

# An Analysis of Supply Chain Environment in Great Wall Motor Based on Life-Cycle Assessment

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**Abstract:** Great Wall Motor (GWM), a leading automotive manufacturer, places a strong emphasis on environmental sustainability and social responsibility. The company focuses on comprehensively evaluating and enhancing its supply chain to align with these objectives. This evaluation spans the entire product life cycle, encompassing design, manufacturing, packaging, distribution, usage, and recycling and disposal processes. Key areas of focus include optimizing raw material selection, improving product recyclability, reducing energy consumption and waste emissions, and minimizing carbon emissions during transportation. Through these endeavors, GWM not only enhances its environmental performance by reducing carbon emissions and resource consumption but also bolsters its brand image and competitiveness in the market. GWM's dedication to environmental innovation and technological leadership serves as a driving force behind sustainable development and social responsibility within the industry.

**Keywords:** Environmental assessment; Sustainability; Resource conservation; Carbon emissions; Social responsibility

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## 1. Introduction

### 1.1. Life-cycle assessment

Life-cycle assessment (LCA) is a comprehensive and systematic approach used to evaluate the environmental impact of products, processes, or services throughout their entire life cycle<sup>[1]</sup>. It considers various stages, starting from raw material procurement, through manufacturing, distribution, product use, and finally waste disposal.

LCA plays a crucial role in quantifying and assessing the adverse environmental impacts associated with each stage. This information enables decision-makers to develop effective environmental strategies and implement improvement measures<sup>[2]</sup>. Additionally, LCA can provide valuable insights to consumers regarding the environmental performance of products, promoting sustainable consumption practices and encouraging

environmentally conscious purchasing behavior<sup>[3]</sup>.

Through LCA, a comprehensive understanding and effective management of the environmental impacts related to the supply chain can be achieved. This knowledge allows companies to reduce resource consumption, minimize waste generation, and achieve their sustainability goals<sup>[4]</sup>. Furthermore, by prioritizing environmental factors and implementing sustainable practices within the supply chain, companies can enhance their environmental image and strengthen their market competitiveness<sup>[5]</sup>.

## 1.2. Research background

Great Wall Motor (GWM), a leading Chinese automobile manufacturing company established in 1976 and headquartered in Baoding, Hebei Province, is primarily engaged in the design, development, production, and sales of passenger vehicles, commercial vehicles, new energy vehicles, and automotive components. GWM enjoys a high level of recognition and market share both domestically and internationally, making it an important representative in the Chinese automotive industry. As a company that prioritizes sustainable development and social responsibility, GWM is committed to implementing a green supply chain strategy to reduce environmental burden, enhance competitiveness, and meet consumer demand for sustainability.

Conducting environmental assessments and research on GWM's supply chain is crucial not only for meeting environmental responsibilities and legal requirements but also for improving resource efficiency and cost control, fostering innovation and technological advancement, and contributing to sustainable development and social responsibility. This holds significant implications for GWM, the automotive industry as a whole, and the advancement of sustainable development in society.

- (1) Assessing environmental impacts: Through comprehensive environmental assessment methods, GWM evaluates the environmental impacts of its supply chain at different stages. This includes assessing various aspects such as product design, raw material procurement, production and manufacturing, logistics and transportation, product usage, and disposal. By utilizing quantitative and qualitative assessment indicators like energy consumption, carbon emissions, waste generation, and water resource utilization, a comprehensive understanding of the supply chain's environmental impact can be obtained.
- (2) Proposing improvement measures: Based on the results of the environmental assessment, GWM formulates improvement measures and action plans to minimize the environmental impact of the supply chain. This may involve optimizing product design, selecting environmentally friendly materials and manufacturing processes, improving energy efficiency, reducing waste and pollutant emissions, enhancing logistics and transportation methods, and promoting circular economy practices and waste recycling, among others<sup>[6]</sup>. The improvement measures should be feasible and sustainable, ensuring the reduction of negative environmental impacts while maintaining product quality and meeting customer demands.
- (3) Establishing a sustainable green supply chain strategy: Building upon the assessment results and improvement measures, GWM develops a sustainable green supply chain strategy. This includes setting clear goals and targets, establishing effective environmental management systems, collaborating and communicating with supply chain partners, driving green technology innovations, providing training for employees and suppliers, and monitoring and reporting environmental performance, among other initiatives<sup>[7]</sup>. The implementation of this strategy requires long-term commitment and alignment with the company's core values and strategic objectives.

Supply chain environmental assessments and research facilitate innovation and development in environmental technologies and sustainable solutions. GWM contributes to industry progress and sustainable

development by researching environmentally friendly materials and production processes and promoting the application and advancement of eco-friendly technologies.

## 2. The whole life cycle of GWM products

Figure 1 illustrates a summary of the GWM product life cycle.

