STUDY ON THE OPPORTUNITY OF AN INCLUSIVE CIRCULAR ECONOMY FOR ARMENIA

VALUE CHAIN ANALYSIS

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Contents

Figures

Tables

Executive Summary

Armenia's transition toward an inclusive circular economy must be understood not as an environmental add-on to existing sectoral policies, but as a structural transformation of its production model, resource management system, and industrial competitiveness framework. The value chain analysis conducted across garments and textiles, plastics packaging, metals (scrap and mining residues), fishing and aquaculture, and fruit and vegetable processing demonstrates that Armenia's economy remains predominantly linear in structure: material inflows are heavily import-dependent, value addition is concentrated in selected downstream activities, and significant volumes of potentially recoverable resources exit the system as waste. At the same time, each sector contains specific leverage points where circular interventions can generate measurable economic, environmental, and social returns if approached strategically and sequentially.

Across all five value chains, a consistent pattern emerges. Armenia imports a large share of its raw and intermediate inputs—textile fabrics and fibers, primary plastic polymers, chemical agricultural inputs, fish feed components, packaging materials, and in many cases semi-processed industrial goods. Domestic production frequently focuses on assembly, processing, or conversion stages rather than upstream raw material generation. Once products reach the end of their functional life or production residues are generated, structured recovery systems are weak, fragmented, or absent. Landfilling remains the dominant disposal pathway for municipal and industrial waste streams, while recycling and valorization activities are concentrated in a narrow set of high-value materials, such as ferrous scrap and selected non-ferrous metals. This structural configuration results in continuous resource leakage, exposure to external supply shocks, lost domestic value addition, and avoidable environmental pressures.

In the garments and textile sector, Armenia has built a socially important and export-oriented manufacturing base that employs more than thirteen thousand workers, predominantly women, and integrates into regional and European markets through cut–make–trim production models. However, the sector's structural reliance on imported fabrics and accessories limits domestic value retention at the upstream stage. Production generates relatively clean cutting off-cuts—typically 10 to 20 percent of fabric input—yet systematic reuse or recycling capacity remains minimal. At the post-consumer stage, textile waste is almost entirely mixed with municipal waste and disposed of in landfills, as no nationwide collection or sorting system exists. The absence of textile-specific extended producer responsibility schemes, automated sorting infrastructure, and fiber-to-fiber recycling facilities means that valuable material embedded in garments is effectively lost. Nevertheless, Armenia's textile value chain also presents realistic entry points for circular improvement. Cutting optimization technologies, digital pattern planning, and operator training can reduce fabric waste without requiring radical restructuring. Pilot textile collection systems in urban areas, combined with aggregation of homogeneous production off-cuts, could gradually build the feedstock base required for future recycling investment. In this sector, circular transition should begin with production-stage efficiency and structured collection pilots rather than with capital-intensive recycling plants that exceed current market scale.

The plastics packaging value chain illustrates a different but equally structural circularity gap. Armenia has developed a modest but growing downstream plastic conversion industry that produces packaging, bottles, films, and household items from imported polymer resins. Imports of primary plastics and finished plastic packaging products remain high, and domestic consumption of plastic packaging has increased steadily in recent years. However, approximately ninety to ninety-five percent of plastic waste is landfilled. Only a small fraction—primarily PET bottles and rigid HDPE containers—is recovered through formal or informal channels. The central bottleneck is not the absence of recycling firms, but the lack of systematic source separation and clean feedstock capture. Post-consumer plastics enter mixed municipal waste streams, become contaminated, and lose economic recyclability. At the same time, virgin polymers often remain cheaper and more consistent in quality than recycled materials, further weakening incentives for recovery. Circular reform in plastics must therefore prioritize feedstock capture over production technology. Phased introduction of deposit-return systems for beverage containers, expansion of urban source separation, and carefully sequenced extended producer responsibility mechanisms for packaging can significantly improve recovery rates. Equally important is the development of stable domestic demand for secondary plastics in non-food applications, such as construction materials and pipes, to ensure that recovered materials have predictable market outlets. Without downstream demand and clean input streams, recycling cannot scale sustainably.

In the metals sector, Armenia demonstrates that circular transformation is possible when economic incentives and regulatory measures align. The mining industry remains a cornerstone of exports, particularly in copper and molybdenum concentrates, yet most primary concentrates are exported for processing abroad, limiting domestic value addition. By contrast, the scrap metal segment has undergone a structural shift following the introduction of scrap export restrictions. Retention of ferrous scrap for domestic use has enabled expansion of scrap-based steel production through electric arc furnace technology. This shift has increased local value addition, reduced dependence on imported steel products, and positioned Armenia within a lower-carbon steel production pathway relative to blast furnace systems. Nevertheless, circularity in metals remains incomplete. Electronic waste recycling is largely absent, end-of-life vehicle dismantling systems are underdeveloped, and large volumes of mining tailings remain stored rather than reprocessed or valorized. Informal scrap collection networks limit traceability and material quality control. The next stage of metals circularity must therefore focus on formalization of collection systems, structured extended producer responsibility for batteries and electronics, and pilot projects for tailings reprocessing or reuse in construction materials. The metals case illustrates that circularity becomes economically viable when secondary materials are treated as strategic industrial inputs rather than as waste streams.

