oriented industrial system, more specifically.

IP and EIP have also been the hubs for the development and progression of new, advanced technologies; Some of them have reached the international advanced level, forming a technology innovation system with industry-university-research integration. These technologies belong to 'eco-innovations', which means technological and non-technological innovations that prevent, alleviate, and allow recovery from environmental pollution and damage. Eco-innovation provides novel ways of recycling and reusing materials, giving them other industrial applications through technology improvements. This category of innovations has been fundamental in the development of CE policies (Yupeng Fan, 2020).

For what regards waste policies, concerns about industrial pollution and waste emerged in China already in the 1950s, but did not rise enough attention back then (Junming Zhu, 2018).

"In the 1990s, the State Environmental Protection Administration established a set of regulations and standards to prevent pollution from solid waste. The policy-making efforts became better grounded and systematic after the Law of the Prevention and Control of Environmental Pollution by Solid Waste was enacted in 1995; this law was then later reviewed in 2004 and 2016. The regulation made an explicit linkage between mitigation of solid waste generation and CE efforts, such as cleaner production and CUR. Unlike other types of policies, these waste policies contribute to CE flows indirectly, simply by partially inducing the waste flows to return back into resource extraction and production processes (Junming Zhu, 2018).

Lastly, use-oriented and life cycle policies have received less attention in the CE policies general framework built up in China in the last decades. "One of the few examples is a regulation on remanufacturing of automobile parts, announced by the National Development and Reform Commission in 2008, which extends the life span of in-use of auto parts", while a more recently-released policy is the 'Promotion Plan of Extended Producer Responsibility (EPR) Policy' issued by the State Council in December 2016. The policy objective is to integrate environmental impacts related to the distribution, use, and disposal of products into producers' design and production decisions" (Junming Zhu, 2018, p. 113); in other words, it is a policy approach that shifts the responsibility for products along the entire lifecycle- including at the post-consumer stage- directly to the producers.

After presenting the four main types of policies composing the wider category of CE policies in China, I can now delineate a proper timeline of policies and regulations approved by the Chinese government in the years from the 1970's, which mark the beginning of economic reforms for the country till today:

- "In the late 1970s and 1980s, a series of policies particularly dedicated to promotion of CE practices emerged, still with a focus on comprehensive utilization of resources" (Junming Zhu, 2018, p. 113);
- The concept of circular economy was formally introduced and accepted in China in 2002 after more than a decade of rapid development and socio-economic success and realising environmental challenges with increasing debate about cleaner production (Raimund Bleischwitz, 2022);
- In 2003 the first formal policy introducing EIP was released, followed by a wider range of policies in the years 2006-2008 (Junming Zhu, 2018);

- In 2005, the State Council promulgated “Opinions on accelerating the development of circular economy”, including a policy framework, key principles and objectives, key tasks and policies, and promoting both resource productivity and pollution mitigation as the targets (Junming Zhu, 2018), (Raimund Bleischwitz, 2022);
- In 2008, the 11th National People's Congress published the “Circular economy promotion law of the People's Republic of China”, which entered into force on January 1, 2009. This policy was particularly relevant for two main reasons: it was the first official policy body using the exact words “circular economy” and it highlighted the role of the 3R strategy (reduce, reuse, recycle) in developing CE as a key tactic for national economic and social development (Junming Zhu, 2018) (Raimund Bleischwitz, 2022) (Yupeng Fan, 2020);
- In 2009, the State Council issued “Regulation on the administration of the recycling and disposal of waste electrical and electronic products”, being the administrative application of the “Circular Economy Promotion Law” released in the same year (Yupeng Fan, 2020);
- A series of other regulations regarding waste management, fly ash etc were issued in the next few years (Yupeng Fan, 2020);
- “The Central Committee and State Council in 2015 issued ‘Opinions on accelerating the construction of ecological civilization’ to further clarify ‘take the green, circular and low-carbon development as a basic way to build ecological civilization’” (Yupeng Fan, 2020, p. 3);
- The following policies, clarified in the Revised Indicators of the “Circular Economy Promotion Law” released in 2017, further emphasized the circularity of industrial systems, after the achievement of relevant improvement in resource and energy efficiency (Raimund Bleischwitz, 2022);
- “The 13th Five Year Plan (2016–2020) validates the importance of CE as a national policy and as a fundamental pillar of the economy.” (Raimund Bleischwitz, 2022, p. 3);
- The “Circular Development Leading Action Plan”, published in 2016 by National Development and Reform Commission (NDRC), aims to address drivers of environmental and social externalities and focuses on opportunities in new digital solutions, such as the eco-innovation tools (Raimund Bleischwitz, 2022);
- In 2018, the “Circular Economy Promotion Law” (first issued in 2008) was revised and amended (Raimund Bleischwitz, 2022);

- The 14th Five Year Plan on Circular Economy , valid for the period 2021–2025, continues to promote resource conservation and recycling in China by setting targets and help ensure national resource security, and even more relevant, it clearly emphasises it as an approach to tackle climate change and achieve carbon neutrality by 2060, in line with the declared key objective (Raimund Bleischwitz, 2022).

As appears evident by looking at this regulatory timeline, government agencies involved in the CE gradually became more pluralized in China, too. They formed a comprehensive operational entity, where each of the agencies has its own specific role in issuing laws and regulations
"The National People's Congress, as the legislature, enacts laws that support the CE, among which the most related are the "Circular Economy Promotion Law", the "Cleaner Production Promotion Law", and the "Law on Prevention and Control of Environmental Pollution by Solid Waste". The State Council, as the top executive branch, emphasized the CE as a development strategy and designed overarching rules and programs to guide more detailed policies and implementation. Within the State Council, three agencies lead in promoting the CE, namely the National Development and Reform Commission (NDRC), the Ministry of Industry and Information Technology (MIIT), and the Ministry of Environmental Protection (MEP)" (Junming Zhu, 2018, p. 113-114).

The main policies instruments employed since the beginning for implementation of circular economy policies have been:

- Mandatory measures: mostly direct mandates of firm behaviour (i.e. using a certain technology, reusing waste etc.), or standards, such as standards for materials or energy efficiency in the production process;
- Incentive-based tools, including a wide range of instruments, with tax relief and subsidies being the most used;
- Demonstration projects, that function by recognizing the provinces, cities, and local jurisdictions where a CE has been well developed with national nominations, and taking them as models to be followed by other areas to improve in socio economic development.

(Junming Zhu, 2018)

More specifically, “since the official approval by the State Council in 2005, the NDRC has been organising two batches of national CE demonstration pilot projects together with relevant departments; later, during the 12th Five Year Plan (2011–2015), China’s NDRC synthesized 60 best practices from the pilot projects at enterprise, industrial park, and regional levels (NDRC, Circular Economy best practices). These projects have been examined through an ‘Assessment scheme of national circular economy standardization pilot project’, which included four assessment criteria:

1) Operational efficiency mode of a CE;
2) Development of a CE standard;
3) Application and readiness of dissemination of CE standards;
4) Development of a CE standard information platform”.

(Raimund Bleischwitz, 2022, p. 6)

This system of demonstration projects has been implemented with the objective of promoting inter-regional or inter-cities learning and ideas’ exchanging and this method seems to have worked efficiently.

So, what have been the main achievements of the circular economy system in China, and what its weaknesses?

“Since CE, unlike environmental protection, is not in conflict with China’s aspiration for economic and industrial progress and development, and has therefore always met the State Council and political leaders’ favour, CE policies have developed vastly and progressively, attaining great results in implementing economic growth and industrialization” (Junming Zhu, 2018, p. 116).

Moreover, policy making has substantially benefited from knowledge drawing from international experiences, such as from Japan, the USA, the Soviet Union, UN and the European Union.

In addition, the common efforts of various bodies and organizations have led to the creation of a comprehensive set of policies and government agencies that coordinate and cooperate with one another, a constantly increasing coverage of reuse opportunities, a continuous evolution of production-oriented measures on multiple geographical level (top-down approach), and a plurality of policy instruments (Junming Zhu, 2018).

As a result, CE policies in China have reached remarkable achievements in the last decades, contributing to the country's journey to sustainable development.

"According to the National Bureau of Statistics, China's CE development index reached 137.6% in 2013 taking 2005 as the base period, with an average annual growth rate of 4%, and China's resource recycling industry output value was 1.5 trillion yuan in 2015. Compared with primary resources utilization, resources recycling saved nearly 200 million tons of standard coal and reduced emissions of 9 billion tons of wastewater and 1.15 billion tons of solid wastes. In 2005–2015, China has reused 2.04 billion tons of industrial solid wastes, including 790 million tons of steel scrap, 80.85 million tons of recycled non-ferrous metals (recycled copper, recycled aluminium, recycled lead, and recycled zinc), 188 million tons of waste plastics, and 603 million tons of waste paper. In the first four years of "12th Five Year", resource productivity increased by about 10%, while energy consumption per unit of GDP and water consumption per industrial added value decreased by 13.4% and 24%, respectively." (Yupeng Fan, 2020, p. 4,5)

Although both resource and carbon intensity have been successfully reduced in China, and are now reaching closer to ratios observed in the Organisation for Economic Co-operation and Development countries (OECD) (Raimund Bleischwitz, 2022), Chinese CE policies still present some issues and weaknesses, namely:

- The current policy framework stresses too much on the means toward the CE, while it should focus more on its objectives and future targets (Junming Zhu, 2018);
- Lack of a systematic, life cycle perspective that can be observed in current CE policies may not only leave above-mentioned expanded foot print unattended, but also allow environmental problem shifting (Junming Zhu, 2018);
- Moreover, there is a variety of incentive-based measures, but none of them is market-based, that is, internalizing externalities and shifting the market toward efficiency (Junming Zhu, 2018). In addition, "the bonus system for public officials that is aligned with broader macro-economic goals is not yet encouraging transformations in each province" (Raimund Bleischwitz, 2022, p. 8), as explained above;
- Other challenges regarding the effective implementation of EIP projects are the gaps of guidelines and standards of EIPs, the disjoint between EIP planning and its practical implementation, the distortion of EIP concepts and the lack of comprehensive assessment frameworks (Raimund Bleischwitz, 2022);

- In general, unclear law enforcement bodies, weak enforcement strength, and single enforcement means have seriously prevented the resource recycling system from being accepted and implemented by the public and enterprises, being the cause of the differences in implementation and effectiveness of CE policies among different provinces across China (Yupeng Fan, 2020);
- For what concerns the possible contribution of CE to future decarbonisation, there are a few issues to be solved: there is at the moment no indicator system linking CE and decarbonisation in either eco-industrial park indicator system released by the National Ministry of Environmental Protection or circular economy industrial park indicator system issued by the NDRC, and systems thinking should go beyond technology and industrial supply and entail a perspective on deep transitions and path dependencies at the provincial and sectoral level in China; last but not least, China is becoming a consumption society with high aspirations from the emerging middle class, so there are risks of a societal division (Raimund Bleischwitz, 2022).

The unequal deployment and effectiveness of CE policies in China has been further investigated by the study conducted by Yupeng Fan and Chuanglin Fang, which assessed the circular economy development levels of 31 Chinese provincial regions in 2017 using Data Envelopment Analysis (DEA). The results confirmed the differences in the application and effectiveness of CE policies, and three main clusters were individuated:

- Cluster I, with the best CE-performer cities, includes: Beijing, Tianjin, Shanghai, Guangdong, Hainan, Tibet, Qinghai, and Ningxia, scoring an overall efficiency of 1. These are directly under the central government, which have new development concepts, advanced resource reuse and recycle technologies, efficient industrial structure and a complete infrastructure system. Moreover, due to special natural endowments, Hainan and Tibet mostly employed clean and renewable energy. Qinghai is an important source of fresh water in China as the source of the Yangtze, Yellow, and Lantsang Rivers. 90% of Qinghai land is restricted and prohibited zone, only 10% is available to be developed. Most of the best performing provinces are in the coastal developed area;
- Cluster II, including a few provinces scoring between 0.669 (Zhejiang) and 0.482 (Henan), is at the middle level of CE development, with high urbanization, high

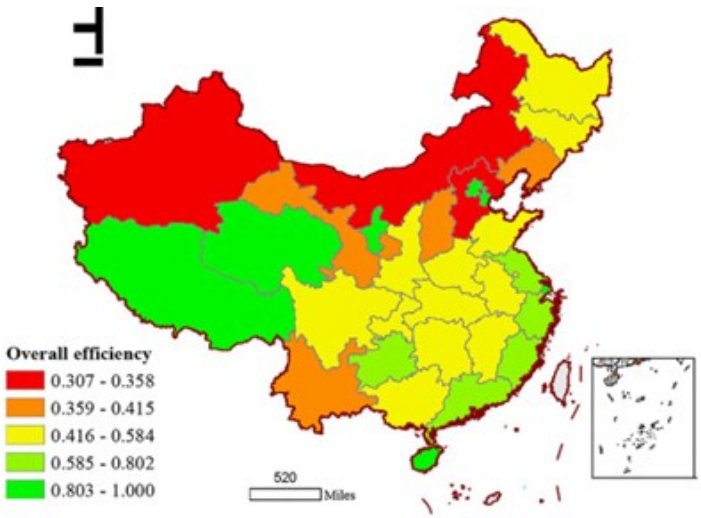
pollution and high industrial development as the main causes preventing them from achieving good CE results;

- Cluster III, which has the lowest OE values, accounts for 29% of the total amount, including Hebei, Shanxi, Inner Mongolia, Liaoning, Hunan, Guangxi, Yunnan, Gansu, and Xinjiang. In particular Liaoning, Shanxi, Xinjiang, Hebei, and Inner Mongolia were the top five worst regions in overall efficiency with the average value is 0.359. These five provinces are the major heavy industrial bases in China and consume excessive energy. For example, in Xinjiang, secondary industry occupied 40% of total GDP in 2017, among which 84% are occupied by heavy industry, including extraction of petroleum and natural gas, processing of petroleum, processing of nuclear, manufacture of raw chemical materials and chemical products, and mining and washing of coal.

(Yupeng Fan, 2020)

Figure 11 illustrates the OE (Overall Efficiency), PTE (Pure Technical Efficiency) and SE (Scale Efficiency) of the 31 provinces analysed, with red colour indicating the worse scoring ones, and bright green highlighting the best performing ones.

Figure 11. Overall Circular Economy efficiency of PRC's 31 provinces



Source: (Yupeng Fan, 2020, p. 6)

To sum up the topic of circular economy, I can certainly state CE policy framework has progressively developed during the last few decades, achieving valuable results in both resource efficiency and carbon emission reduction for the country, and contributing to the development of new, more efficient technologies and circular cities and industrial systems; however, CE inevitably need improvements and constant policy-adaptation to continue to positively affect China's sustainable development in the future. Nevertheless, circular economy surely is a key mitigation strategy for China's environmental issues, together with waste management, that I will deeply analyse and investigate in the next chapter.