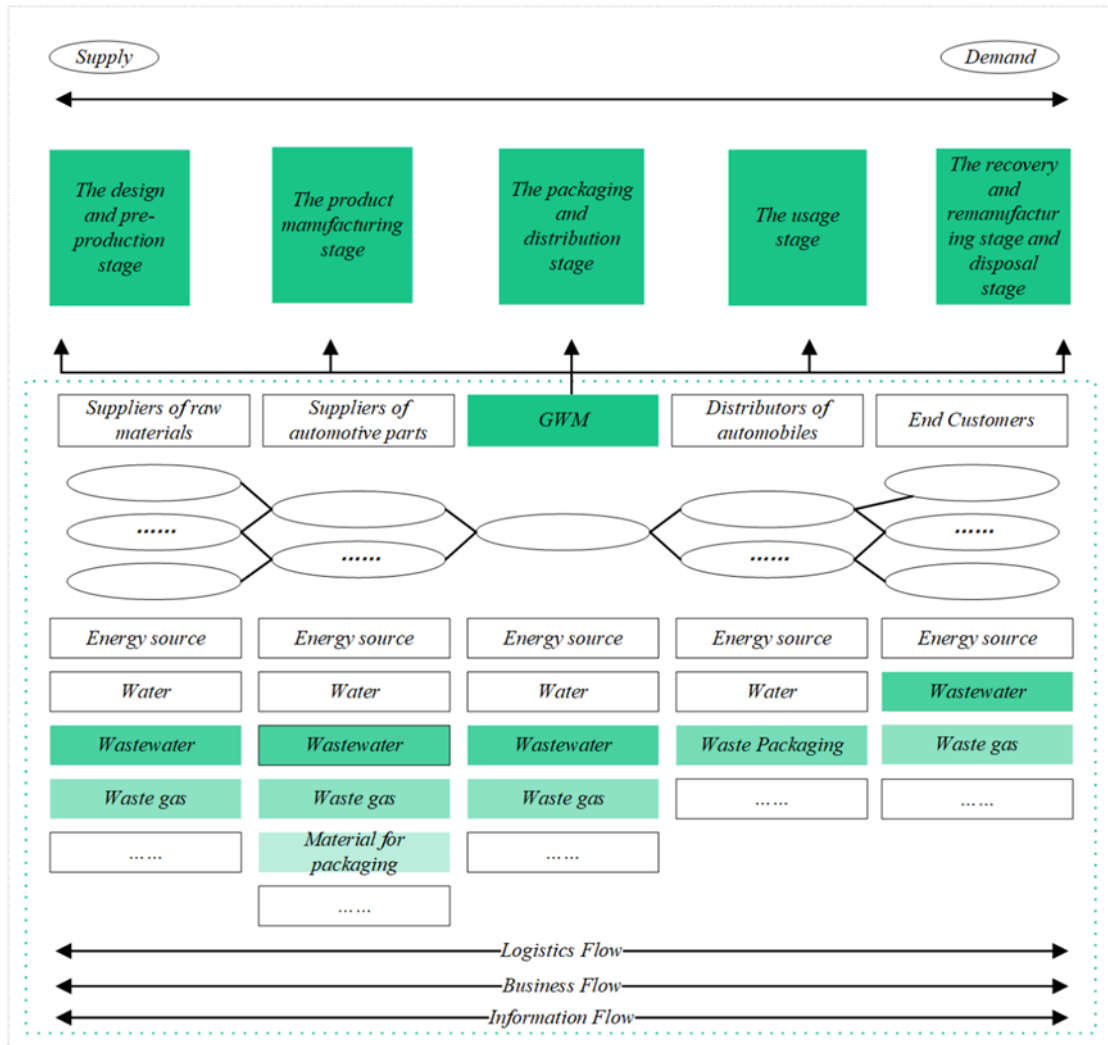


Figure 1. The full life cycle of GWM products

- (1) In the product design and pre-production phase, GWM focuses on considering the environmental impacts throughout the product's life cycle. By selecting environmentally friendly materials and optimizing product structures and processes, GWM aims to reduce resource consumption and environmental impacts. During the product design process, emphasis is placed on improving product performance, functionality, and safety while also prioritizing environmental friendliness. The use of eco-friendly materials helps reduce the pressure on natural resources caused by raw material extraction, while optimized product structures and processes minimize energy consumption and waste generation. By comprehensively considering various factors, GWM strives to achieve sustainable product design to meet consumers' environmental demands, reduce negative environmental impacts,

and ensure better environmental performance throughout the product's life cycle <sup>[8]</sup>.

- (2) In the product manufacturing phase, GWM is committed to reducing energy consumption, waste generation, and pollutant emissions. The company focuses on introducing efficient production processes and advanced manufacturing equipment to ensure product sustainability and environmental performance. Firstly, GWM improves production efficiency through process optimization and workflow enhancements. The adoption of advanced manufacturing technologies and automation equipment enhances production line efficiency and flexibility, thereby reducing energy consumption and human resource utilization. Additionally, supply chain management and production scheduling are optimized to ensure the rational utilization of raw materials and efficient operation of production processes. Secondly, GWM emphasizes quality control and product reliability. By implementing rigorous quality management systems and control processes, the company ensures that products meet standards and customer requirements. Reducing the rejection and defect rates during production decreases resource waste and environmental risks. Moreover, GWM is committed to reducing energy consumption and environmental pollution. The company employs energy-saving technologies and equipment, such as energy recovery systems and efficient energy utilization devices, to minimize energy consumption during the production process. Proper waste management and pollutant treatment are implemented to reduce waste generation and environmental pollution, ensuring the environmental friendliness of the production process.
- (3) In the product packaging and distribution phase, GWM focuses on using eco-friendly packaging materials and designs to reduce resource consumption and waste generation. The company emphasizes the selection of recyclable and biodegradable packaging materials, such as paper, cardboard, and recyclable plastics, to reduce the demand for natural resources <sup>[9]</sup>. Additionally, GWM optimizes logistics and distribution networks by implementing proper logistics planning and route optimization to minimize transportation distances and times, thereby reducing carbon emissions and energy consumption. Through collaboration with supply chain partners, GWM establishes efficient distribution networks and storage systems, reducing the environmental impact of packaging and transportation processes while enhancing supply chain sustainability and efficiency. GWM also promotes reusable and recyclable packaging solutions to minimize the use of disposable packaging materials. These initiatives aim to reduce the environmental burden of GWM's supply chain through eco-friendly packaging and efficient logistics, thereby achieving sustainable development goals.
- (4) In the product usage phase, GWM focuses on improving fuel efficiency and reducing emissions to minimize energy consumption and environmental impacts. Through the adoption of advanced engine technologies, energy-efficient driving training, and intelligent driving assistance systems, GWM provides efficient transportation solutions. Furthermore, GWM actively promotes clean energy vehicles and new energy vehicles, such as electric vehicles and hybrid vehicles, to reduce exhaust emissions and dependence on fossil fuels, driving the development of sustainable transportation. GWM also encourages users to adopt green driving habits, such as rational throttle and brake usage and minimizing sudden accelerations and decelerations, to minimize energy consumption and environmental pollution. Additionally, GWM emphasizes the importance of maintenance and upkeep. Through regular maintenance and proper vehicle repairs, the company ensures that products maintain optimal performance and fuel efficiency. These measures actively reduce energy consumption and environmental impacts during the product usage phase, contributing to sustainable development.
- (5) In the product recycling, remanufacturing, and disposal phase, GWM takes proactive measures to