The fishing and aquaculture value chain reveals a different structural vulnerability. Armenia's aquaculture sector has expanded rapidly, driven largely by export demand, particularly from the Russian market. However, production remains heavily dependent on groundwater abstraction, especially in the Ararat Valley, where hundreds of millions of cubic meters of water are used annually for fish farming. From a circular economy perspective, water efficiency and nutrient management are the central challenges. Recirculating aquaculture systems have been introduced in limited cases, but widespread adoption is constrained by high capital costs and technical complexity. At the processing stage, several thousand tons of fish residues are generated annually, yet Armenia lacks industrial fishmeal, fish oil, or bioenergy facilities. Most residues are disposed of or handled through low-value pathways. Circular reform in this sector must prioritize water recirculation technologies, effluent reuse for irrigation, and centralized valorization of fish processing waste into feed, fertilizer, or energy. In parallel, regulatory enforcement must be strengthened to ensure compliance with water-use limits and waste management requirements. As export markets increasingly incorporate sustainability criteria, improved resource efficiency can also become a competitiveness advantage rather than solely a compliance obligation.

The fruit, vegetable, and grape processing sector presents both structural concentration and significant circular potential. The sector has grown steadily, with grape spirits forming the dominant export category and representing a high-value segment within Armenia's manufacturing base. At the processing stage, large and relatively homogeneous organic residues—grape pomace, fruit peels, seeds, and trimmings—are generated. While some residues are transferred informally for animal feed or limited oil extraction, systematic valorization remains underdeveloped. International experience demonstrates that processing-stage residues can be converted into compost, biogas, bio-based materials, oils, polyphenols, and other high-value products through structured biorefinery models. In Armenia, fragmentation within the fruit and vegetable processing segment limits economies of scale, but the grape-processing sub-sector—characterized by greater concentration and homogeneous feedstock—offers a particularly promising pilot domain. Composting, anaerobic digestion, and targeted extraction of high-value compounds could reduce methane emissions from landfill disposal, generate renewable energy, and increase domestic value retention. However, scaling such interventions requires regulatory clarity regarding by-product classification, aggregation mechanisms among processors, access to concessional finance, and development of structured downstream markets for secondary outputs.

A cross-sector assessment confirms that Armenia's circular economy transition is constrained less by conceptual awareness than by systemic economic and institutional barriers. Feedstock aggregation is weak in textiles, plastics, agro-processing, and even scrap metals outside the ferrous segment. Economic signals are misaligned, as landfill disposal and virgin material imports often remain cheaper than recovery and reuse. Institutional responsibilities are fragmented across ministries and agencies, complicating coordinated implementation. Small domestic market size limits economies of scale for capital-intensive recycling facilities, necessitating careful prioritization and sequencing of investments. Financial constraints and limited access to affordable credit further discourage private investment in circular technologies, particularly among SMEs.

Despite these constraints, Armenia possesses tangible strengths. Several sectors exhibit concentrated industrial nodes suitable for pilot interventions. Export orientation creates long-term incentives to align with evolving sustainability standards in international markets. Experience in scrap-based steel production demonstrates that well-designed regulatory measures can successfully redirect material flows toward domestic value addition. Moreover, Armenia's relatively compact territory can facilitate aggregation and coordination if appropriate policy frameworks are established.

Overall, the transition toward an inclusive circular economy in Armenia should proceed through a phased and prioritized strategy. In the short term, policy should focus on high-impact material streams that combine economic value with technical feasibility: PET beverage containers in plastics; ferrous scrap in metals; grape pomace in agro-processing; production off-cuts in textiles; and fish processing residues in aquaculture. Strengthening collection systems and improving feedstock quality must precede large-scale investment in recycling technologies. Gradual and proportionate extended producer responsibility schemes can provide financing for collection and sorting infrastructure, but should be tailored to Armenia's SME-dominated industrial structure. In the medium term, investments in centralized bio-waste facilities, deposit-return systems, end-of-life vehicle dismantling infrastructure, and formalized e-waste recycling can expand circular loops. In the long term, Armenia can position itself as a regional hub for scrap-based steel production, water-efficient aquaculture, and structured valorization of agro-industrial biomass, provided that regulatory coherence and market development keep pace with technological upgrades.

The overarching conclusion of the value chain analysis is that Armenia's circular economy opportunity lies not in replicating large-scale European models immediately, but in leveraging sector-specific leverage points to progressively close material loops. Circular transition should be embedded within industrial policy, export strategy, and environmental governance simultaneously. By retaining secondary materials domestically, improving resource efficiency, and reducing landfill dependency, Armenia can strengthen economic resilience, reduce exposure to external supply shocks, create new forms of employment, and align its manufacturing base with emerging international sustainability standards. The pathway forward is incremental but structurally transformative: each sector contains achievable interventions that, when coordinated across the economy, can shift Armenia from a predominantly linear system toward a more resource-efficient and inclusive circular model.