2.3.4 Circular economy: the Chinese internal debate

Through the analysis of the results found on CNKI (China National Knowledge Infrastructure), which is the biggest online academic database currently existing in China, the presence, frequency and content of academic articles, academic thesis and research -fully written and prepared by Chinese authors- on the topic of circular economy as a mitigation tool for the harmful effects of the BRI and the Green BRI were investigated; the objective was to verify the level of activity of the Chinese internal debate on this argument, and to investigate the specific topics of discussion.

Findings are the following:

- Number of sources= by typing *"*Circular economy Belt and Road Initiative*"* on CNKI a total of 44 results appeared; however, only 6 were actually relevant to the topic of circular economy development within the context of the Belt and Road Initiative. All the others were just partially matching results and were therefore not included in the analysis.
- Typology of the texts: 2 of the 6 total pertinent texts were academic thesis, while the remaining 4 were published in Chinese scientific journals, prepared in collaboration with Chinese universities;
- Academic bodies involved: the Chinese universities involved specifically are the "Sichuan Institute of Chemical Technology", the "Law School of Nankai University", the "Beijing Normal University" and the "Xi'an University of Technology";

- Journals involved: the journals which published the selected articles were “Resource Recycling” and the journals corresponding to the above-mentioned universities;
- Date of publication: the sources retrieved were published in 2017, 2018, 2021, 2023, and 2024 respectively.

Given that the research was not consistent nor satisfying, due to the lack of resources and evidence, we can assume that the Chinese internal debate is not very active and dynamic on the topic. We changed the keywords and tried to look for “Circular economy China”, instead.

The research was much more fruitful, resulting in 673 total articles as an outcome. For obvious reasons I did not analyse every single source, but -by applying some filters- I tried to establish a trend to define the internal debate about China’s circular economy at the moment, and I selected some results:

- Date of publication: between 2017 and 2023 an average of 21 texts were published on CNKI, suggesting a lively and proficient Chinese internal debate on the topic, however in 2024 the articles issued on the platform decreased to only 4, and in 2025 only 3 articles were issued. This could tell us that in the last few years the debate on circular economy within Chinese students and authors has significantly declined, probably because they shifted their attention to other topics, possibly the geo-politic global situation, or more in general climate change, or other topics;
- Specific topic: the sub-topic denominated “Environment science and resource utilization” gave out 67 articles (out of the total 673). From this data I can assume that the articles actually investigating both circular economy and the mitigation of environmental harmful impacts originated from the implementation of the BRI and Green BRI projects, or circular economy and other environmental-related topics (such as waste management, CO2 emissions, industrial sustainable development and so on) are quite a consistent part of the total texts;

To sum up, the Chinese internal debate on circular economy evolution in China seems to be quite lively and active, even thought it has undergone a decrease in the last two years.
Opposite, the internal debate on the topic of Circular Economy as a mitigation tool to the negative environmental impacts of the BRI and the Green BRI appears to be very limited and static. This means that China as a country has certainly been developing circular economy

policies and practical actions, but it has probably not yet put them in relationship to BRI projects and effects, at least within the scientific and academic debate.

Chapter 3: The waste management

3.1 The waste management in China

3.1.1 Waste management definition and its importance to China

"'Waste Management' can be defined as the process of collecting, transporting, processing, recycling, or disposing of waste materials in an environmentally responsible way. It involves practices and methods to preserve the environment, by reducing air and water pollution, the carbon-footprint and improving public health. Its main aim is to create a circular economy (within a country or a more specific geographical area) by transforming waste into a valuable resource. Therefore, it is also connected to the concept of "Waste to Energy" (WTE)" (Rohit Panchal, 2021, p. 11).

Waste management is still a challenging global issue because of the huge and fast increase in the amount of waste produced as a result of rapid economic growth, technological development, population growth and consumerism (Na Song, 2021). All of these reasons surely apply to China, a fast growing and developing country.

"Plastics are very harmful, not biodegradable materials. This means that -instead of decomposing- once discarded, they slowly break down into smaller particles, the so-called 'micro plastics' that remain into the environment nearly forever and can also enter our food chain. It is estimated that from 1950 through 2015, global cumulative generation of primary and secondary (recycled) plastic waste amounted to 6300 (MMT), of which only about 10% (600 MMT) were recycled and utilized" (Shi, Zhang, & Chen, 2020, p. 188). However, plastic waste has dual characteristics of solid waste and secondary material (Shi, Zhang, & Chen, 2020). This means that, on one side, their discard and process produce environmental pollution; on the other side, as secondary materials, recycled plastic waste is a substitute to virgin materials, thus avoiding shortage of the latter and contributing to economic benefits (Shi, Zhang, & Chen, 2020).

Why is waste management so important to China?
There are at least two main reasons why the process of waste management has become such an urgent topic in a country like China, namely the growing environmental awareness and the compliance to new, stricter regulations.

Environmental consciousness has grown in the country in the last few years, particularly since 2017. China, indeed, is a nation that has gone through a huge, fast-paced development and urbanization in a relatively short period of time. During the years of China's opening up, roughly from the mid-1990s till the early 2010s, the Chinese industrial system started to grow enormously and the demand for raw materials also increased consequently. "China has cumulatively imported 112 MMT plastic waste in the past 26 years. The total output of plastic products in China increased from 4.43 MMT in 1992 to 58 MMT in 2012" (Shi, Zhang, & Chen, 2020, p. 195). Initially, large amounts of solid wastes used to be treated in small-scale family workshops, which evidently did not have pollution control facilities. Therefore, organic waste gas, dust and odour were directly discharged into the environment, causing heavy environmental problems. This is why the Chinese government started setting a legal system to regulate the growing amount of imported plastic waste.

3.1.2 Waste management: the regulatory framework

In order to give a brief overview of waste management regulatory system, I can state that in 1995 the "Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Wastes" was approved (Tan, Ren, Han, & Chen, 2021), followed in 1996 by the "Interim Administration Provisions of Environmental Protection for Wastes Import*"* regulation, that introduced a permission approval procedure for solid waste import into the country and introduced the need for imported wastes to meet specific quality and pollution control standards (Shi, Zhang, & Chen, 2020). In the following years the Chinese government released a set of norms and provisions regulating industrial solid waste, waste recycling and disposal and hazardous waste disposal (Tan, Ren, Han, & Chen, 2021). These laws led to the setting up of a consolidated and relatively complete solid waste management system, that has recently been revised in 2020[1].

With regard to the issue of plastic waste trading networks, "China has been the world's largest importer of plastic waste for the last three decades" (Shi, Zhang, & Chen, 2020, p. 187).
"The trade network grew significantly from the mid-1990s to early 2010s; The global total trade volume increased from 0.9 million tons in 1992 to 16.4 million tons in 2012 and the number of trade connections from 452 to 2248 in the same period" (Shi, Zhang, & Chen, 2020,

[1] For reference see Table 1 in the Appendix.

p. 191). Moreover, in the period between 1997 and 2012, the intercontinental or sub-continental trade flows raised from 38% to 64%, indicating longer transport distances and a higher spatial separation among trade partners in the network, given that after 1997 China grew rapidly as the largest importer of plastic waste from Europe and all other areas of the world (Shi, Zhang, & Chen, 2020). It is from 2012 onward that China started raising awareness on the need to better manage solid wastes, in particular plastics.

With reference to Table 1 in the Appendix, I can notice how the General Administration of Customs (GAC) launched the "Green Fence Action" from February to November 2013, in order to investigate and sanction unauthorised and unqualified solid waste import flows, such as smuggling of plastic waste without government permission and imports that did not abide by environmental standards (Shi, Zhang, & Chen, 2020). As a result, the family-workshops mentioned beforehand were shut down and, more in general, the quality of imported plastic waste improved. In this second phase, characterized by increasing concerns related to the import of plastic waste, the 18th Party Congress implemented the "Five-in-One" overall layout, introducing the concept of entwining economic development, political reforms and social progress. In other words, the CCP had the objective to build a rich, stable and sustainable future for China, by focusing on five areas:

1. Economic development, particularly on sustainable, high-quality growth;
2. Reforms, following the previous path of regulations and norms;
3. Political democracy, in order to consolidate the political system and meet the requirements of modern governability, but always maintaining the CCP control;
4. Social culture, focusing on promoting values strengthening the social cohesion;
5. Environment and ecology, enacting a development plan in line with the principles of ecology and sustainability.

(Tan, Ren, Han, & Chen, 2021)

To sum up, "the introduction of the "Opinions of the CPC Central Committee and State Council on Accelerating the Ecological Civilization Construction" and the formal introduction of the Five Development Concepts provided strong policy guidance and theoretical support to the solid waste management" (Tan, Ren, Han, & Chen, 2021, p. 361). In China, in fact, a key feature that has always encouraged and facilitated the deployment of a variety of projects, including that of a better waste management system, is the support of the State, both from a monetary and a regulatory point of view.

It is this evolving and fast-changing context that eventually led China to the approval of the "Import Ban" promulgated by the General Office of the State Council in April 2017. This crucial reform consists of a comprehensive action plan to prohibit trash import and reform the national solid waste import management system. In particular, according to this ban and the follow-up policies, post-consumer plastic waste was no longer allowed to be imported into the PRC from January 2018 and plastic waste from industrial sources were banned from January 2019. The five categories of post-consumer plastic wastes that were banned are:

1. parings and scrap of ethylene polymers (HS commodity code: 391510);
2. styrene polymers (391520);
3. vinyl chloride polymers (391530);
4. polyethylene terephthalate (PET, 3915901);
5. parings and scrap of other plastics (3915909).

(Shi, Zhang, & Chen, 2020, p. 188)

"The 'Import Ban' inevitably had an enormous impact on plastic waste trade networks and this raised international media attention. China's solid waste ban changed the global recycled solid waste supply chain, which diverted solid waste to other markets, like Malaysia, Thailand and Indonesia and to Southeast Asia in general" (Na Song, 2021, p. 1118). Thailand had both the largest increase of import of 0.41 MMT and the largest growth rate of 260%. Import by Chinese Taipei and Indonesia also raised by more than 100% (Shi, Zhang, & Chen, 2020). However, the aforementioned countries have been very cautious not to become "dumping sites" for developed nations and, consequently, issued regulations and provisions to restrict the import of plastic waste into their national borders. This was also necessary considering that diverted plastic scrap appeared to be handled by small scale waste processors, operating under little to no environmental standards. This also increased the flow of potentially hazardous waste (Na Song, 2021). In fact, the volume of import by Thailand and Malaysia in 2019 reduced to below its 2017 level (Shi, Zhang, & Chen, 2020, p. 196), proving the speculations about these countries becoming new centres for receiving and processing such waste to be false.

This in turn is leading to major global waste producers such as the USA, UK, Japan, and Australia facing the challenge to establish alternative mechanisms to deal with the solid waste within their borders (Na Song, 2021).

On the other hand, most of the main exporters of plastic waste have reduced their volume of export. For example, the USA exported 1.1 MMT of plastic wastes in 2018, which is 36% compared to 2017. Its export to China declined by 82% from 2017 to 2018. Export volume of the USA further declined to less than 0.7 MMT in 2019, or 41% of the 2017 level. Similar trends also took place in Japan and South Korea. On the other hand, European countries were less affected. For example, exports from Germany, the UK and France only dropped by 5% to 15%. Regional trade networks forming within Europe have somehow relieved the shock produced by China's import ban (Shi, Zhang, & Chen, 2020).

To sum up, the "Import Ban" approved by China in 2017 has certainly had a major impact on global plastic waste trade relations, particularly shaking the East and Far East side of the world; however, it also stimulated the creation of new regional trade communities within Europe, while also aiding China to reach a better balance between economic development, political reforms and sustainable growth.

3.1.3 The waste to energy process

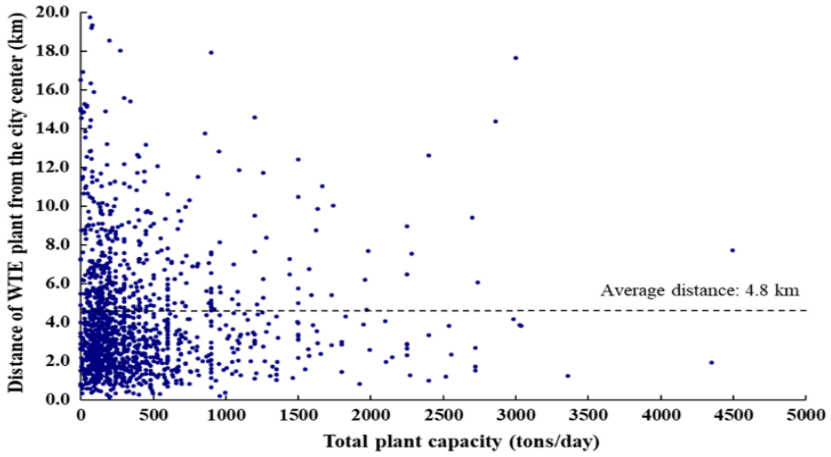
It is now insightful to discuss Waste to Energy (WTE), that "refers to the process of generating energy in the form of electricity or heat from the combustion or conversion of waste materials, including Municipal Solid Waste (MSW). More precisely, WTE recovers two forms of energy from the combustion of residual MSW: (a) electricity (0.4–0.5 MWh/t of waste), and/or (b) steam (>0.5 MWh/t). These can be used for: a) district heating/cooling, and b) the industry, e.g., desalination, wastewater plants, paper mills, etc." (Bourtsalas, 2023, p. 309). The main difference between conventional incinerators and the high-end process of combustion based WTE is that the latter operate with advanced Air Pollution Control (APC) systems, and abide by strict air quality standards; moreover, combustion based WTE mostly use non-hazardous urban and industrial by-products. Furthermore, considering that these plants operate at high temperatures, around 850–1000 °C, the process significantly destroys the pathogens contained in the residues. On average, WTE reduces the volume of wastes by 90%.

Naturally, WTE presents some disadvantages, too. First of all, the fact that WTE facilities are often considered anaesthetic has been an obstacle to their development. However, modern WTE facilities operating in the US, Europe, Japan, and China are designed with this concern

in mind. For example, WTE plants located in the centre of architecturally relevant cities, such as Vienna, Osaka, and Paris, have shown that such plant designs are congruent with local aesthetic requirements (Bourtsalas, 2023).

Another issue is the distance of WTE facilities from the city centres: "an analysis of primary data by the Earth Engineering Centre of Columbia University (EEC) showed that the average distance of WTE plants from the city centre is about five kilometres; Most of the plants in Japan and the EU are located close to city centres, while the 'outliners' are mostly situated in the USA (Bourtsalas, 2023, p. 311), as noticeable from Figure 12.

Figure 12. WTE capacity (x-axis) vs distance of WTE from city centre (y-axis). The analysis represents all the about 1000 WTE plants of the World.