promote product recycling, reuse, and proper disposal, aiming to minimize waste generation and negative environmental impacts. GWM implements effective recycling and remanufacturing strategies to convert materials and components from discarded products into new raw materials, reducing resource consumption. Additionally, GWM is committed to promoting the recycling and reuse of waste materials, working towards the goals of a circular economy. By establishing appropriate recycling networks and facilities, GWM ensures the proper collection, categorization, and disposal of discarded products. Collaborating with partners, GWM researches and develops innovative remanufacturing technologies to transform discarded products into high-quality remanufactured products, extending product lifecycles. Through these initiatives, GWM maximizes resource utilization, reduces waste landfilling and incineration, and promotes the sustainable development of the environment in the product recycling, remanufacturing, and disposal phase.

### **3. Assessment and analysis of the environment in the whole life cycle**

#### **3.1. Environmental impact of raw material selection for product design and pre-production stage**

The selection of raw materials plays a crucial role in the environmental assessment of the GWM supply chain. It directly affects the environmental performance of products and indirectly influences production processes, waste generation, and resource utilization. Through environmental assessment of raw material selection, GWM can identify the types and sources of materials that have significant environmental impacts on the supply chain and develop corresponding improvement measures. When evaluating raw material selection, GWM considers the following key factors.

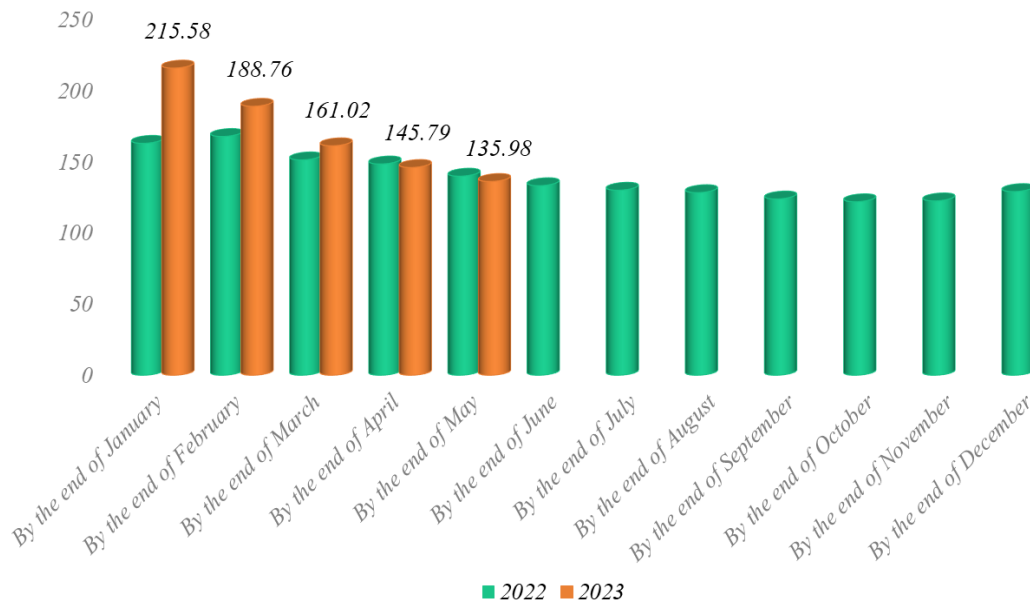
- (1) Environmental friendliness: Prioritizing environmentally friendly materials, such as renewable, recycled, and low-carbon materials. These materials can reduce resource consumption, environmental pollution, and dependence on non-renewable resources <sup>[10]</sup>.
- (2) Production process impacts: Assessing the environmental impacts of raw material production processes, including energy consumption, waste emissions, and pollutant releases. Choosing materials with lower environmental impacts can reduce the environmental burden on the supply chain <sup>[11]</sup>. The production and processing of metal materials like steel and aluminum, for example, release significant amounts of greenhouse gases, with carbon dioxide (CO<sub>2</sub>) emissions being a major concern. The production processes of textile and chemical materials require substantial water resources, leading to local water stress and pollution issues.
- (3) Material recyclability: Considering the recyclability and reuse potential of materials. Choosing materials that are easy to recycle and reuse can reduce waste generation and promote the practice of a circular economy.
- (4) Supply chain transparency: Collaborating with supply chain partners to ensure that the sourcing and procurement of raw materials comply with environmental and social responsibility standards <sup>[12]</sup>. This can reduce the use of materials with disputed or illegally sourced origins, thus minimizing negative impacts on the supply chain.

Through comprehensive evaluation and improvement of raw material selection, GWM can reduce the environmental impact of its supply chain, promote sustainable development, and establish the company's environmental image and market competitiveness.

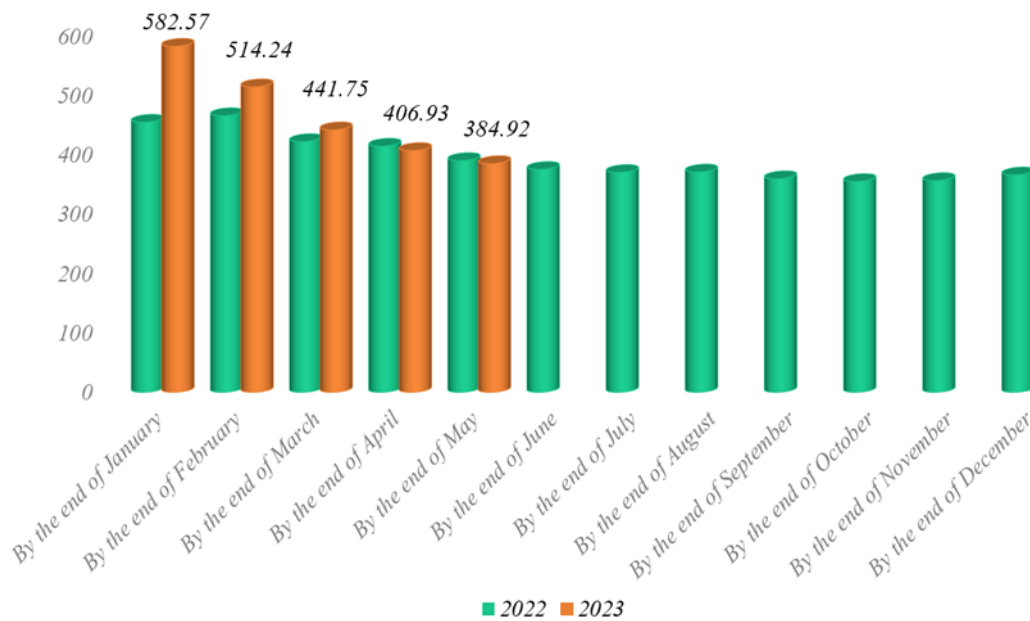
### 3.2. Energy consumption, waste emissions, and environmental pollution in the manufacturing phase of product production

- (1) Energy consumption: GWM faces challenges in energy consumption during its manufacturing processes. The low energy efficiency of production line equipment leads to energy waste. Additionally, GWM relies on traditional energy sources such as coal and petroleum instead of clean energy, resulting in increased energy consumption and carbon emissions. As shown in **Figure 2**, the cumulative energy consumption per unit in May 2023 reached 135.98 kilograms of standard coal, and the cumulative comprehensive energy consumption amounted to 56,600 tons of standard coal. By the end of May 2023, the manufacturing center had cumulatively used 30.58 million kilowatt-hours of green electricity, representing a year-on-year growth of 3.94%. This green electricity accounted for approximately 24.26% of the total electricity consumption of the manufacturing center.
- (2) Waste emissions: GWM still faces certain waste emission issues in its production processes. The handling of these waste materials and wastewater has an impact on the environment. For instance, wastewater discharge can pollute water resources and aquatic life. Improper management of waste materials, such as discarded materials, waste liquids, and emissions, can lead to pollution of soil, air, and water bodies. According to the report, there is room for improvement in waste management in some of GWM's factories. This includes increasing the proportion of waste classification and recycling, reducing waste generation and emissions, and improving the environmental friendliness of waste treatment. As depicted in **Figure 3**, by the end of May 2023, the manufacturing center had a carbon emission of 384.92 kgCO<sub>2</sub>e per unit, with cumulative comprehensive carbon emissions reaching 148,300 tons of CO<sub>2</sub>e. This represents a year-on-year decrease of 9.16%. The reduction in carbon emissions can be attributed to increased production volume as well as decreased usage of steam/natural gas for air conditioning in the painting workshop due to the rise in external temperatures. Additionally, the discontinuation of heating resulted in a reduction in fixed energy consumption.
- (3) Environmental pollution: GWM needs to pay further attention to environmental pollution and emissions. Specifically, the release of volatile organic compounds (VOCs) during the vehicle painting process can contribute to air pollution. While GWM has implemented measures to control exhaust and wastewater emissions, there is still room for improvement. According to environmental monitoring reports, some of GWM's factories still face certain levels of environmental pollution, such as emissions of nitrogen oxides (NO<sub>x</sub>) and particulate matter in exhaust gases <sup>[13]</sup>. To address these concerns, GWM should strengthen its management and monitoring of pollutant emissions, and implement more effective control measures to minimize the environmental impact. This may involve improving the painting process, introducing more environmentally friendly materials and technologies, and enhancing the construction of environmental facilities for exhaust gas and wastewater treatment. By continuously improving and monitoring these aspects, GWM can elevate its environmental management practices, reduce pollutant emissions, and achieve more sustainable production and development.

To enhance the environmental performance of GWM's supply chain, it is crucial to prioritize energy efficiency, waste management, and pollution control measures. Implementing cleaner energy sources, improving equipment efficiency, enhancing waste treatment processes, and adopting advanced pollution control technologies are essential steps toward achieving sustainable environmental practices.



**Figure 2.** Energy consumption per unit of GWM products (kg of standard coal)



**Figure 3.** Single unit carbon emission of GWM products (kgCO<sub>2e</sub>)

### 3.3. Resource consumption and waste generation in the product packaging and distribution phase

The packaging and distribution phase in GWM’s supply chain environmental assessment plays a crucial role and requires studying the impact of packaging materials and methods on resource consumption and waste generation. By comprehensively optimizing this phase, GWM can effectively reduce environmental impacts and enhance sustainability. When assessing the packaging and distribution phase, GWM should focus on the following aspects.

- (1) Resource consumption: GWM excessively relies on traditional non-renewable resources, such as plastics and paper, for packaging materials. The extensive use of non-renewable resources depletes

them and increases environmental pressure. To mitigate resource consumption, GWM can consider using more environmentally friendly renewable or recyclable materials, reducing reliance on non-renewable resources. Additionally, optimizing packaging processes to minimize excessive use of packaging materials can help reduce waste.

- (2) Waste generation: GWM generates a significant amount of waste packaging materials during the packaging process, including plastic films, cardboard boxes, and foam. Improper handling of these wastes can have adverse environmental impacts. GWM can take measures to reduce waste generation by optimizing packaging designs to minimize material usage, promoting the use of recyclable packaging materials, and establishing channels and mechanisms for recycling and reuse. Collaborating with supply chain partners is essential to enhance the collection and recycling of waste packaging materials <sup>[14]</sup>.

By comprehensively optimizing the packaging and distribution phase, GWM can reduce resource consumption and waste generation, thereby minimizing negative environmental impacts. Adopting environmentally friendly packaging materials and methods and promoting sustainable packaging and distribution practices contribute to enhancing GWM's environmental image and market competitiveness. These efforts align with GWM's commitment to environmental protection and sustainable development. GWM will continue to improve the environmental performance of the packaging and distribution phase and actively promote the overall sustainability of the supply chain.