Source: (Bourtsalas, 2023, p. 311)

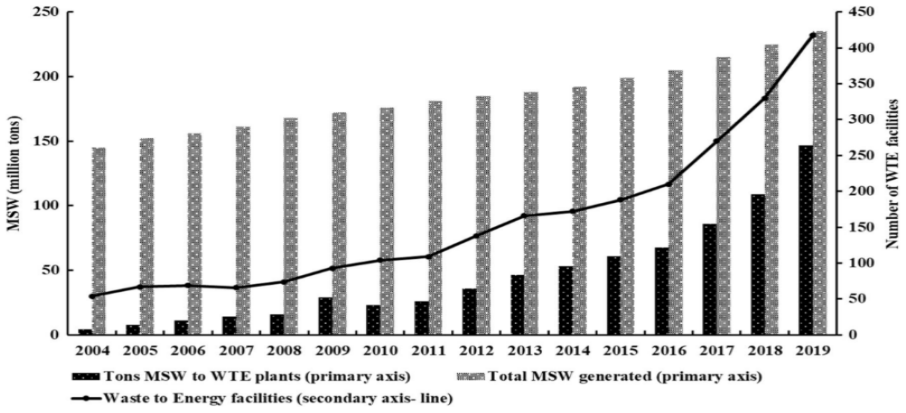
Furthermore, the main challenge of the landfill ban for lower-income regions is the consideration that low charges may not provide sufficient incentives against land filling, while high charges may result in illegal disposal. This leads us to address the topic of policies and fiscal tools necessary for an efficient WTE deployment. Indeed, policy and economic incentives are required to support the waste management infrastructure, as well as comprehensive standards for renewable energy production. On one side the EU has approved the "European Renewable Energy Directive" -which has been a brilliant way to encourage the increasing use of waste to energy technologies in Europe. On the other side in China, national policies included WTE as a form of renewable energy, with the first augmentation seen in the "Renewable Energy Law" approved in 2005, where the national government accepted most of the risk of the investments, by endorsing effective Public and Private Partnerships (PPP). For what regards the success of the Chinese development of WTE facilities, in fact, the strong support given by national and local governments to the sector has been essential. Favourable

policies and incentives include: tax incentives, such as corporate income tax exemption for the first five years of operation, electricity subsidies, and municipal subsidies through waste disposal fees.

However, WTE infrastructure development has encountered significant public opposition; this happened, for example, on occasion of the construction of the Nanjing WTE plant. In this and other cases, governmental authorities have played a crucial role in mitigating the protests (Bourtsalas, 2023).

Moreover, the Chinese government has also contributed significantly to the deployment of WTE facilities in China by means of high governmental funds. More specifically, "the national Government of China invested USD 12.3 billion in the WTE sector, in the period from 2011 to 2015, resulting in a dramatic reduction in improper land filling and the conservation of land resources and the 13th Five Year Plan allocates more than USD 40 billion of funding to new facilities" (Bourtsalas, 2023, p. 314). In addition, "in most of the WTE developments, the local or national government will provide a significant part of the initial capital investment and will seek private investors that are able to provide 30% of the initial capital and meet the financial, technical and environmental performance requirements asked by the national government" (Bourtsalas, 2023, p. 315).

Figure 13. Growth of WTE in China



Source: (Bourtsalas, 2023, p. 313)

As shown in Figure 13, since the beginning of this century China has seen an enormous growth in the implementation of WTE facilities. Between 2000 and 2019, in fact, about 400 new plants were installed in China. Noteworthy, in 2019, the combined capacity of the plants in China, about 130 million t/a year or 402,000 t/d, was higher than the combined capacity of the EU and the USA plants together, which amounted to about 127 million tons (Bourtsalas, 2023).

To conclude this topic, I can firmly state China has demonstrated a way to make WTE deployment economically attractive is combining high governmental (monetary and non-monetary) support, reduction of capital costs through Resource and Development and mass production and appropriate policies and regulations, also contributing to public health and pollution reduction.

3.2 “The Visible Journey”: my experience in Visottica Group

3.2.1 Company’s contextualised overview

Visottica Group is a B2B global market leader producing components for eyewear; its parent company is Visottica Industrie S.p.A. (based in Susegana, Treviso, Italy). The Group also includes other companies, based in Italy, in China and in Hong Kong, namely: Ookii S.r.l. (since 2017), itself incorporating Matrix S.r.l., Eurodecori S.r.l. (acquired in 2020), Ethos S.r.l. (since 2022), Ideal S.r.l. (obtained in 2023) and Comotec Optical Products (Dongguan) Ltd; The latter is also called Cdg (Comotec Dongguan) and has served as the Asian headquarter for the Visottica Group since 2010. The production plant, designed to optimize production flow, guarantees quality and efficiency to meet the high standards of the Group. Boluo Comotec Surface Treatment Company Ltd (CBL) has been the automatic plant for the galvanic treatment of its components since 2015. The holding company of the industrial activities in China and distribution company of Visottica Group in the Far East since 2010 is O’Reilly Industrial Ltd, situated in Hong Kong.

Comotec Optical Products (Dongguan) Ltd. is the plant I have had the opportunity to visit during the first part of my internship, while I was based at the O’Reilly office in HK. I have had the chance to do research on its Environmental, Social, Governance (ESG), Sustainability, and Marketing department. I specifically worked on gathering detailed information related to sustainability data, especially those regarding packaging and logistics, understanding how packaging can become more sustainable and process-effective, through the employment of new or improved materials, or innovative process flows for packaging, always bearing in mind the main objective of protecting the products’ integrity. Between 2023 and 2025 some important improvements have been achieved; specifically, 16 packaging cartons were substituted by Forest Stewardship Council (FSC) compliant cartons, 7 types of plastics bags used for packaging were changed to Global Recycled Standard (GRS) 90% recycled material and 8 types to GRS 100% recycled material; 5 plastics trays used for packaging were also substituted with GRS 50% recycled material and wood and plastic pallets were all changed to regrinded plastic ones. I have also had the chance to analyse the way the Group manage their residues and recycle their industrial water. In this paragraph I am going to illustrate Visottica Group’s sustainability project, called “The Visible Journey”, and the methods they employ to reuse and recycle their waste, as an example of a Chinese company’s waste management system. Their

vision is, in fact, focused on integrating sustainability into everything they do, contributing to a better future in the eyewear industry and all the sectors in which they operate. Their commitment, "The Visible Journey", is characterised by transparency, innovation, honesty, and integrity. The Visottica Group launched the aforementioned sustainability project to share its path to sustainable management in a clear way with all internal and external stakeholders, communicating details of its sustainability initiatives and goals. The intention is to share future objectives and initiatives while involving and inspiring all stakeholders to contribute actively to the necessary positive change (Visottica Group ESG team, 2023)

3.2.2 The regulatory framework: how does Visottica Group comply to it?

At the beginning of this sub-chapter I must make a disclaimer: all the info and data presented in this specific section are either retrieved from Visottica Group's 2023 Sustainability Report (published online on November 4, 2024) or are first-hand testimonies collected during the interviews to my colleagues at Cdg, that I personally took during my internship. For a stylistic and practical reason, therefore, I did not put this sub-chapter's whole text under quotation marks, nor have I mentioned the precise page of the Sustainability Report in my citations; however, the whole Sustainability Report[2] is available at the URL reported in the Appendix, for reference and for any clarification.

First, I will give an overview of the regulations on waste management both for China and for EU companies working and trading in and with the PRC. As I have previously illustrated, the Chinese Government has been issuing and implementing laws on waste management and pollution control since 1995/1996, particularly restricting the categories of plastics and solid waste allowed into the country and the way these must be managed and disposed of. Noteworthy, China categorizes solid waste into two main categories: hazardous waste and industrial waste.

The "Guideline for the Management of General Industrial Solid Waste Ledger" is a regulation issued for the implementation of the "Law on the Prevention and Control of Environmental Pollution by Solid Waste" (1996) stating that "unit that generates industrial solid waste shall establish an industrial solid waste management ledger, and truthfully record the information such as the type, quantity, flow direction, storage, utilization, and disposal of industrial solid

[2] For reference see the link in the Appendix

waste, so as to realize the traceability of industrial solid waste." Moreover, it requires "To clarify the person in charge, the related facilities and venues." All the information concerning the type, quantity, flow direction, storage, usage and disposal of industrial solid waste should be recorded in order to fill in the regulation's Attachments 1-3 (annually or monthly, depending on the Attachment) and keep every information traced and verifiable. Attachment 4 to Attachment 7 are optional information, mainly used to record information on the storage, utilization, and disposal of solid waste inside the waste-generating unit. These attachments are to be filled in according to local government and enterprise management requirements. The provision also prescribes that "When the waste generating unit fills in the ledger record form, it should select the corresponding solid waste type and code from the attached Table 8 according to its own solid waste generation, and determine the specific name of the solid waste according to the solid waste type". In addition, the regulation claims "To encourage the waste-producing units to adopt the electronic ledger for general industrial solid waste management established by the country to simplify data filling and ledger management", and states that "Electronic ledgers developed by local governments and enterprises should be connected with the national system. Waste-producing units that have established electronic ledgers can no longer record paper ledgers."

This is the Guideline followed by the Asian plants of Visottica Group in order to handle the waste they produce. An example of Attachments 1-5 and of Attachment 8 is provided in the Appendix[3], while Attachments 6 and 7 are currently not being filled in by Visottica Group (Wang, 2025). This Guideline, however, is not applicable to hazardous waste.

For the Visottica Group, correct waste management is fundamental for achieving its sustainable development targets.

They strive to minimize the amount of waste by:

- adopting practices that optimize the use of materials and reduce production waste;
- actively promoting the recycling of waste;
- adopting circular economy practices.

(Visottica Group ESG team, 2023)

More in general China has recently issued strict rules on waste management, making it mandatory for companies within the Chinese territory to trace their solid waste from the

[3] For reference see Attachments on number 3 in the Appendix.

moment they buy it from the supplier until the moment they dispose of it. Moreover, waste dealers must be legally licensed and frequently controlled by the company giving out waste materials to them. The Visottica Group has always maintained adequate control of the suppliers of the individual companies and, within the sustainability plan, is now implementing a Group-level mapping programme. The aim is to identify critical concerns and to consolidate the supply chain towards shared value, with absolute respect for the Code of Ethics, the Supplier Code of Conduct and the sustainability targets. In Asia, the supplier selection process involves a work group called "T4", formed of a procurement representative, a member from the planning department, a quality service manager, and an expert from the technical office. This group carefully evaluates potential suppliers, taking into consideration various fundamental requirements such as reliability, the quality of the products or services offered, the proposed price, the economic/financial conditions of the company, and even social aspects. Only after in-depth analysis and completion of a detailed checklist to integrate environmental and social information, does the "T4" group decide whether to establish a collaboration, guaranteeing a careful and informed selection of partners appropriate to the company's needs in Asia (Visottica Group ESG team, 2023).

How does Cdg comply with these requirements? On a practical basis, Comotec Dongguan follows the aforementioned regulations, recording and keeping track of each kind of solid industrial waste used in production plants. The scrap dealers cooperating with Cdg are all licensed and they sell the waste materials collected from the factory to other companies which in turn melt and reuse them. Not only, all solid waste is stored inside closed rooms, in order to avoid soil pollution (Wang, 2025). Table 3 displays a more detailed explanation of the disposal process, for each category of solid industrial waste.

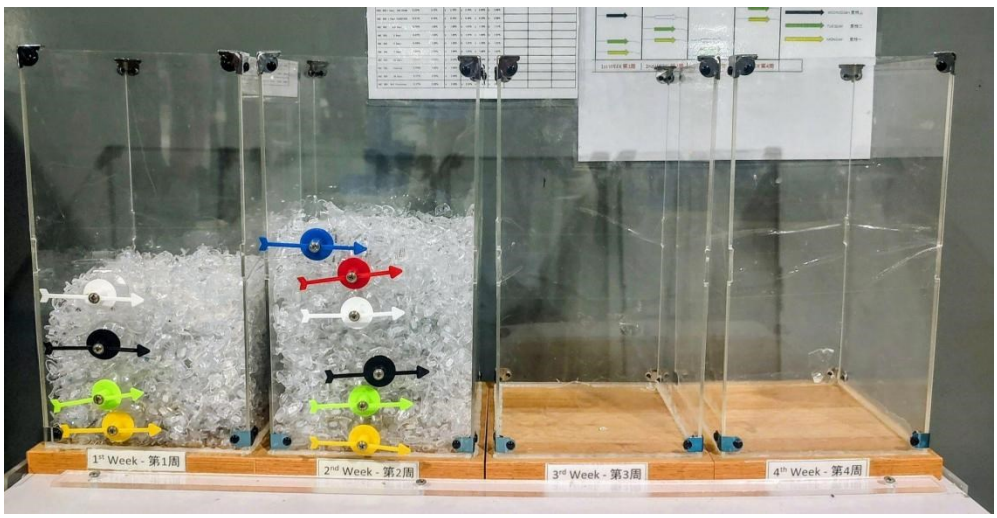
Table 3. Disposal method and dealer by waste type for the Visottica Asian plants.

Waste type	**Dealer**	**Disposal process**
Scrap from production	Scrap dealer (licensed)	Sort + resell to refiner
Defective goods	Scrap dealer (licensed)	Sort + resell to refiner
End of (metal) bars	Raw material supplier	Melt
Raw material	Raw material supplier or scrap dealer (licensed)	Melt or resell

Source: author's own work

In other words, Comotec Dongguan has full tracking of the destination of each of the solid waste it produces. Not only that, they also work on reducing the amount of solid waste, especially the carton waste, by improving the quality control department week by week. If the production and the quality checks are both improved, indeed, there will be fewer defective goods and therefore less waste to be disposed of. Moreover, since 2023 they have been sending empty plastic boxes originally containing cutting tools for production back to one of their suppliers, called Ose Lan Xing Tools, so that it can recycle them and give them back to Cdg or other customers. This is an example of circular economy, implying zero cost to Comotec Dongguan, since the supplier itself takes charge of the transportation costs. In particular, during 2023 this method allowed Cdg to recycle 7.5 kg of plastic, while during 2024 the plastic recycled thanks to this method amounted to 6.15 kg (Visottica Group ESG team, 2023). These certainly are not significant amounts, but contribute to take circular economy one step further and have great possibilities of progression for the future. Furthermore, in Cdg's quality control department there are four big jars where defective nose pads are put. Each jar represents one week of the month and the coloured arrows symbolize each day of the week. This is a visual, intuitive method to help workers self-assess their performance and contribute to the reduction of defective goods and therefore of solid waste.

Figure 14. Visottica Group's Cdg visual method for workers' self-assessment



Source: author's own picture

Figure 14 in particular shows the 4 jars dedicated to the defective silicone nose pads. As we can notice, at the moment I took the picture (the first day of the third week at 5 pm) the situation seemed to be improving compared to that of week 1 and week 2. The big gap between week 1

and week 2 was determined by the fact that during week 1 Friday, Saturday and Sunday were bank holidays in China, so the production plant had not been working. Thanks to this method it was possible for Cdg to reduce defective goods from 14% to only 3% in the last few years, which is a remarkable result.

The Visottica Group is a competitive leader in its attention to following international sustainability standards, with a particular focus on the SDGs, the targets for 2030 agreed by the member States of the United Nations as part of the Global Agenda for Sustainable Development approved in September 2015 and composed of 17 goals
structured into interconnected 169 targets, designed so that the pursuit of one goal also aids the others. The SDGs provide a shared action plan and have various targets, such as tackling the challenges of climate change, reducing poverty and inequality, guaranteeing the economic, environmental and social sustainability of communities in the long term. From a practical point of view, the Asian plants of the Group have various Environmental, Social and Governance (ESG) activities ongoing, such as the yoga, taichi and square dance classes organized inside Cdg, in their dormitory's sport field, and open to the whole staff or the workers' committees in which the employees can exchange ideas to improve their work-life balance and general well-being. Furthermore, the Group is committed to promote internal gender equality and inclusiveness, guaranteeing equal opportunities for all employees; In Cdg periodical "Sustainability Pills" presentations are held in English, Italian and Chinese to target all departments' managers and employees, with the aim to raise awareness on some key topics, such as the supply chain's sustainability and gender equality and the empowerment of women; the latter is the specific topic I personally had the chance to present to the whole staff on 2 April, 2025 during my internship experience, both in English and Chinese language (Visottica Group ESG team, 2023).

The Group is also working to reduce its environmental impact by adopting sustainable practices such as the efficient management of energy and water resources, the use of environmentally sustainable materials and the reduction of greenhouse gas emissions (Visottica Group ESG team, 2023).

To delve deeper into the matter, I can focus on a number of individual topics.

First of all, I will give a better understanding of the management of raw materials. The main aim of the Group is to adopt an integrated approach and implement practices to reduce, reuse and recycle raw materials, seeking to minimize waste and optimize production processes, since the raw materials employed in its productive phases may originate from processes that negatively impact the environment and society. In particular, at Visottica Industrie S.p.A., the process is planned and implemented as follows: during component production, the nickel silver bars, the primary raw material, are processed and generate waste in the form of metal shavings, which are subsequently collected and sent to a settling process to separate them from the industrial oil. The oil is extracted using a centrifuge, which separates the fluids from the metal, and filtered to remove any impurities, then reused in the company's machines. The end pieces of the bars, considered waste, are collected and washed. These are sent alongside the shavings back to the supplier to be melted and to obtain a new raw material. Similarly, at the Comotec Optical Products (Dongguan) plant, the material management process returns the end pieces of the bars to the supplier to be melted and recycled, as I have already explained above. Focusing on oil, since industrial cutting operations use a large quantity of oil, in order to achieve high performance, combined with a low environmental impact, Visottica Industrie S.p.A. has chosen to use oil which offers better performance in terms of process quality and is formed of approximately 70% from renewable sources of plant origin. Not only, the formulation of this oil is safer for workers' health, thanks to its low allergen content. As I have had the chance to find out during my research and data gathering on packaging sustainability during my internship, at the Asian plant of Comotec Optical Products (Dongguan) Ltd., significant improvements have been made in the use of materials. In particular, the standard cardboard for packaging has been replaced with FSC certified cardboard, the wooden pallets with pallets made from recycled plastic, and the standard plastic bags with 90% and 100% GRS certified plastic bags, depending on the model. The company is also evaluating the use of GRS certified recycled materials for its raw materials (metal and plastic), though this process will take time and is still in production testing (Visottica Group ESG team, 2023).

Secondly, I can move into energy consumption. The Visottica Group recognizes the importance of managing its energy consumption properly to reduce its environmental
impact. The main ways the Group acts towards this aim are: optimizing production processes, monitoring and constantly assessing energy performance within its plants, seeking new opportunities and technologies to improve efficiency. More specifically, for what concerns the Italian plants, bulbs with higher energy efficiency were installed: Ookii S.r.l. uses self-

produced electricity from a photovoltaic plant, while at the Matrix S.r.l. production plant the installation of a photovoltaic roof has been completed and activated in the early months of 2024. Furthermore, in 2023, additional energy efficiency initiatives were implemented in Asia. In particular, at the Comotec Optical Products (Dongguan) Ltd. plant, the compressed air system was improved. This measure involved the installation of a real-time control and monitoring system for electricity and air consumption, as well as an automatic regulation system for compressed air, based on production requirements. The start-up and shutdown systems were optimised, too. In 2023, two new variable power compressors were adopted, capable of meeting approximately 95% of the production requirements, in addition to a new industrial drier. Inside Cdg plant, including the dormitories and the canteens, light sensors were installed in the stairs in order to reduce energy consumption (Visottica Group ESG team, 2023).

Another key point is the reduction of greenhouse gas emissions. The latter contribute to the so-called "greenhouse effect" a natural phenomenon that retains heat in our atmosphere: these gases in fact act as an insulating covering around the planet, retaining the heat of the sun and contributing to global heating and climate change. Therefore, the Group undertakes to monitor and progressively mitigate them as much as possible. There are two main types of greenhouse gas emissions: scope 1 direct emissions and scope 2 emissions. The former refers to the greenhouse gases produced directly by the sources controlled by an organization or company. For the Visottica Group, the calculation of direct emissions included the following energy vectors: natural gas, vehicle fuel and refrigerant gases.

Table 4. Visottica Group direct scope 1 emissions in 2022 and 2023

DIRECT (SCOPE 1) GHG EMISSIONS[7]			
TYPE OF CONSUMPTION	**UNIT OF MEASUREMENT**	**2023**	**2022**
NATURAL GAS	tCO_2e	656	587
VEHICLE FUEL[8]	tCO_2e	223	183
REFRIGERANT GASES	tCO_2e	15	12
TOTAL	tCO_2e	**893**	**782**

Source: https://www.visotticagroup.com/en/sustainability/

Scope 2 emissions represent the greenhouse gas emissions deriving from the consumption of electricity purchased and used by organizations and companies. Two distinct approaches are

used to calculate these indirect emissions: market-based and location-based. Location-based Scope 2 emissions are calculated using the average emissions factors relating to energy generation at national level. Market-based Scope 2 emissions, on the other hand, are based on the CO2 emissions of suppliers from which the organization purchases electricity through contracts, also considering the energy originating from renewable sources with a guarantee of origin or other factors specific to the market of reference. The Visottica Group pays particular attention to this aspect: Location-Based Scope 2 emissions decreased overall by 1% compared to 2022, while Market-Based emissions recorded a 14% increase. This is a positive result if I consider that the 2023 figures include a new company, Ideal S.r.l., within the reporting boundary, which alone accounts for approximately 8% of the Group's total consumption.

Table 5. Visottica Group indirect scope 2 emissions in 2022 and 2023

INDIRECT (SCOPE 2) GHG EMISSIONS[9]			
SCOPE 2	**UNIT OF MEASUREMENT**	**2023**	**2022**
ELECTRICITY PURCHASED – LOCATION BASED	tCO_2e	7.750	7.858
ELECTRICITY PURCHASED – MARKET BASED	tCO_2e	10.793	9.587
STEAM PURCHASED	tCO_2e	135	93

Source: https://www.visotticagroup.com/en/sustainability/

Table 6. Visottica Group total emissions in 2022 and 2023

TOTAL EMISSIONS[10]			
SCOPE 1 + SCOPE 2	**UNIT OF MEASUREMENT**	**2023**	**2022**
TOTAL EMISSIONS (SCOPE 1 + SCOPE 2 – LOCATION BASED)	tCO_2e	8.778	8.733
TOTAL EMISSIONS (SCOPE 1 + SCOPE 2 – MARKET BASED)	tCO_2e	11.821	10.462

Source: https://www.visotticagroup.com/en/sustainability/

As shown in Table 4 and Table 5, the Group Scope 1 emissions and scope 2 emissions both increased between 2022 and 2023, but this is due to the acquisition of the new company Ideal S.r.l. in 2023. Certainly, Visottica still highly engages and puts effort in working for the reduction of greenhouse gas (Visottica Group ESG team, 2023).

Now comes the crucial point of the management of the water resource. On a planet with continuous population growth, water is a precious and scarce resource and this is a particularly relevant topic in the Asian continent, the most populous in the World with over 4.7 billion people, about 60% of the total global population. Noteworthy, India and China are the two most populated countries worldwide. Consequently, responsible management of the water resource is a Group priority; by adopting water recovery and reuse systems, we seek to reduce consumption and limit the impact on local ecosystems. In Italy, both Visottica Industrie S.p.A. and Ethos S.r.l. have implemented monitoring and management systems capable of recovering the wastewater used during production. After adequate treatment, the wastewater is reintegrated into the industrial cycle. Ethos S.r.l. also uses a rainwater harvesting tank system, which, when adequately treated, is then partially reused in the production cycle. For what regards Asia, the production plant of Comotec Optical Products (Dongguan) Ltd. has implemented a Water Recycling Project, through which it achieved significant results in 2023, allowing for between 85% and 90% of the water used to be recycled. The project was launched in October 2021 with an assessment of the existing water treatment system and the identification of critical concerns and opportunities. After in-depth research and analysis, improvement measures were carried out on the system between January and April 2022. These measures included lowering the plant's capacity from 200 m^3 per day to 100 m^3, increasing the number of aerobic bacteria to improve the quality of the water sent to Reverse Osmosis (RO) filtration, and the complete cleaning of sludge sediments to reduce dissolved substances. Between August and October 2022, a Membrane BioReactor (MBR) system and RO system was installed and commissioned. Thanks to these systems, the recycled water reached a higher quality than tap water. Future goals include the reduction of the level of wastewater from production to near zero, a continuous optimization of the production processes, monitoring of water consumption and greater employee awareness, as well as the reduction in the use of chemicals and solid waste.
Moreover, at the Boluo Comotec Surface Treatment Company Ltd., meters were also installed on various production lines to map daily water consumption, in addition to new pumps capable of regulating the flow and reducing the use of water (Visottica Group ESG team, 2023).

As can be noticed from Table 7, the Group's water withdrawals have decreased by 16% since 2022. In particular, Comotec recorded a considerable 19% reduction between 2022 and 2023, thanks to the full working capacity and operation of the water recycling product in 2023. This result is also attributable to the measures adopted by the Visottica Group to improve water

resource management, which include implementing more efficient technologies and upgrading water recycling processes (Visottica Group ESG team, 2023).

Table 7. Visottica Group water withdrawal in 2022 and 2023

WATER WITHDRAWAL					
		2023		2022	
TYPE OF CONSUMPTION	UNIT OF MEASUREMENT	ALL AREAS	WATER STRESSED AREAS	ALL AREAS	WATER STRESSED AREAS
THIRD-PARTY WATER (AQUEDUCT)	ML	88	0	105	0
FRESH WATER (≤ 1000 MG/L TOTAL DISSOLVED SOLIDS)	ML	88	0	105	0
OTHER WATER (> 1000 MG/L TOTAL DISSOLVED SOLIDS)	ML	0	0	0	0
TOTAL WATER WITHDRAWAL	ML	**88**	**0**	105	**0**

Source: https://www.visotticagroup.com/en/sustainability/

Lastly, I will delve deeper into the topic of waste management, which I have already partially discussed above. I have already explained, indeed, that in Cdg each industrial solid waste is recorded and kept track of, then given to licensed scrap dealers or back to the raw material supplier, who later melt and/or reuse it.

Within the Visottica Group Waste Management system, revamping is another key method. Revamping of machinery means the restoration and updating of existing machines to improve their efficiency and prolong their life cycle, even for different uses to those for which they had initially been designed. Visottica is firmly committed to the reuse of resources and raw materials, so it regularly carries out revamping activities at the Susegana plant. The company even purchases machines intended for disposal and rebuilds them for use in the production of components. In addition to complete updates, it also optimises machinery already in its possession, improving its efficiency, reducing waste and prolonging its production cycle. In 2023, a total of 9 revamping interventions were carried out. Moreover, for what concern the Chinese plant of Comotec Dongguan, BU3 washing line was dismissed and integrated to BU1; this way material, space and chemical material's stocking were all reduced. The number of pieces washed in BU4 was also reduced and integrated to BU1, with the same results just discussed above (Visottica Group ESG team, 2023).

The Chinese plant of Comotec Optical Products (Dongguan) Ltd has applied in 2024 to a local sustainability prize awarded by Dongguan Municipality. The contest functions as follows: local companies can candidate their factories, the city government then checks if each factory meets the sustainability criteria and, if so, admits it to the so-called “white list”. Cdg won the prize and was awarded in April 2025. Not only, the Dongguan plant also won a local campaign for the “Best Waste Management factory” and now holds this certification, too.

(The Visible Journey Sustainability Report 2023, 2024)

3.2.3 Waste management system of Guangdong province: a survey to local firms

In order to gain valuable insights into waste management and water recycling practices among Chinese companies, particularly within the Guangdong province, I personally elaborated and distributed a survey to a range of local firms. The main findings from the survey are outlined below, while the full version of the questionnaire is available in the Appendix[4]. The firms were selected on the basis of their personal relationship with Comotec Dongguan’s HR manager Judy Wang and of their willingness to participate in the questionnaire.

Analysis of the results:

A total of 15 companies participated in the survey, including Cdg. The companies involved are as follows:

- 东莞可米食品有限公司 Dongguan Kemi Foods Co.;
- 东莞市冠霖环保滤材配件有限公司 Dongguan Guanlin Environmental Protection Filter Accessories Co., a professional manufacturer of eco-friendly air filters and fruit and vegetables purifiers; it pays attention to environment protection as a common point of interest with the Visottica Group;
- 东莞市建诚高分子材料有限公司 Dongguan Jiancheng High-performance Solenoid Co.;
- 广东雷诺医疗科技有限公司 Guangdong Reynolds Medical Technology Co.;
- 慷德 Kangde (literal translation: "generous");

[4] For the full version of the survey see the Appendix

- 深圳市速腾聚创科技有限公司 Shenzhen Suteng Juchuang Technology Co., an artificial intelligence-based robotics technology company, developing and selling perception solutions;
- 东莞森玛仕格里菲电路有限公司 Dongguan Semax Griffey Circuit Co. (Somacis), a foreign-owned high-tech enterprise, jointly owned by the Italian Somes Group and the British Griffith Group, which produces multilayer printed circuit boards in series;
- 东莞市华美食品有限公司 Dongguan Huamei Foodstuff Co., a group of companies in Dongguan, producing various types of food and snacks;
- 福哥 Fuge (literal translation: "Brother Fook")
- 阪和钢板加工（东莞）有限公司 Hanwa Steel Sheet Processing (Dongguan) Co., a company producing steel sheets;
- 首屋尔金属（东莞）有限公司 Sowuer Metals (Dongguan) Co., producing mother screws, small precision screws and shafts for electronic products, such as electronics, communications and audio. Leveraging advanced design capabilities and development technology, they produce high-quality products with high price competitiveness;
- 广州丽高塑料制品有限公司 Guangzhou Ligao Plastic Products Co., an established brand in the field of plastic packaging materials for daily-use chemicals in China, national high-tech enterprise and one of the first “specialized, sophisticated and innovative” enterprise groups in Guangzhou
- 东莞市科根钢制品有限公司 Dongguan Cogne Steel Products Co.;
- 东莞市拓展实业有限公司 Dongguan City Development Industry Co., a private enterprise focused on resource recycling and environmental protection technology. The company mainly produces recycled polyester fibres, which are widely used in toys, furniture padding and other industries, so just as Comotec Dongguan this is a B2B focused on environmental protection;
- 来利眼镜制品(东莞)有限公司 Lai Li Optical Products (Dongguan) Co. (also known as Comotec Optical Products Dongguan or Cdg).