### **3.4. Fuel efficiency, emissions, and waste in the product use phase**

GWM recognizes the importance of the product usage phase in the environmental assessment of its supply chain, encompassing aspects such as fuel efficiency, emissions, and waste management.

- (1) Fuel efficiency is a key concern, and some GWM vehicle models may exhibit lower efficiency, resulting in increased fuel consumption, greater demand for limited resources, and higher carbon emissions. To address this, GWM can implement measures such as introducing advanced powertrain systems and energy-saving technologies to reduce fuel consumption and carbon emissions.
- (2) Emissions also pose a significant challenge. Certain GWM vehicle models may have emissions issues, which can adversely impact air quality and human health, particularly with regard to greenhouse gases like carbon dioxide and harmful substances such as nitrogen oxides and particulate matter. GWM can mitigate emissions by adopting advanced emission control technologies and purification devices to minimize pollutants released by vehicles.
- (3) Effective waste management during the usage phase is crucial. GWM faces challenges in handling waste generated, such as used oil, discarded components, and worn-out tires, which can lead to environmental pollution and strain waste disposal systems. GWM can address this by implementing waste classification and recycling policies, promoting waste reuse and recycling, and employing environmentally friendly waste treatment methods, including compliant waste disposal and appropriate waste treatment facilities <sup>[15]</sup>.

By addressing fuel efficiency, emissions, and waste management during the product usage phase, GWM can significantly reduce its environmental impact and contribute to sustainable development. This proactive approach enhances GWM's environmental image, strengthens its market competitiveness, and aligns with the company's environmental responsibility.

### **3.5. Recycling and disposal phase: reverse logistics and closed-loop supply chain**

- (1) Strengthening the reverse logistics system: GWM should expand the coverage of the recycling



network and improve the efficiency of the recycling process. This can be achieved by collaborating with recycling partners, establishing collection centers in strategic locations, and implementing efficient sorting and processing methods.

- (2) Enhancing recycling and remanufacturing capabilities: GWM should invest in research and development to improve recycling and remanufacturing technologies. This includes exploring innovative methods for disassembling and processing discarded products and developing efficient remanufacturing processes to extend the lifecycle of components and materials.
- (3) Promoting supplier involvement: GWM should engage suppliers in the closed-loop supply chain by establishing clear requirements and guidelines for sustainable procurement. This includes selecting suppliers that prioritize environmental responsibility and actively participate in recycling and remanufacturing initiatives.
- (4) Improving closed-loop supply chain systems: GWM should develop comprehensive closed-loop supply chain systems that integrate recycling, remanufacturing, and distribution processes. This involves streamlining material flow, optimizing transportation routes, and establishing effective information systems to track and trace recycled materials.

By implementing these strategies, GWM can enhance the effectiveness and efficiency of reverse logistics and closed-loop supply chain systems. This will result in increased recycling rates, reduced waste generation, and minimized environmental impact. Moreover, GWM's commitment to sustainable practices can improve its brand image, attract environmentally conscious consumers, and foster long-term competitiveness in the market.

#### **4. Reinventing the green supply chain for GWM products**

**Table 1** provides a comprehensive analysis of GWM's product lifecycle by considering five subsystems. This analysis enables us to explore strategies for reshaping GWM's green supply chain.

- (1) The green design subsystem focuses on considering environmental friendliness and sustainability during the product design phase. This includes selecting eco-friendly materials, optimizing product structures to reduce resource consumption and waste generation, improving energy efficiency and durability, as well as enhancing repairability and recyclability. Through green design practices, GWM can minimize the environmental impact of its products and achieve better environmental performance throughout their lifecycle <sup>[16]</sup>.
- (2) In the green procurement subsystem, the emphasis is on the procurement process of raw materials. The objective is to select environmentally friendly and sustainable suppliers and materials. This involves evaluating suppliers' environmental management capabilities and social responsibilities, considering the environmental impacts and recyclability of raw materials, and promoting supply chain transparency and compliance. Through green procurement practices, GWM can reduce environmental risks and social responsibility issues in its supply chain, while driving sustainable development within the supply chain <sup>[1]</sup>.
- (3) The green production subsystem focuses on minimizing environmental impacts during the production process. By optimizing production processes, improving energy efficiency, and reducing waste and emissions, GWM can minimize the negative environmental effects of its production activities. Additionally, green production involves promoting the application of clean production technologies and renewable energy sources to foster sustainability and low-carbon development within the supply chain.

**Table 1.** GWM product green supply chain system indicators

Tier 1 indicator	Tier 2 indicators	Tier 3 indicators
Green supply chain evaluation index system for automotive products	Green design	Rate of raw material utilization
		Recycle rate of raw materials
		Cleanliness of fuel
		Material renewability
		Safety of products
		Recyclability of products
		Easy dismantling of products
	Maintainability of products	
	Green procurement	Packing material greenness
		Material renewability
Recyclability of materials		
Cost of purchase		
Certification of ISO14001		
Green manufacturing	Green recognition of suppliers	
	Supplier environmental performance	
	Volume of wastewater production	
	Volume of exhaust gas production	
	Volume of solid waste production	
Green sales	Volume of noise production	
	Green degree of the whole vehicle	
	Rate of cost recovery	
	Rate of equipment utilization	
	Satisfaction of green needs	
	Usage rate of green tools	
	Rate of green storage	
	Rate of green unloading	
Rate of green transportation		
Green recycling	Middlemen green awareness	
	Greenness of marketing network	
	Greenness of advertising	
	Degree of green promotion	
	Cost of waste disposal	
	Rate of complete vehicle returns	
Rate of parts return		
Handling capacity of used cars		
Rate of waste material recycling		
Rate of wastewater recovery		
Recycling rate of end-of-life products		
Rate of harmless waste treatment		

- (4) The green sales subsystem addresses the promotion and sales processes of products in the market. This includes providing accurate and reliable product environmental information, promoting environmental and sustainable consumption awareness, and establishing communication channels with consumers to understand their environmental needs and opinions. Through green sales practices, GWM can enhance consumer awareness and recognition of its environmentally friendly products, and encourage the adoption of sustainable consumption behaviors.
- (5) The green recycling subsystem focuses on the end-of-life stage of products, particularly the recycling and reuse processes. By implementing effective recycling and remanufacturing strategies, GWM can minimize waste generation and adverse environmental impacts. Green recycling also involves promoting proper waste disposal and the circular utilization of resources to foster the practice of a circular economy and achieve sustainable development.