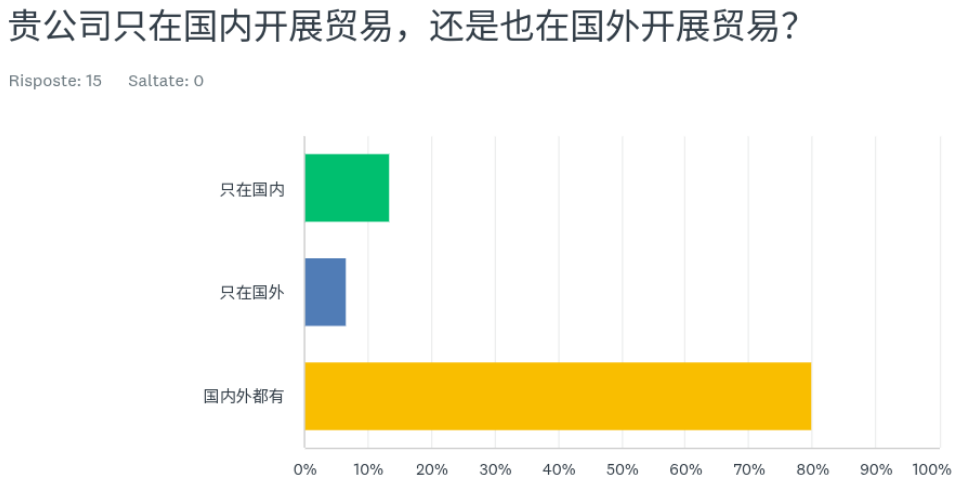
Out of the 15 firms surveyed, 11 are located in the city of Dongguan, with the remaining firms based in Huizhou (1: 广东雷诺医疗科技有限公司 Guangdong Reynolds Medical Technology Co.), Foshan (1: 慷德 Kangde), Shenzhen (1: 深圳市速腾聚创科技有限公司 Shenzhen Suteng Juchuang Technology Co.), and Guangzhou (1: 广州丽高塑料制品有限公司 Guangzhou Ligao Plastic Products Co.). The companies span a range of industries: two are involved in food production, others are specialized in technology manufacturing, some are

engaged in metal production, one focuses on medical technology, another is involved in the production of plastic packaging and one produces optical components (Cdg). It is noticeable that at least three companies among the sample are openly engaged in "eco-friendly" production, namely 东莞市冠霖环保滤材配件有限公司 Dongguan Guanlin Environmental Protection Filter Accessories Co., 东莞市拓展实业有限公司 Dongguan City Development Industry Co., 来利眼镜制品(东莞)有限公司 Lai Li Optical Products (Dongguan) Co.

Regarding the founding years, only four companies were established between 1983 and 1999, while eight were founded between 2000 and 2009, before the onset of the global economic crisis. The most recent companies were founded in 2014, 2017, and 2018. However, all of the surveyed companies have been in operation for at least five years and this makes them suitable samples for the survey.

When it comes to trade activities, 80% of the companies (12 out of 15) engage in both domestic and international trade. One company (东莞可米食品有限公司 Dongguan Kemi Foods Co.) operates exclusively abroad, while two companies (广东雷诺医疗科技有限公司 Guangdong Reynolds Medical Technology Co. and 慷德 Kangde) trade solely within the domestic market.

Figure 14. Graphical representation of one question of the survey elaborated by the author

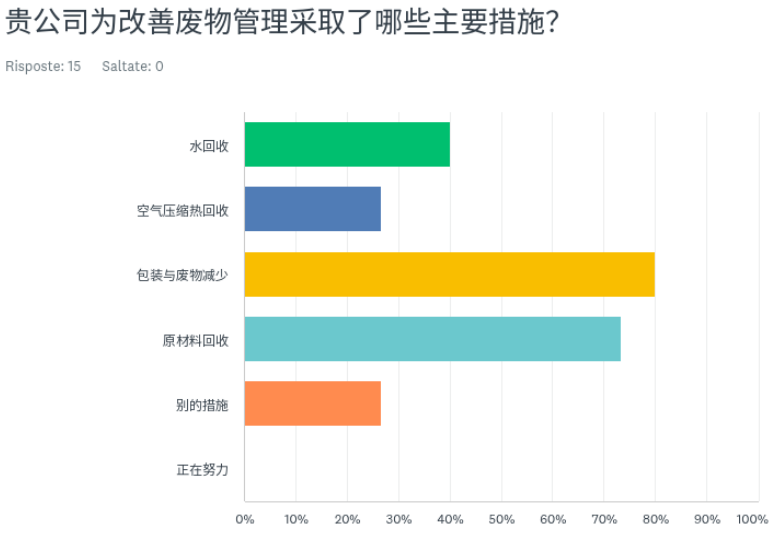


Source: https://it.surveymonkey.com/analyze/data-trends/T1iVixc9oF_2BugK32BTETr6m_2BahGoUUcWrg1JH813k7E_3D

In order to assess the companies' engagement with environmental protection and waste management practices, a series of questions were posed regarding the adoption of specific green measures. The analysis of responses revealed the following insights:

- 6 companies (40% of the sample) reported that they actively recycle industrial water.
- 12 companies (80%) indicated efforts to reduce both production waste and packaging.
- 11 firms (73.33%) are engaged in the recycling of raw materials.
- The least implemented measure was air compression heat recovery, with only 4 businesses (26.67%) adopting this practice.

Figure 15. Graphical representation of one question of the survey elaborated by the author



Source: https://it.surveymonkey.com/analyze/data-trends/T1iVixc9oF_2BugK32BTETr6m_2BahGoUUcWrg1JH813k7E_3D

To sum up, all the companies interviewed have declared to adopt at least one of the proposed measures, and 4 companies have also selected the option "other measures not listed", suggesting an even wider engagement towards sustainable development.

A crucial question in the survey concerned the percentage of industrial water that gets recycled. The findings are as follows:

- 1 company, 东莞市建诚高分子材料有限公司 Dongguan Jiancheng High-performance Solenoid Co., reported that they do not use industrial water at all.
- 1 company, 广州丽高塑料制品有限公司 Guangzhou Ligao Plastic Products Co., stated that their production facilities produce no water pollution.
- 2 companies reported recycling 0% of their water.
- 1 company recycles 10% of its industrial water.
- 3 companies, 东莞可米食品有限公司 Dongguan Kemi Foods Co., 东莞森玛仕格里菲电路有限公司 Dongguan Semax Griffey Circuit Co. and 东莞市拓展实业有限公司 Dongguan City Development Industry Co. recycle between 60% and 75% of their industrial water.
- 2 companies, namely 来利眼镜制品(东莞)有限公司 Lai Li Optical Products (Dongguan) Co. and 东莞市华美食品有限公司 Dongguan Huamei Foodstuff Co. recycle 80% of their water.
- 慷德 Kangde recycles 90% of its water.
- Finally, the last 3 companies recycle 100% of their industrial water.

These findings indicate that there is still considerable room for improvement in water recycling practices, as only 9 out of 15 companies recycle half or more of the industrial water used in their production processes.

The results related to waste recycling are more promising. 13 out of 15 companies reported that their production waste is either recycled, melted, or reused. Only 2 companies, namely 东莞可米食品有限公司 Dongguan Kemi Foods Co. and 东莞市华美食品有限公司 Dongguan Huamei Foodstuff Co. stated that they do not recycle or reuse their production waste. This

shows that significant progress has been made in waste management within the Guangdong province, with most companies implementing responsible practices for waste handling.

Moving to the supply chain field, the survey also investigated how companies adhere to the Code of Ethics and Supplier Code of Conduct. The findings revealed that:
- 10 out of 15 companies (more than 66%) stated they send the Code of Conduct to their suppliers and require them to fill it out.
- 6 companies go a step further by not only ensuring compliance with the Code of Conduct but also offering related training to their staff.
- In line with Chinese law, 12 out of 15 companies reported organizing regular inspections and audits to verify the fair functioning of their supply chain.

When it comes to the use of certified materials in the production process, the results are quite disappointing:
- Only 2 companies reported using GRS certified materials; GRS is a voluntary certification that tracks and verifies the content of recycled materials in the final product.
- Only 东莞可米食品有限公司 Dongguan Kemi Foods Co. stated that they use FSC certified materials, which ensure the sustainability of forest resources.
- 1 company, namely 东莞市华美食品有限公司 Dongguan Huamei Foodstuff Co., declared the use of both GRS and FSC certified materials.
- The remaining 11 companies (out of 15) reported that they do not currently use any certified materials in their production processes.

More positively, the implementation of a sustainability report shows promising trends:
- 4 companies have already published their sustainability report.
- 8 companies (more than 50%) are actively working on developing one.
- However, 3 companies admitted they have neither published a sustainability report nor are currently working on producing one.

The survey results highlight that companies in the Guangdong area are showing a commitment to adhering to ethical standards and improving supply chain practices, particularly in terms of audits and compliance with the Code of Conduct. In my view, the two main reasons leading Guangdong's companies towards the implementation of sustainable actions in their life-cycle

process are: compliance to local and national laws and regulations, mainly in order to positively go through audits and the need for firms to have a good and "modern" reputation, especially in this period when China and Chinese companies are more and more in contact with European and international partners. However, the usage of certified materials in production remains limited, indicating that there is considerable room for improvement in the adoption of sustainable materials. On the brighter side, the fact that more than half of the companies are working on implementing a sustainability report suggests a growing awareness of the importance of transparency and accountability in sustainability efforts. The continued focus on certifications and regular audits will likely encourage a more responsible and sustainable supply chain in the near future.

3.3 The waste management in other countries

3.3.1 The issue of waste management in other countries

"Since China introduced the "Green Silk Road" in 2015, and especially after its formalization in 2017, the government has been working on making the country's transcontinental infrastructure development plan (the BRI) more sustainable, while also focusing on exporting Chinese ecological norms, laws and best practices to other countries along the BRI route" (Xiaofeng Liu, 2023, p. 236). Of course, as already discussed above, one of the main reasons that pushed China to do so was the rising global concern towards its fast-paced development and the connected risk of exporting its "polluting" model to other nations.

"In 2015, sustainable development became further institutionalized following the adoption by 195-member states of the UN2030 Agenda for Sustainable Development, also known as Sustainable Development Goals (SDGs). This agenda includes 17 goals structured into 169 targets and over 300 indicators and its objectives are to make the economy, the society and the environment more sustainable; the Chinese State firmly promotes the principles of the SDGs. To support developing countries in achieving the SDGs, Chinese President Xi Jinping launched a South-South Cooperation Assistance Fund in 2015, whose capital he increased at the second international BRI summit in 2017. Notably, the Chinese state promotes the Green BRI as an endeavour that incorporates the SDGs" (Xiaofeng Liu, 2023, p. 241).

The question that arises is "to what extent the so-called Green BRI best practices and policies have been exported and adopted by other countries along the BRI route, in particular those regarding waste management and waste to energy?"

Due to factors like population growth, migration, rural and urban development, the economic race for development and as a direct consequence of China's Import Ban (2017), South East countries such as Thailand, Indonesia and Malaysia have faced a rapid surge in the production and the import of solid waste. It is predicted that South Asia will produce 466 million tons of waste by 2030 and 661 million tons by 2050, making it the second-largest waste producer, just after East Asia and the Pacific (Ali, Faqir, Haider, Shahzard, & Nosheen, 2022).

Most of the South Asian part of BRI depends on coal power projects which are higher in greenhouse emissions. Specifically, the increase in waste and pollutants from construction projects and the burning of municipal solid waste can contribute to higher levels of CO2, CO (carbon monoxide), SO2 (sulphur dioxide), and NO2 (nitrogen dioxide) emissions, worsening air pollution. Inadequate Waste Management might damage public health, the environment, and disrupt industrial productivity and the economy. To support this, the Global Waste Management Outlook (GWMO) suggests that the economic costs of inaction on waste management are 5-10 times higher than the costs of implementing proper waste management systems (Ali, Faqir, Haider, Shahzard, & Nosheen, 2022). In fact, air pollution caused by particulate matter in China has increased so much in recent years that it has attracted worldwide attention; "in a study from the Chinese University of Hong Kong, air pollution has been estimated to cause an economic loss of 267 billion RMB in terms of early deaths and lost food production, which amounts to 0.7% of the national GDP" (Roh Pin Lee, 2020, p. 175). These data highlight how a bad waste management system can not only harm China from an economic point of view, but also from a human and social point of view.

It is evident that a coordinated, international waste management system is needed, both to prevent nations like Thailand, Indonesia or Malaysia from becoming "pollution heavens" and to avoid the BRI infrastructural plan raising concerns among the global community (Ali, Faqir, Haider, Shahzard, & Nosheen, 2022).

3.3.2 Waste management system: China's overseas projects

"In the period between 2006 and 2021 China has funded a total of 12 waste management projects across Asia. Collectively, these 12 projects amounted to a total of US $274.23 million. They were distributed this way: half of the beneficiaries of these projects were South East Asian (SEA) countries, namely the Philippines, Cambodia, Laos, Myanmar, Timor-Leste, and Malaysia. Other 5 Chinese-funded development finance projects on waste management were allocated to Nepal, Sri Lanka and Maldives. The remaining project was allocated to Central Asia. Additionally, between 2013 and 2020, 4 projects worth a total of USD 201.34 were commissioned, with recipients including Timor-Leste and Malaysia" (Hung, 2024, p. 7). "Among the 6 Chinese development finance projects on waste management displayed in the search engine results for SEA, there are 5 directly funded waste management campaigns, which were funded in the form of grants. However, the remaining project, directed to Malaysia, was aimed at building and maintaining gas-fired power plants and was funded in the form of loans. This data suggests that not only were Chinese private enterprises and SOEs more

willing to fund SEA's waste management projects in recent years, but the funding directly contributing to building and expanding waste management campaigns within the region were all grants rather than loans. Consequently, SEA countries, at least solely from a financial perspective, were not burdened with any debt related to these initiatives" (Hung, 2024, p. 7).

"Narrowing the lens and focusing on Thailand, the rapid urbanization and economic growth have led to increased consumption and waste production, including packaging waste, electronic waste, and municipal solid waste" (Hung, 2024, p. 5). The problem of waste management has caused a number of different issues to the country.

First of all, ineffective waste management is one of the key causes of marine litter in Thailand and this greatly impacts the tourism sector, on which the nation has been relying to support the country's national growth. If waste management and water quality are not improved, tourists may choose other destinations in the area, thus posing a menace to the competitiveness of Thai eco-tourism.

Another key problem is the lack of infrastructure; the country suffers from scarcity of appropriate waste management infrastructure, as for example waste collection and classification systems. Therefore , the country fails to appropriately separate and recycle its residues and solid waste is often disposed of in the open environment and into the ocean, causing the aforementioned marine, air and soil pollution (Hung, 2024).

Given that the intense tourist activities combined with the shortage of waste management infrastructure and system, if left unaddressed, may threaten Thailand's natural environment and ecosystem, the country's government has recently been working on a series of regulations and provisions. Thailand has adopted laws like the "Enhancement and Conservation of National Environmental Quality Act" (1992), which requires the application of Environmental Impact Assessments for industrial and infrastructural projects. It is also noteworthy that Thailand has recently drafted a "Sustainable Packaging Act". Thailand aims to establish a regulatory framework to favour waste management, suggesting that the country may be willing to welcome China and other valuable economic partners to invest in waste management projects directed to Thailand (Hung, 2024).

Thailand in endowed with rich biomass resources, including wood residue and crop straw. Existing biomass gasification projects have encountered issues such as poor fuel flexibility, low gasification efficiency, high tar content in gas and secondary pollution from tar wastewater. Thailand is facing an urgent need to improve equipment reliability and operation and maintenance capabilities to diminish investment and operating costs (Hung, 2024).

As already stated above, in line with the Green BRI project, China has been trying to export its "green development" best practices, policies and regulations to other countries along the BRI route. One of China's major Green-BRI development partners is Thailand. Just as it is undertaking such initiatives domestically, the Chinese government is also making significant economic investments in green development projects in Thailand, in order to help the nation, implement better waste management system and eco-tourism practices.

"By the end of 2021, China had funded 3 green development projects with the objective to promote eco-tourism in Southeast and South Asia.

The first project was committed on January 1 2005, with a total value of USD 542560. The project was successfully completed on November 29 2010. The funding constituted a donation to the United Nations Development Programme for the "Development of Sustainable Eco-Tourism in the Southern Districts of Thailand" project, providing financial support for the 2005 recovery plan for individuals and entities affected by the 2004 Indian Ocean Tsunami" (Hung, 2024, p. 6). The program was crucial for the diversification of the touristic offer in Southern Thailand, since it also incorporated eco-tourism. The term "eco-tourism" defines a form of sustainable travel that focuses on preserving the ecosystem, respecting the local culture, educating the tourists and minimizing environmental harm. In the case of Thailand, it included actions to facilitate small tourism businesses in the sustainable management of eco-tourism, raising media awareness to highlight the relevance of maintaining an eco-friendly tourism industry and promoting green hotel services that meet environmental-friendly standards. Moreover, it has also involved the promotion of community-based tourism, meaning tourism per se is organised, arranged and delivered by local Thai citizens to serve the tourists; this practice has actually been incentivized by Thailand since the 1990s. Clearly, local citizens serving visitors have been able to benefit directly financially and occupationally from the influx of international travellers (Hung, 2024).

"The second completed China-financed green development project aimed at advancing eco-tourism was the provision of support worth USD 397600 from the Lancang-Mekong Cooperation Special Fund. This financial support was dedicated to poverty alleviation and forest preservation in Northeast Thailand, and the project was commissioned on December 24 2019. As part of the project, over 20000 tree seedlings had been planted by the end of 2021, contributing to the establishment of sustainable eco-tourism and a forest economy in Northern Thailand" (Hung, 2024, p. 7)

For what concerns waste management, China's Guangzhou Institute of Energy Conversion of the Chinese Academy of Sciences has partially collaborated with universities and companies from

Thailand and Pakistan to build an innovative and highly efficient multi-generation demonstration project based on biomass gasification in Nakhon Phanom, a city located in Thailand. China's government objective was helping Thailand in the process of turning waste into value and promote biomass energy technological development (Hung, 2024).

Figure 16. Picture of the multi-generation demonstration project based on biomass gasification in Nakhon Phanom in Thailand



Source (Chen, 2023)

The abundant biomass resources present in Southeast Asia mainly include waste from agriculture and forestry. Thailand, in particular, has abundant crop straw and wood residue. However, the existing biomass gasification projects have faced problems like poor fuel flexibility, low gasification efficiency, high tar content in gas, and secondary pollution from tar wastewater. Therefore, it is urgent to improve equipment reliability and operation and maintenance capabilities, in order to reduce investment and operating costs and ensure system stability (Chen, 2023).

As already deeply investigated, the energy demand in China and other ASEAN countries has been rising significantly due to economic development, fast-paced urbanization and population growth. Therefore, promoting modern biomass energy technology in the area may contribute to building a sustainable energy supply system and preserving the environment. Important examples are Indonesia and Malaysia; these two countries account for 80% of the global total supply for palm oil. However, given that the palm residues cannot be effectively used, they have been disposed of directly into the environment for a long time, through burning and discard, causing harmful environmental pollution. In order to solve this issue in the most efficient way, the Institute of Process Engineering (IPE) of the Chinese Academy of Science (CAS) has been cooperating with the Malaysia Innovation Hub (MIH) in the development of bio-based plastics made of palm fibre and other biomass as primary raw materials. In particular, the IPE developed new functionalized ionic liquid modifiers to treat palm residues and built a 10,000-tonne bio-based material demonstration project in Wuqiao County, in

Northern China's Hebei Province, where qualified bio-based material packaging products have been in this was produced (Chen, 2023).

Figure 17. Picture showing the 10,000-tonne bio-based material demonstration project, built by the Institute of Process Engineering of the Chinese Academy of Sciences, in Wuqiao County, north China's Hebei Province.



Source: (Chen, 2023)

Another initiative that will be implemented in Malaysia is the introduction of new technology and a 30,000-tonne bio-plastics production line investment, jointly developed by the National Farmers Organization of Malaysia and the United Arab Emirates; its aim will be to target the Middle East and European markets with eco-friendly products as an alternative to traditional fossil-based plastics (Chen, 2023). These projects are still in progress, but the cooperation has laid a solid foundation for future exchanges between China and its BRI partners, and relevant technologies and experience will be extended to countries such as the Philippines, Brunei, and Thailand to improve local people's well-being and reduce climate change.

To sum up this part, “it is evident how since 2013 -the year marking the official launch of China’s BRI- the number of Chinese finance projects on green development, specifically centred on eco-tourism and Waste Management campaigns, has risen significantly, with a peak in 2021” (Hung, 2024, p. 7). As aforementioned, Thailand’s interest in ecological principles has been emerging since the 1990s. However, it was only in recent years, with the implementation of Sino-Thai collaboration projects, that the country began putting into practice the concepts it had been theorizing about eco-tourism and, more broadly, waste management and environmental protection.

3.3.3 Waste to energy: China's overseas projects

"Regarding the topic of WTE, a number of Chinese private enterprises and SOEs have been investing in WTE endeavour in countries along the BRI route. Thailand is in the early stages of WTE deployment. Electricity generation from WTE is expected to increase to over 200 MW by 2021 and the government has a long-term target to increase WTE capacity to 550 MW, under the Alternative Energy Development Plan. A regulation is in place that provides $155–$190/MWh to WTE plants. In Indonesia, a national plan has been announced for the construction of WTE plants in twelve major cities of the country by providing a WTE electricity price of USD 133/MWh"

"These projects have, however, been encountering a variety of obstacles during their implementation in SEA countries, namely:

1. the scarce creditworthiness of BRI countries, especially of the developing ones;
2. the low Willingness to Pay (WTP) for WTE by the municipality or the government who participate in a PPP (Public Private Partnership);
3. the Willingness to Accept (WTA) by citizens/voters of a possible increase in the waste disposal fee, or the municipal tax that includes Waste Management for WTE development, which is very uncertain;
4. the underdeveloped waste management system that characterizes many countries along the BRI region, causing an imprecise separation and collection of waste, impacting quality of the fuel that can be processed in WTE plants, considering that moisture and low calorific value wastes, e.g., food, are not removed upstream;
5. high expectations that local stakeholders usually have from the private entities that participate in the PPP;
6. the low level of citizen compliance combined to inadequate public information/education;
7. the lack of local expertise in WTE processes;
8. fiscal and political fluctuations, high financing costs for WTE facilities, and institutional and regulatory barriers"

(Bourtsalas, 2023, p. 316)

Another major challenge and, at the same time, opportunity for BRI regions is informal recycling, a practice that provides a source of income for about 2% of the population in many emerging countries. Obviously, the main challenge lies in the fact that citizens working in these groups of informal waste dealers are not keen on becoming part of the formal system, since they are isolated by the communities and their contribution to waste management is undervalued or even neglected (Bourtsalas, 2023).

The solutions to this obstacle are mainly two: the first is to give indirect incentives, such as housing or health services to these people, to spark their interest to be part of the formal system; the second is to employ informal recyclers as workers in new WTE facilitiess, leveraging their professionalism and familiarity with waste channels and actors in the market, as has already been experimented in China (Bourtsalas, 2023).

The Green BRI can certainly act as the bridge between the knowledge accumulated by Chinese companies during the construction of numerous WTE plants and the needs for a better waste management system of other countries along the BRI route. "As an example, Zhejiang University, sister academic institution of Columbia University in sustainable waste management, has become the National Centre on Waste Combustion, with several WTE pilot facilities and a training centre for engineers, managers, and policy makers" (Bourtsalas, 2023, p. 317). However, as noted earlier, the new WTE plants installed or to be installed in BRI-partner nations should only employ the best available technologies and comply fully with EU, US and recent Chinese standards; performance-based indicators should be used to verify and ensure the sustainability of the projects.

3.4 China's sustainable waste management: potential, challenges and opportunities on a comparative basis according to the international debate

Once having given an overview of the situation of waste management and circular economy in China, especially from the point of view of policies and their implementation, is now time to better understand these topics on a comparative basis. "This is particularly important if we take into consideration the fact that China is at the start of its transition from a linear to a circular carbon economy, and can thus draw on waste management experiences of other nations, such as Germany, which operates one of the few systems worldwide that completely avoids the landfilling of untreated municipal solid waste (MSW) and exhibits strong rates for the recycling and recovery of MSW" (Roh Pin Lee, 2020, p. 169, 176).

How far has China progressed in comparison with other nations in East Asia and Europe?

3.4.1 Chinese progresses in comparison with other countries

"The trend of increasing MSW generation is higher in China compared to other Asian countries. Among the total waste generated from East Asia and Pacific region, up to 70 % waste is generated

from the PRC. It is moreover predicted that in 2030 China will likely produce twice as much MSW as the US" (Manik Mian, 2016, p. 1127).

The amount of MSW produced in mainland China cities has increased from 135 million tons in 2001 to 228 million tons in 2018. This amount did not take evaluate MSW produced in Chinese counties, towns and villages. When they are taken into consideration, China is believed to have produced >400 million tons of MSW in 2016 (Rohit Panchal, 2021).

But how do MSW's collection and recycling practically work in China?

"In China, MSW is collected and transported by the local Sanitary Bureau, however the generated wastes are not fully collected such as in some urban and rural joint areas. There are 2 types of MSW collection in China: formal and informal one. People engaged in the latter are twice as many as those involved in the formal system. The collection process is carried out in two phases: first, at a local level and then at municipalities' level" (Manik Mian, 2016, p. 1128).

There are unfortunately some problems regarding MSW collection in China, namely:

1. "generally, it is only mixed collection system and this is problematic for secondary waste segregation: even though many municipalities have waste sorting facilities, their efficiency is quite low.
2. Only about 20% of discards are recovered for recycling (mainly those attributable to informal waste collection). This is also determined by the fact that, unlike many developed countries, in China the recycling and separation of collected waste is excluded from municipal responsibilities;
3. Another difference between China and other developed nations is that while in the latter there are precise rules to collect recyclable waste materials, as the European Union Directive, this is not true in China, where it is more unregulated and fragmented; just recently, however, some Chinese cities (Beijing, Shanghai, Guangzhou, Shenzhen, Hangzhou, Nanjing, Xiamen and Guilin) have started some pilot projects for the source separation MSW collection;
4. Another practice implemented in China that creates some issues is co-disposal of MSW, defined as the disposal of two different types of waste (e.g. MSW waste and industrial waste) in the same solid waste disposal unit (Law insider , s.d.); the improper co-disposal creates several environmental problems, including odour, leaching, landfill gasses and reduces the potentiality of effective landfilling and incineration;
5. Costs to be sustained for the installation of waste disposal facilities are high and are often not compensated by the fees collected through the system of waste management tax. For example,

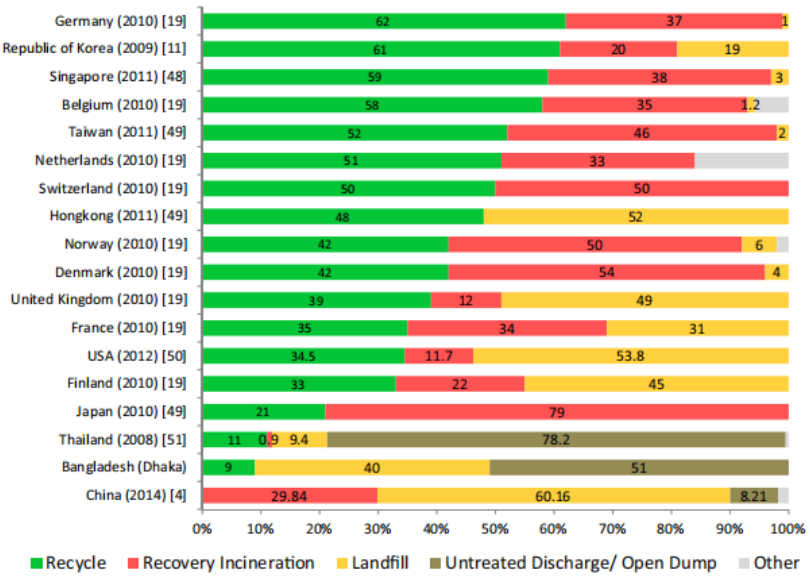
up to 2008 the construction cost of municipal solid waste disposal establishment in Beijing was far more than the fees collected".

(Manik Mian, 2016, p. 1129, 1130, 1132)

There are two main ways to dispose of waste: landfill and incineration.

Let's now see difference, similarities and point of progress of China and other countries in the process of waste collection, disposal and recycling.

Figure 18. MSW management hierarchy in different countries



Source: (Manik Mian, 2016, p. 1133)

As displayed by Figure 18, "some developing countries like Bangladesh and middle-income countries like Thailand have a large portion of open and illegal waste dumping. The open dumping or untreated discharge still exists in China" (Manik Mian, 2016, p. 1132). More precisely, according to these data, Thailand is the worst country, with 78.2% of untreated discharge/open dump, Bangladesh follows with 51% and the third worst nation is China with a lower but still consistent 8.21%. We can also see that China has a predominance of landfill over incineration. All countries included in the graph except China present some recycle, with Germany and Korea being the leading MSW recycling nations with 62 and 61 per cent of recycled waste respectively. Noteworthy, this graph was created with 2014 data, so I can affirm, basing also on my field-work and studies, that nowadays -more than 10 years later- China has started recycling its waste, too. There are then 4 countries which score higher on waste incineration: Japan places first with 79%, Denmark follows with 54% and Norway and Switzerland share the third position with 50%. Their advanced technology and incineration equipment are

considered as environmentally friendly and this makes them become the best performers (Manik Mian, 2016).