Through a comprehensive assessment and improvement of the green design, green procurement, green production, green sales, and green recycling subsystems, GWM can establish a comprehensive green supply chain system. Such a green supply chain system will help reduce the environmental impacts of GWM's supply chain, achieve sustainable development goals, and enhance the company's environmental image and market competitiveness. The efforts and practices of GWM in building a green supply chain not only hold significance for the company itself but also serve as an exemplary model for the entire automotive industry's pursuit of sustainable development.

#### **4.1. Increased physical properties and recyclability of products**

In the environmental assessment of GWM's supply chain, optimizing product physical characteristics and increasing recyclability are key areas for improvement. Here are some approaches to achieving these goals <sup>[17]</sup>:

- (1) Material selection: Choose environmentally friendly materials that have low environmental impacts throughout their lifecycle. Prioritize materials that are recyclable, renewable, or sourced from sustainable and responsibly managed suppliers. By selecting materials with favorable environmental characteristics, such as a low carbon footprint or reduced resource consumption, GWM can enhance the overall sustainability of its products <sup>[18]</sup>.
- (2) Design for disassembly: Design products with disassembly in mind to facilitate the separation of different components and materials at the end of their lifecycle. This enables easier recycling and remanufacturing processes, as well as reduces waste generation. By incorporating modular design principles and using standardized fasteners and connectors, GWM can enhance the ease of disassembly and increase the potential for component reuse.
- (3) Minimize hazardous substances: Ensure that products are free from hazardous substances and comply with relevant regulations and standards. Avoid using materials that contain toxic or harmful substances, such as lead, mercury, or certain types of flame retardants. By minimizing the presence of hazardous substances, GWM can reduce environmental pollution risks during the product lifecycle and promote safer recycling and disposal processes.
- (4) Packaging optimization: Evaluate and optimize product packaging to reduce material usage and minimize environmental impacts. Use packaging materials that are recyclable or made from recycled content. Additionally, consider implementing packaging designs that are space-efficient during transportation to reduce energy consumption and emissions.
- (5) Energy efficiency: Improve product energy efficiency to reduce overall energy consumption during the use phase. This can be achieved through innovations in vehicle design, such as lightweight

materials, aerodynamic improvements, and advanced powertrain technologies. By reducing energy consumption, GWM can lower its carbon footprint and contribute to mitigating climate change.

- (6) Collaboration with suppliers: Engage with suppliers to foster a sustainable and responsible supply chain. Encourage suppliers to adopt environmentally friendly practices, improve their environmental performance, and provide transparency regarding the origin and environmental impact of their materials. Establish partnerships that prioritize sustainable sourcing, waste reduction, and resource efficiency.
- (7) Consumer education and engagement: Raise consumer awareness about the environmental benefits of choosing products with optimized physical characteristics and recyclability. Provide clear and accessible information to consumers regarding the environmental attributes of products, such as recyclability, energy efficiency, and emissions performance. Encourage consumers to participate in recycling programs and support sustainable consumption behaviors.

By focusing on these aspects and implementing appropriate strategies, GWM can optimize the physical characteristics of its products and increase their recyclability. This will contribute to a more sustainable supply chain, reduced resource consumption, minimized waste generation, and enhanced environmental performance.

## 4.2. Key segment environmental hotspots identified and optimized

In the environmental assessment of GWM's supply chain, the production of the entire vehicle is a critical stage that requires attention to address environmental hotspots. Here are some areas to focus on for improvement<sup>[19]</sup>:

- (1) Energy efficiency: Enhance energy efficiency in the production process by implementing energy-saving measures, such as upgrading equipment, optimizing production lines, and utilizing energy-efficient technologies. This includes improving the efficiency of machinery and equipment, reducing energy consumption during manufacturing operations, and promoting the use of renewable energy sources where feasible<sup>[20]</sup>.
- (2) Emissions control: Implement measures to reduce emissions of greenhouse gases (GHGs) and air pollutants during the production process. This can involve the installation of advanced emissions control technologies, such as catalytic converters and particulate filters, to minimize the release of pollutants into the air. Additionally, proper maintenance and calibration of equipment and vehicles can help ensure optimal performance and reduce emissions<sup>[21]</sup>.
- (3) Waste management: Develop effective waste management practices to minimize waste generation and promote recycling and reuse within the production process. This includes implementing waste reduction strategies, segregating different types of waste, and establishing partnerships with recycling facilities to maximize the recovery of valuable materials. GWM can also explore opportunities for circular economy principles, such as remanufacturing or refurbishing parts and components.
- (4) Water conservation: Implement water-saving measures and promote water recycling and reuse within the production process. This can involve the installation of water-efficient technologies, optimizing water usage in manufacturing operations, and treating and reusing wastewater where feasible. By reducing water consumption and minimizing the discharge of wastewater, GWM can contribute to water resource conservation and minimize the environmental impact on local ecosystems.
- (5) Supply chain collaboration: Collaborate with suppliers to promote sustainable practices and ensure environmental responsibility throughout the supply chain. Encourage suppliers to adopt environmentally friendly production methods, source materials responsibly, and comply with relevant environmental regulations and standards. Establish clear communication channels and work together

to address shared environmental challenges and identify opportunities for improvement.

- (6) Continuous improvement and innovation: Foster a culture of continuous improvement and innovation within the production process. Encourage research and development activities aimed at developing and adopting cleaner technologies, optimizing production processes, and exploring alternative materials with lower environmental impacts. Regularly monitor and evaluate the environmental performance of the production process, identify areas for improvement, and implement appropriate measures accordingly.