3.4.2 China's Import Ban and its impact on Chinese waste management system

It's also important to discuss the consequences of China's 2017 Import Ban. "It's already known that the key controllers of plastic waste flow are China, the US, Germany, and the wider EU, and it is difficult for other large economies to replace China's role within the trade network in the short term" (Na Song, 2021, p. 1119). In fact, "in the past there has been a significant gap in the strength of environmental policies and regulations between a developed country and developing countries like China (as per United Nations definitions) which made waste trade possible based on the difference in regulations and financial costs in each country" (Na Song, 2021, p. 1118).

The Import Ban promulgated by China in 2017, as already stated, had both positive and negative effects. Most probably China announced the ban to protect the domestic environment and improve human health; however, the positive effect is negated because of a variety of internal issues. Growing Chinese urbanisation produces a lot of constructions and demolition residues which is sent to landfills; this consequently increase the need for landfill space. This waste is also secretly, and illegally, dumped in the countryside (''fly-tipping'') and this phenomenon became even more common in many jurisdictions during the covid-19 pandemic (Na Song, 2021). "An analysis of the environmental impact on the life cycle of used Polyethylene Terephthalate (PET) shows that the absence of imported used PET in China leads to an increase in virgin PET fibre production using manufacturing processes that are based on carbon-intensive coal. All of these factors produce a direct harmful impact on environment and citizens' health" (Na Song, 2021, p. 1126).
On the other side, it was also revealed that the ban decreased the transport distances of waste plastics, thus reducing related environmental impacts such as a decrease of 84.8% marine eco-toxicity potential.

"Alongside the 2017 Import Ban, China also launched an ambitious five-year plan released on 18th January 2020 with the aim to control plastic pollution. This plan bans and/or restricts the production, sales and use of environmentally unfriendly plastic within China's national borders; this means that regular plastic demand will be cut by 2025 across the whole country" (Na Song, 2021, p. 1121).

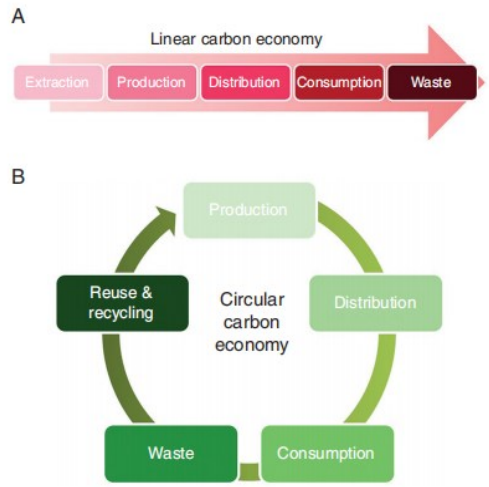
Talking about the future, it is certain that the Import Ban aim was to cut down the

amount of solid waste entering the country, therefore, decreasing the quantity of waste going to landfills; however -at the moment- landfill space is reducing quickly while emissions from previously disposed waste are up surging, which might drive to higher cost of landfill and more illegal dumping of domestic Construction and Demolition Waste (CDW) (Na Song, 2021).

"What the future brings about could be landfill mining, which in principle means the excavation, processing, treatment and/or recycling of previously landfilled materials" (Krook Joakim, 2012). In fact, the practise of landfill mining would be a choice to reduce landfill space demands, especially for those in big cities where urbanisation expands fast. Moreover, landfill mining could bring more opportunities if technological advances in waste re-processing were accelerated, which is the reason why I will soon suggest a number of possible suggestions and solutions for China's future.

While making hypothesis on the future of China's waste management system, it would also be fruitful to talk about the main endeavours the country is initiating.
"China has initiated ambitious programs to transform carbon intensive sectors. The predominant focus on addressing problems associated with the energetic utilization (i.e. combustion) of carbon resources for electricity and mobility has catapulted China to a leading position in terms of renewable energy output and in related technologies such as electric vehicles" (Roh Pin Lee, 2020, p. 170).
Moreover, as Figure 19 shows, in recent years China has started a transition from a linear to a circular carbon economy.

Figure 19. Graphical representation of a linear carbon economy and a circular carbon economy



Source: (Roh Pin Lee, 2020, p. 171)

“Circular Carbon Economy (CEE) extends the concept of a circular economy (reduce, reuse, recycle) by including remove and focusing exclusively on carbon and energy flows. “Reduce” represents all of the carbon mitigation options that reduce the amount of carbon entering the atmosphere system. Energy efficiency will reduce energy consumption and, consequently the associated carbon emissions” (Alqahtani).

The reliance on landfill sites as the dominant linear approach for waste disposal in China is associated with diverse problems, which in turn can lead us to suggest some solutions for the future.

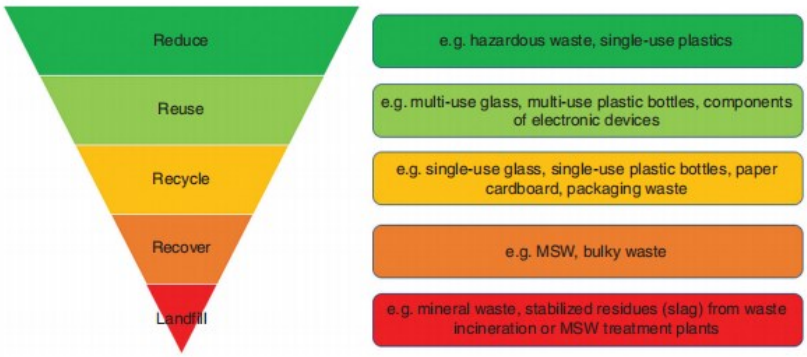
1. Insufficiency of available landfill locations: “various landfill sites in major Chinese cities such as Chongqing, Guangzhou and Guangzhou are already fully filled and had to be retired in advance. For example, the Jiangcungou landfill site in Xi’an City in the Shaanxi Province was designed to last until 2044, however due to having taken 4 times the amount of waste it was expected to, its capacity is anticipated to be reached about 25 years ahead of schedule” (Roh Pin Lee, 2020, p. 172). “This particular case, and the many similar others, should remind China that location for landfill sites should be chosen accurately, considering the landfill’s costs and effects on the environment and human health” (Manik Mian, 2016, p. 1134) ;
2. Emission of landfill gases: “landfill sites not only emit carbon dioxide (CO2) as well as other gases such as ammonia (NH3); they also represent a major source of CH4 emissions; the latter is a greenhouse gas which has a global warming potential 21 times greater than CO2. Furthermore, landfill gases such as CH4 are combustible and could increase the risk of open-surface or underground fires” (Roh Pin Lee, 2020, p. 172) and this is exactly what China should avoid for a better and more sustainable waste management in the future. In fact, “Chinese municipalities should establish advanced waste incineration plants to ensure high heat recovery and to do so they must prepare raw waste properly, and ensure lower moisture, ash (originating from the fires) and high combustible ratio” (Manik Mian, 2016, p. 1134). “Despite the disadvantages associated with waste incineration, it is a proven technology that can be implemented on a large scale in the short term to manage the urgent waste problems faced in China. Its contribution to resolving China’s current waste challenges is thus significant” (Roh Pin Lee, 2020, p. 176).
3. Soil and water contamination: “landfill leachate is formed when rainwater infiltrates and seeps through decomposing waste in a landfill site. It is characterized by high contents of organic and inorganic pollutants and is extremely toxic to the environment. Hence, a badly designed

or managed landfill site can be the source of soil and groundwater pollution About 47% of landfill sites in China are built without an effective leachate disposal system" (Roh Pin Lee, 2020, p. 172).

In general, over reliance on landfill and a bad waste management and disposal system combined can be the cause of serious environmental problems, but may also be harmful to Chinese citizens' health and safety. This is why Chinese MSW Management authorities should strictly implement separate waste collection system, establish separate bins with different colours for waste throwing and encourage citizens to follow this separation and respect the disposal rules (Manik Mian, 2016). For example, "Germany and Italy and just two examples of European countries that strictly separate domestic and public waste into categories and provide different-coloured bins for each category. In Germany, waste is separated into five categories and thrown in different colours bins or sacks, such as blue for paper/cardboards/cartons and yellow for plastic and aluminium" (Roh Pin Lee, 2020, p. 179).

China can certainly take other inspirations from Germany. First of all, "a key objective for Germany is the implementation of the waste hierarchy as stated in the European Waste Framework Directive 2008/98/EC. This hierarchy consists of five levels, as shown in the image below. As evident from the picture, the aim is to only allow landfilling for remaining waste fractions for which none of the treatments listed below is available. Germany is a pioneer in implementing the European Waste Framework Directive in its national laws. The waste
hierarchy, in fact, is at the centre of the Circular Economy Act" (Roh Pin Lee, 2020, p. 177).

Figure 20. Graphical representation of the 5 phases of waste disposal, according to type of waste



Source: (Roh Pin Lee, 2020, p. 177)

Even in case of employment of the landfill, drawing on European landfilling strategy, Chinese MSW landfilling should separate organic materials from landfilling in order to avoid leaching, odour and other environmental problems (Manik Mian, 2016).

On a more practical and daily level, some other hints for China are: a) to avoid unnecessary products and packaging by, for example, promoting tap water and ensuring better access to tap water in public areas, b) to make packaging and other products more environmentally friendly, for example by giving out incentives for ecological design and c) enhance recycling and utilize more recycled materials (Roh Pin Lee, 2020).

Going back to Germany's guiding example, "the country has founded the "Green Dot" in 1990 as the first dual system of its kind in the world. It is indeed a dual system established in order to liberate producers and retailers from their individual take-back and recovery obligations under the Packaging Ordinance. In establishing a dual disposal system besides the public-sector waste disposal service, it provides nationwide collection of used packages and facilities that enable their recirculation back into the economy as raw materials for production" (Roh Pin Lee, 2020, p. 179). Despite the huge dimensions of the Chinese nation and its still fragmented waste collection system, this could be a hint for China in the long period, too. Indeed, "in Germany -between 1990 and 2014, the Green Dot reported a decrease in total MSW from 35.4 million tons to 32.5 million tons. Of these, the proportion of residual MSW decreased considerably from 30.5 million tons to 13.1 million tons" (Roh Pin Lee, 2020, p. 179).

Lastly, another crucial problem characterizing China's waste management system is the lack of a proper taxation for MSW disposal. Fixed volume or weight base disposal charge could encourage people to reuse their waste, and increase recycling (Manik Mian, 2016). On the same line, "Germany started applying the "polluter-pays" principle, a strategy to make waste producers responsible for its recycling and disposal. The German industry became legally obliged to take back, reuse and recycle packaging materials that they had produced and placed on the market. For instance, Germany is the first nation worldwide where this principle is applied to MSW. Furthermore, in line with the 'polluter pays' principle, German households pay extra service fees for waste collection and disposal. To encourage a reduction in residual MSW, costs for the collection, treatment and disposal of black and green bins generally increase according to the size of the bins and frequency of collection" (Roh Pin Lee, 2020, p. 179,180).

To sum up the comparison on this topic, China -as a nation that is at the start of its journey in extending its waste management strategy- is in a good position to draw on the waste management experiences of other countries and evaluate the opportunities for transference to support its development of zero-waste cities pilot project (Roh Pin Lee, 2020).

3.4.3 "Zero-waste cities" in China

China's "zero-waste cities" initiative, launched in 2018, represents a transformative strategy to address increasing solid waste challenges through systemic governance and circular economy principles. The Zero Waste International Alliance (ZWIA) has defined it as "the responsible production, consumption, reuse and recovery of materials without burning or harmful discharges". Actually, in the last few decades, the "zero waste" concept has emerged as a global imperative (Yushuang Li, 2025).

For a successful implementation of zero-waste cities, a carbon transition that integrates the efficient and intelligent utilization of domestic primary and secondary carbon resources is key. "According to the international debate, this must be based on three main transformation pillars:

- A transformation from fossil to renewable energy sources: this is already observable in the electricity and mobility sectors, in which China is a global leader in terms of renewable energy output;
- The transition from a linear to a circular carbon economy, already discussed above, and for which China can surely draw on Germany's example;
- From reliance on imported carbon resources to domestic carbon resources for production, especially in the chemical industry" (Roh Pin Lee, 2020, p. 192).

"As of 2018, ''11 + 5'' cities and regions were labelled as zero waste construction pilot city or region on basis of Chinese administrative division, including eleven cities: Shenzhen city, Xining city and so on; one new district: state-level Xiong'an new area in Hebei province; one development zone: Beijing Economic and Technological Development Area; one international cooperative: Sino-Singapore Tianjin Eco-City, one county: Guangze county of Fujian province; one county-level city: Ruijin county-level city of Jiangxi province" (Na Song, 2021, p. 1125).

Chang and Eric Sheppard, in a study of Dongtan Eco-City and Chongming Eco-Island near Shanghai, demonstrate that sustainable urbanism in China manifests in suburban eco-city projects that seek to maintain agriculture and employment on the urban fringe.

Though indefinitely stalled, Dongtan and Chongming are framed as models of green development for other Chinese cities, despite being located in sensitive ecological zones and offering mainly high-end real estate (Harlan T. , 2020).

“Diverse Chinese cities have begun waste separation, with initial success -according to the Chinese and international debate- being reported for example in Shanghai”.
“In order to fully achieve ‘zero-waste cities’ in the future, the three pillars mentioned above are not sufficient; it is necessary that China complement the existing strategies of waste reduction, waste separation and waste utilization via energy recovery with recycling strategies such as mechanical pre-treatment and chemical recycling in order to facilitate the transition from a linear to a circular carbon economy” (Roh Pin Lee, 2020, p. 193,195).

In conclusion, China has surely been achieving valuable results in implementing a better waste management system, also learning from other countries’ examples, especially from Germany’s experience. However, the journey is still long and the nation can put into action a series of measures and tools in order to became even more sustainable, in line with the Green Belt and Road Initiative project launched more than a decade ago.

Conclusions

In conclusion, this research has examined China's environmental journey during the past 60 years and highlighted several key insights that contribute to our understanding of the evolution of the Belt and Road Initiative and of the Green Belt and Road Initiative, of their effects on the environment and ecosystems along the whole BRI route and has subsequently proposed and analysed some key mitigation tools to reduce environmental and social harm produced by BRI and Green BRI implementation, namely circular economy and waste management more specifically. The thesis has also investigated the international and Chinese debates on the main topics of analysis, after having delineated the policy frameworks and concrete actions undertaken. At the end of the research a paragraph has been dedicated to foresee possible future evolution of China's -and other countries'- sustainable development journey, including some insightful suggestions.

The research was guided by the following questions:
1) What have been the crucial steps of China's environmental path, since the start of the reform era in the 1970s?
2) How can the Belt and Road Initiative and the Green Belt and Road Initiative be described, and what are their origins?
3) What have been the consequences and effects of the BRI and the Green BRI on China's and other countries' environmental and social sphere?
4) What are the tools available to guide China and the other BRI-adhering nations towards a more sustainable future development?
5) What are the main challenges and possible future scenarios?

In order to address them, a combination of literacy review and discursive compilation was employed across three main chapters. In the third chapter, moreover, a survey was included. The latter was handed out to a sample of firms operating in the Guangdong area, particularly in Dongguan city (PRC) and the answers were analysed to further contribute to the assessment of the research questions.

The first part of the research firstly outlined the origins and development of both the BRI and the Green BRI starting from 2013 onward. After that, it demonstrated that the Chinese Government, since 2013, has implemented both written policies and norms and practical actions in order to further develop the Belt and Road Initiative and to make it "green" -in China and abroad- through three main fields: green finance, green energy and green cooperation mechanisms. However, the results of this

impressive endeavour have not always been positive, nor have always been positively welcomed by the international public opinion. In particular, it seems like BRI investments are actually contributing to green development in higher-income countries, but more resemble "greenwashing" in lower-income countries; this is because very often Chinese green cooperation objectives are more focused on mitigating the already existing environmental issues, rather than concentrated on promoting low-carbon and low-impact infrastructural development. The first chapter also analysed both the international and the Chinese debates on the topic.
The main suggestions highlighted by the first part in order to attain a more effective Green BRI are: to work towards a more equitable implementation of the policies and norms, both in higher-income countries and lower-income nations, further enhance international research and exchange to strengthen intellectual contributions to worldwide ecological development and prioritizing green development in people-to-people exchange, particularly by establishing an extensive partnership with the UNEP and the UNDP, so that the Green BRI can reach a broader consensus.

The second part highlighted the main implications of the Green BRI application on the environment and on the socio-economic sphere. In particular, the first part of the second chapter investigated the issue of carbon emissions and verified the presence of the Kuznets environmental curve in the involved countries. It also presented the negative effects on ecosystems and natural habits, such as deforestation, biodiversity loss, species' extinction etc., and the harmful impacts produced by the infrastructure construction programme and the massive employment of cement. In the last part of this chapter, the research proposed the fundamental ways to mitigate the negative impacts described, which are: legal mitigation (highlighting the need for a comprehensive and coordinated implementation of both EIAs and SESAs), practical mitigations and circular economy. After a comprehensive description, including policy framework and history and CE current situation, circular economy was further investigated by looking at the Chinese internal debate, to verify its level of activity and dynamicity.

Finally, the third section assessed the topic of waste management. Firstly, waste management was defined and its deployment was analysed within the Chinese State's borders, both from a regulatory point of view and a more concrete one. The sub-topic of waste to energy was also revealed. The chapter continued by describing my internship experience in China and Hong Kong at the Visottica Group Asian plants, which gave me hand-on highlights about the actual situation of waste management in the country and also the possibility to hand out a survey to a sample of 15 local firms, to investigate their efforts for a sustainable and efficient waste management. An analysis of the results

was also produced. The third chapter then investigated the waste management practices in other countries along the BRI route, by analysing China's overseas BRI projects -both regarding waste management and waste to energy - and the host countries' responses and consequent implications. Lastly, this section analysed the challenges and opportunities of China's sustainable journey and its possible future development according to the international debate and on a comparative basis, also including the topic of zero-waste cities.

These results contribute to the existing literature on the topics analysed, which all together delineate China's environmental "green" journey, while also offering new insights on the most recent innovations, such as zero-waste cities and new tools to better manage waste. In addition, they also give a hand-on, first-person perspective thanks to the presentation of my personal experience in China and the analysis of answers personally given by Chinese firms' managers.

From my personal point of view, what this research revealed is an ambivalent behaviour: China, on one side, has been paying a lot of attention and making great efforts to become "green", and more specifically to make the widest infrastructural strategic project -the Belt and Road Initiative- more sustainable on a long-term. The Chinese Government is also doing their utmost and investing huge funds to help the other countries along the BRI route catch up and following in China's footsteps towards a more sustainable future development; this particularly applies to lower-income, developing nations, such as Malaysia, Laos or Thailand. The latter, in fact, are doing their best to further develop their industrial and economic system, thus reaching China's growth level, but they need to be careful and learn from China's past "errors". Only in this way they will be able to develop rapidly and efficiently, but without negatively impacting their natural ecosystems and their society. On the other hand, we have to think about the reasons that are leading China into this "green" turning point. The question is: are they actually led by a genuine willingness to improve the environmental quality at the global level, and keep growing with a positive impact, both for the country itself, and fort its partners along the BRI route? Or are they instead driven by the need to be accepted by the worldwide community and by international organizations, to reach a wider consensus that will allow the nation to keep at the highest positions in the global ranking for the richest and most developed countries? Are they actually motivated by genuine intentions to make their actions more and more sustainable or is the Green BRI just a slogan to mitigate international concerns towards China's "brown model of development" and attract the global public opinion's consensus?

Nevertheless, the study is not without limitations. First, the results only partially answered the guiding questions, given that the topics investigated are still evolving and other questions emerged, as we

explained above. Second, the study doesn't give a complete review of the whole previous literacy. Such limitations should be considered when interpreting the results.

In conclusion, this thesis has provided an overview of China's sustainable journey, both from a legal framework point of view, and a more practical, hand-on point of view. The research has also presented Chinese internal debate, leveraging the precious contribution of a sample of Guangdong province local firms that accepted to answer my survey. The international academic and scientific debate was also investigated. While challenges remain, the study offers valuable insights and lays the groundwork for future investigations into China's "green" path that will certainly unfold even faster in the next few decades. In fact, further studies are also needed to assess the results of the descripted policies' application and of the sustainable tools and initiatives' effectiveness, since the outcomes often take many years to be revealed.

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Appendix

1. Table on important policies and regulations relevant to plastic waste management and trade in China.
   Source: table made by the author retrieving relevant data and info from (Shi, Zhang, & Chen, 2020, p. 192)

Policies/regulations	**Government institution**	**Promulgation and/or enactment year**	**Main contents**
Law on the Prevention and Control of Environmental Pollution by Solid Waste	National People's Congress	Promulgated in October, 1995 and enacted in April, 1996	Provide the basic legal framework for solid waste management in China
Interim Administration Provisions of Environmental Protection for Wastes Import	National Environment Protection Agency(NEPA), Ministry of Foreign Trade and Economic Cooperation (MOFTEC), General Administration of Customs (GAC), State Administration for Industry and Commerce (SAIC), General Administration of Quality Supervision (GAQS)	Promulgated and enacted in March, 1996	Formulate detailed administrative processes for wastes import, including permission application procedures and penalty clauses. Catalogue of solid wastes subjected to this regulation was listed. Plastic wastes were not included in the initial catalogue, but were supplemented soon after.

Environmental Protection Control Standard for Imported Waste (Trial) (GB16487.12)	NEPA	Enacted in August, 1996	Regulate the permitted limits on the impurity content, physical and chemical characteristics of imported plastic wastes.
Notification on Supplementing the National Catalogue of Solid Wastes as Raw Materials under Import Restriction	NEPA, MOFTEC, GAC, SAIC, GAQS	Promulgated and enacted in October, 1996	Four types of plastic wastes (HS code: 391510, 391520, 391530, 391590) were added into the catalogue under import restriction.
Notification about Refunds on Value-Added Tax For Waste Materials Recycling Enterprises	Ministry Of Finance , State Administration of Taxation	Enacted in January, 1995 and lapsed in November,1999	Preferential value-added tax policies are implemented for waste materials recycling enterprises and 70% of the value-added tax is refunded.
Tenth Five-Year Development Plan for Recycling and Utilization of Renewable Resources	State Economic and Trade Commission	Enacted in January, 2002	Encourage the recycling of solid wastes, and proposed a plan of recycling 5-6 million tons of plastic wastes per year
Amendment of Law on	National People's Congress	Promulgated in December, 2004 and	Establish a three-tier management system

the Prevention and Control of Environmental Pollution by Solid Waste		enacted in April, 2005	for waste import. Solid wastes are classified into three categories, i.e., prohibited, restricted and automatic permitted.
Regulations on Environmental Protection Management of Imported Plastic Wastes	Ministry of Environmental Protection (MEP)	Promulgated in January, 2013 and enacted in April, 2013.	Specify types of enterprises that are qualified for plastic waste import and environmental protection requirements that should be met.
The Green Fence Action	GAC	From February, 2013 to November, 2013	Investigate and penalize illegal and unqualified solid waste smuggling and trade
Order by the General Administration of Customs on the supervision of recycled plastic granules	GAC	Promulgated in May, 2014	Stipulate that recycled plastic granules processed abroad and imported to China are also solid wastes and should obey relevant environmental standards and subject to the administrative

			procedures of solid wastes.
Norms and Conditions on Plastic Wastes Utilization Industry	Ministry of Industry and Information Technology	Promulgated in September 2015, and enacted in January 2016	Set market entry conditions, energy and water consumption standards for plastic wastes recycling and processing enterprises.
Implementation plan on prohibiting trash import and promoting the reform of solid waste import management system	General Office of the State Council	Promulgated in April, 2017	A comprehensive implementation plan to prohibit trash import and reform the solid waste import management system. Reform principles, targets and fifteen specific tasks are listed.
Notification on Adjusting the Catalogue of Solid Waste Import Management (2017)	MEP, Ministry of Commerce (MOC), National Development and Reform Commission (NDRC), GAC, GAQS	Promulgated in July, 2017 and enacted in January, 2018	Prohibit the import of postconsumer plastic wastes
Notification on Adjusting the Catalogue of Solid Waste Import	MEP, MOC, NDRC, GAC	Promulgated in April, 2017 and enacted in January, 2019	Prohibit the import of industrial plastic wastes.

Management (2018)			

2. Visottica Group's Sustainability Report 2023 -published in 2024- available and downloadable at the following URL: https://www.visotticagroup.com/en/sustainability/
3. Attachments 1-5 and Attachment 8 of the "Guideline for the Management of General Industrial Solid Waste Ledger" with examples of the method to fill them in.

Attachment 1

General industrial solid wastes generation list (2022)

Person in charge (signature): Completed by： Completed on：

NO	Waste code	Name	Type	Generation process	Physical Characteristics	Main ingredients	Pollution Characteristics	Annual amount of waste generation
1	SW17	Waste paper	Class I general industrial solid waste	Packaging	Solid	Paper	Soil environment	50 ton
2								

Attachment 2

General industrial solid wastes flow summary (2022-05)

Person in charge (signature): Completed by： Completed on：

Waste code	Name	Type	Generation QTY	Storage QTY	Accumulative Storage QTY	Self-utilization method	Self-utilization QTY	Entrustment utilization method	Entrustment utilization QTY	Self-disposal method	Self-disposal QTY	Entrustment disposal method	Entrustment disposal QTY
SW17	Waste paper	Class I general industrial solid waste	0.5 ton	5 ton	10 ton	/	/	/	/	/	/	Other disposal	8 ton /

Attachment 3

General industrial solid wastes delivery process record

Record code.: Person in Charge (signature): XXX Completed on: 2022.5.10

Waste code	Name	Delivery time	Delivery QTY	Delivery process operator	Delivery unit	Transportation Info	Transportation way	Receiving unit	Flow type
SW17	Waste paper	2022.5.10 14：30	3 ton	Warehouse keeper signature (XXX)	Solid waste unit name	Transportation vehicle plate number/ driver name and contact information	road	Solid waste unit name	Intra-provincial transfer
SW15	Waste wood	2022.5.10 14：30	2	Warehouse keeper signature (XXX)	Solid waste unit name	Transportation vehicle plate number/ driver name and contact information	road	Solid waste unit name	Intra-provincial transfer

Attachment 4

General industrial solid wastes generation process record

Record code.：CS20220508 Generation device NO.： Waste generation Department head： Completed on：

Waste code	Name		Generation date	Generation QTY	Transfer time	Transfer to	Generation department operator	Delivery operator
SW17	Waste paper		5.8	200kg	17:00	Solid waste wahouse	XXX	XX

Attachment 5

General industrial solid wastes storage process record

Record code.: Storage deveice NO.: Storage department head Completed on：

In-warehouse								Out-warehouse				
Wastes source	Pre-record code	Waste code	Name	In-warehouse time	In-warehouse QTY	Delivery operator	Storage deopartment operator	Out-warehouse time	Out-warehouse QTY	Wastes flow	Storage deopartment operator	Delivery operator
注塑	CS20220508	SW17	Waste paper	17:00	200kg	Operator signature (XXX)	Operator signature (XXX)	/	/	/	/	/
								2022.5.10 14：30	15 ton	Solid waste unit name	Operator signature (XXX)	Solid waste unit name

Attachment 8

General industrial solid wastes classifications

Wastes Code	Wastes Type	Wastes Description
SW01	Smelting waste	Solid wastes (excluding red mud) from ferrous metal smelting, non-ferrous metal smelting, precious metal smelting, etc., including blast furnace slag from iron making, steel slag from steel making, manganese slag from electrolytic manganese, etc.
SW02	Flyash	The fine solid particles collected from the flue gas generated by the coal-burning process, excluding the ash discharged from the furnace of coal-fired facilities, mainly come from thermal power generation and other industries that use coal-fired facilities.
SW03	Slag	Ash and slag (excluding smelting slag) discharged from the furnace by combustion equipment, excluding the smoke and dust generated during the combustion of fuel.
SW04	Coal wastes	Solid wastes such as gangue and coal slime from coal mining and washing.

SW05	Tailings	The ore mined from metal and non-metal mines, and the solid waste generated after the valuable concentrate is selected by the concentrator, including iron ore, copper ore, lead ore, lead-zinc ore, gold ore (cyanide-related or flotation), Tailings produced after beneficiation of tungsten-molybdenum ore, pyrite ore, fluorite ore, graphite ore and other ores.
SW06	FGD gypsum	In the wet limestone/gypsum process of flue gas desulfurization, the by-products generated after the absorbent reacts with SO2 in the flue gas.
SW07	Sludge	Solid sediments from various types of sewage treatment.
SW09	Red mud	The polluting waste slag discharged after alumina is extracted from bauxite generally contains a large amount of iron oxide, and its appearance is similar to that of red soil.
SW10	Ardealite	A mixture of calcium sulfate dihydrate, acid insoluble matter, undecomposed phosphate rock and other impurities produced when sulfuric acid is used to decompose phosphate rock in phosphoric acid production. Mainly from the phosphate fertilizer manufacturing industry.
SW11	Industrial by-product gypsum	Gypsum wastes with calcium sulfate as the main component produced in industrial production activities, including fluoride gypsum, boron gypsum, titanium gypsum, Glauber's gypsum, salt gypsum, citric acid gypsum, etc., excluding desulfurization gypsum and phosphogypsum.
SW12	Drill cuttings	Mining solid wastes such as drilling cuttings from oil and gas extraction activities and other mining industries, excluding coal gangue and tailings

4. Survey made by the author and handed out to a series of companies located in the whole Guangdong province, China, available at the following URL: https://it.surveymonkey.com/r/DCH6QYC