By focusing on these areas and implementing effective strategies, GWM can address environmental hotspots within the vehicle production stage of its supply chain. This will contribute to the overall environmental performance of the company, promote sustainable practices, and support its commitment to environmental responsibility and stewardship.

### **4.3. Carbon emissions from improved transportation distances and modes**

In the environmental assessment of the supply chain of GWM, the issue of carbon emissions during the product packaging and distribution stage is closely related to transportation distance and mode. Here are the analysis and improvement measures for these issues:

- (1) Route optimization: Evaluate and optimize the transportation routes of the products, selecting shorter distances and more efficient paths. By reducing transportation distance, carbon emissions and energy consumption can be reduced. Advanced logistics planning and route optimization techniques, combined with real-time data and traffic information, can minimize empty runs and unnecessary mileage, thereby improving logistics efficiency <sup>[22]</sup>.
- (2) Intermodal transportation and consolidation centers: Adopt intermodal transportation models that integrate different modes of transportation, such as rail, waterway, and road, to minimize carbon emissions. The establishment and utilization of consolidation centers can also reduce the number of transportation trips and distances for multiple suppliers, optimizing transportation efficiency and reducing reliance on fuel consumption and carbon emissions <sup>[23]</sup>.
- (3) Green transportation vessels: Promote the use of low-carbon and zero-emission transportation vessels, such as electric vehicles, hybrid vehicles, and vehicles powered by renewable energy sources. GWM can consider introducing electric cargo vehicles and utilizing transportation vessels powered by renewable energy sources to reduce carbon emissions and drive sustainable transportation development <sup>[24]</sup>.
- (4) Packaging optimization: Optimize product packaging design to reduce the use and waste of packaging materials. Adopt lightweight packaging and recyclable materials, such as biodegradable cardboard or recyclable plastic packaging, to reduce carbon emissions and resource consumption. Additionally, GWM can collaborate with suppliers to explore innovative packaging solutions, such as reusable or stackable packaging designs, to improve packaging efficiency and sustainability.
- (5) Carbon offset measures: Consider implementing carbon offset measures, such as purchasing carbon credits or supporting renewable energy projects, to offset carbon emissions generated during the transportation process. This helps achieve carbon neutrality goals and promotes low-carbon transportation and sustainable development.

By analyzing and implementing the aforementioned improvement measures for carbon emissions during the product packaging and distribution stage, GWM can reduce carbon emissions in its supply chain, reduce dependence on energy resources, and enhance its sustainability performance. This will contribute to achieving

the company's environmental objectives, enhancing competitiveness, and establishing GWM as a leader in environmental protection.

#### **4.4. Low-carbon driving and green driving habits promotion**

- (1) Driver training: Provide eco-driving training for vehicle owners, teaching them energy-saving driving techniques and principles. This includes utilizing the accelerator and brakes judiciously, reducing abrupt accelerations and decelerations, maintaining appropriate speeds, and using vehicle auxiliary devices reasonably. By raising drivers' awareness and skills, vehicle energy consumption and emissions can be lowered <sup>[25]</sup>.
- (2) Information reminders and feedback: Provide real-time feedback on energy consumption and driving behavior to vehicle owners through built-in vehicle information systems or mobile applications. This helps drivers understand the impact of their driving habits on energy consumption and carbon emissions, motivating them to adopt more environmentally friendly driving behaviors <sup>[14]</sup>.
- (3) Intelligent driving assistance systems: Introduce intelligent driving assistance systems such as energy-saving cruise control, smart energy-saving assistance, and lane-keeping assistance. These systems optimize the power output of vehicles and provide energy-saving driving suggestions, assisting drivers in operating vehicles more efficiently, thereby reducing energy consumption and carbon emissions <sup>[26]</sup>.
- (4) Promotion of electric and hybrid vehicles: Actively promote the use of electric vehicles and hybrid vehicles, reducing the reliance on traditional fuel-powered vehicles. Electric and hybrid vehicles have lower carbon emissions and energy consumption, making them crucial choices for sustainable transportation <sup>[27]</sup>.
- (5) Development of charging infrastructure: Strengthen the development of charging infrastructure, providing convenient charging services and support to promote the widespread adoption of electric vehicles. The accessibility and coverage of charging infrastructure can enhance the availability and feasibility of electric vehicles, encouraging more people to choose low-carbon modes of transportation <sup>[28]</sup>.

Through the promotion of low-carbon driving practices and the cultivation of green driving habits, GWM effectively reduces energy consumption and carbon emissions during the usage phase of its supply chain. This contributes to the achievement of sustainable development goals and establishes GWM as a leader in the sustainable transportation field.

#### **4.5. Waste products sustainable disposal**

- (1) Recycling and reutilization: Establish a waste product recycling system to maximize the recovery and reuse of materials and components from discarded products. By implementing proper dismantling and processing procedures, valuable materials can be recovered, reducing resource consumption and minimizing waste generation and environmental pollution.
- (2) Design considerations: Incorporate the recyclability and potential for reutilization of waste products during the product design phase. Utilize detachable components, standardized interfaces, and easily disassembled materials to facilitate the dismantling and processing of waste products, creating conditions for efficient recycling and reutilization.
- (3) Environmentally sound disposal: Ensure environmentally sound disposal of waste products by complying with relevant laws, regulations, and environmental standards. Choose compliant waste management enterprises or organizations to ensure proper classification, treatment, and disposal of waste products, reducing environmental and health risks.

- (4) Resource circularity: Promote the circular use of resources from waste products by employing suitable technologies and processes to convert them into new raw materials or energy sources. For example, through the remanufacturing of discarded vehicles and utilization of recycled materials, resource circularity can be achieved, reducing the demand for virgin resources.
- (5) Consumer education and engagement: Strengthen consumer education to enhance their awareness of waste product management and sustainable disposal. Encourage consumer participation in waste product collection and disposal actions through the establishment of recycling facilities and promotional activities, providing convenient recycling channels, and fostering behavioral changes among consumers.
- (6) Collaboration with partners: Collaborate with supply chain partners to jointly promote waste product management and sustainable disposal practices. Establish partnerships with recycling enterprises, waste management companies, and relevant organizations to develop and implement waste product management plans, ensuring sustainable treatment and resource recovery of waste products <sup>[29]</sup>.

By exploring waste product management and sustainable disposal methods, GWM can effectively manage and handle waste products in its supply chain, reducing resource waste and environmental pollution. This will contribute to the achievement of sustainability goals while establishing the company's reputation as an environmentally conscious leader in the industry.

## **4.6. Reinventing the green supply chain gain of GWM products**

### **4.6.1. Environmental benefits**

- (1) Reduced carbon footprint: By implementing green practices across the supply chain, such as sustainable sourcing, energy-efficient production, and optimized transportation, GWM can significantly reduce its carbon footprint. This reduction in greenhouse gas emissions contributes to mitigating climate change and preserving the environment.
- (2) Resource conservation: A green supply chain emphasizes the efficient use of resources, including raw materials, energy, and water. Through measures like waste reduction, recycling, and eco-friendly packaging, GWM can minimize resource consumption and waste generation, leading to the conservation of natural resources and ecosystems.
- (3) Biodiversity preservation: Implementing sustainable sourcing practices and responsible land use strategies can help protect biodiversity hotspots and ecosystems. By minimizing habitat destruction, pollution, and other negative impacts, GWM can contribute to the preservation of biodiversity and the restoration of natural ecosystems.

### **4.6.2. Economic benefits**

- (1) Cost savings: Green supply chain practices, such as energy-efficient manufacturing processes, waste reduction, and optimized logistics, can result in cost savings for GWM. By reducing energy consumption, minimizing material waste, and streamlining operations, the company can achieve greater operational efficiency and cost competitiveness.
- (2) Enhanced brand reputation: Embracing sustainability and establishing a green supply chain can enhance GWM's brand reputation. Customers, investors, and stakeholders are increasingly valuing environmentally responsible practices, and a strong commitment to sustainability can attract and retain customers, boost investor confidence, and strengthen the company's market position.
- (3) Innovation and competitive advantage: Shifting towards a green supply chain requires innovation and the adoption of sustainable technologies and practices. By investing in research and development,

collaborating with suppliers and partners, and staying at the forefront of sustainable trends, GWM can gain a competitive advantage and position itself as an industry leader in sustainability.

#### **4.6.3. Social benefits**

- (1) **Stakeholder engagement:** A green supply chain approach involves engaging stakeholders, including suppliers, customers, employees, and local communities. Through transparent communication, partnerships, and responsible practices, GWM can foster positive relationships, build trust, and create shared value with its stakeholders.
- (2) **Health and safety:** Green supply chain practices prioritize the health and safety of workers, customers, and communities. By adhering to stringent environmental and social standards, ensuring fair labor practices, and minimizing exposure to harmful substances, GWM can contribute to the well-being and quality of life of its employees and surrounding communities.
- (3) **Sustainable development:** By driving the transition to a green supply chain, GWM can contribute to the overall sustainable development of the automotive industry and society at large. By setting an example and inspiring other companies to follow suit, the company can contribute to a more sustainable and resilient future.

Overall, the adoption of a green supply chain by GWM generates significant environmental, economic, and social benefits. By embracing sustainability and integrating green practices across the supply chain, the company can contribute to a greener and more sustainable automotive industry while reaping the rewards of improved efficiency, cost savings, and enhanced brand reputation.

## **5. Conclusion**

GWM has achieved significant accomplishments by evaluating and researching the environmental impact of its supply chain, resulting in improved environmental benefits, enhanced competitiveness, and bolstered brand image.

Firstly, GWM has optimized the environmental performance of its supply chain, leading to enhanced environmental benefits. During the product design and pre-production phase, GWM focuses on using eco-friendly materials and optimizing processes to reduce resource consumption and environmental impact. In the production and manufacturing phase, GWM has introduced efficient production techniques and advanced equipment to minimize energy consumption, waste generation, and pollutant emissions. For packaging and distribution, GWM adopts eco-friendly packaging materials and implements rational logistics planning to reduce resource consumption and carbon emissions. During the product usage phase, GWM emphasizes improving fuel efficiency and reducing emissions to lower energy consumption and environmental impact. In the product recycling, remanufacturing, and disposal phase, GWM actively promotes product recycling and reuse, minimizing waste generation and achieving resource circularity. These measures collectively contribute to the improved environmental performance of GWM's supply chain, reducing environmental burdens and enhancing environmental benefits.

Secondly, GWM has strengthened its competitiveness by prioritizing sustainable development and social responsibility. With a strategic focus on a green supply chain, GWM strives for innovation in environmentally friendly technologies and solutions, positioning itself as a technological leader in the environmental field. By reducing environmental risks and ensuring compliance, GWM has enhanced its market competitiveness and reputation, garnering recognition and support from consumers. The assessment of environmental risks in the supply chain enables GWM to identify and manage potential environmental risks, driving innovation in technology and processes, reducing costs and resource consumption, and enhancing product quality and



reliability. These efforts distinguish GWM as a leader in sustainable development and social responsibility, enabling the company to stand out in the market.

Lastly, GWM's commitment to sustainable development enhances its brand image. GWM actively promotes innovation in green technologies and environmental solutions, establishing a prominent position in the environmental field. The company's environmental efforts have gained recognition and appreciation from consumers and society, elevating its brand image and reputation. GWM's dedication to sustainable development further solidifies its position as a leader in the sustainable transportation sector, exemplifying its commitment to corporate social responsibility.

In conclusion, GWM's evaluation and research of its supply chain's environmental impact have contributed significantly to the company's sustainable development and social responsibility. The company's efforts have not only brought about economic benefits and competitive advantages but also facilitated long-term sustainable development and social responsibility.

## Disclosure statement

The authors declare no conflict of interest.

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