Introduction

This Value Chain Analysis (VCA) has been prepared within the framework of the EU-funded **"Study on the Opportunity of an Inclusive Circular Economy for Armenia"** and provides a sector-specific assessment of Armenia's potential transition to a circular economy. It builds on the findings of the Inception Phase and the refined methodology agreed with the contracting authority, and aims to identify those stages of value chains where the current linear "take–make–waste" model results in the greatest resource losses, environmental pressures, and economic inefficiencies, as well as to define **practical circular interventions** relevant to Armenia's context.

The analysis focuses on **five priority sectors**:

- garments and textile waste;
- plastics packaging;
- metals (scrap);
- fishing;
- fruit and vegetable processing.

These sectors were selected based on their economic significance, the volume of waste generated, and their potential to introduce circular solutions involving small and medium-sized enterprises (SMEs) and the creation of local jobs.

For each priority sector, a common analytical framework is applied, comprising:

- mapping of the value chain from raw materials and production through distribution, consumption, and end-of-life stages;
- analysis of material flows to identify points of value creation and areas of loss (waste, by-products, resource leakages);
- identification of circularity gaps, including technological, market, institutional, and regulatory constraints;
- identification of circular interventions across the circular economy hierarchy, including waste prevention, reduction, reuse, repair, recycling, and valorisation.

Cross-Sector Circular Economy Stakeholder Landscape in Armenia

Circular economy (CE) transition in Armenia is shaped not only by the technical characteristics of material flows, but also by the configuration of stakeholders who influence how these flows are generated, managed, regulated, and reintegrated into economic use. Across the five priority sectors covered in this study, stakeholder landscapes exhibit recurring actor groups with distinct roles, incentives, and levels of influence. At the same time, the relative importance of each group varies by sector depending on the structure of the value chain, the nature of waste streams, and the maturity of local recovery markets.

Government and regulatory authorities represent the highest-power stakeholders across sectors, as they define the regulatory framework, enforcement mechanisms, and public investment priorities that determine whether materials remain within linear disposal pathways or can be redirected toward circular use. In practice, the influence of public institutions is often constrained by fragmented mandates, limited enforcement capacity, and competing policy priorities. Nevertheless, sector-specific examples indicate that government action can decisively reshape value chains when policy objectives align with industrial or resource-security interests (e.g., through measures that affect scrap retention and domestic processing). In sectors such as plastics and organics from food processing, the role of authorities is also pivotal in enabling separate collection systems, clarifying permissible treatment routes, and setting sanitary or traceability requirements for secondary use.

Producers, processors, and importers hold significant market power because they determine what materials and products are placed on the market and how production-stage residues are handled. However, their interest in circular practices is uneven and often conditional. In export-oriented manufacturing models—such as garment production under cut–make–trim (CMT) arrangements—firms' autonomy over material choice, product design, and end-of-life responsibility may be structurally limited, while clean and homogeneous production residues are frequently treated as a disposal cost rather than a recoverable resource. In other sectors, producers' engagement with circularity tends to remain selective and reactive in the absence of binding recovery obligations, stable demand for secondary materials, or clear economic incentives.

Municipalities and waste service providers are operationally critical, particularly for post-consumer waste streams, because any scalable separate collection, sorting, and recovery system depends on municipal infrastructure and service delivery. While municipalities have a direct interest in reducing landfill pressure and service costs, their ability to initiate circular practices is often limited by financing gaps and the absence of coordinated national mechanisms. This constraint is especially visible in sectors where separate collection is a prerequisite for circularity (e.g., plastics packaging and textiles), as well as in systems where end-of-life flows remain predominantly mixed and therefore difficult to recover.

Recycling companies and circular economy entrepreneurs represent the core operational actors capable of closing material loops, including through mechanical recycling, processing of secondary materials, and development of circular business models. Across sectors, these actors demonstrate very high interest in expanding circular practices, as their commercial viability depends on reliable feedstock supply and stable markets for secondary outputs. However, their structural power is typically low due to small scale, unstable material supply, limited demand for recycled materials, and exposure to price volatility. In textiles, for example, the recycling segment remains extremely limited, with a single industrial operator engaging in mechanical recycling, illustrating both technical feasibility and the current scale constraint. Similar dynamics apply in other sectors, where circular entrepreneurs can pilot solutions but face barriers to scaling without enabling regulation and predictable feedstock streams.

Civil society, academia, and sectoral intermediaries contribute primarily through enabling functions: research, evidence generation, awareness raising, pilot initiatives, and policy dialogue. Their interest is consistently high, yet their direct influence over material flows is limited. Sectoral coordination bodies—such as industry operators or associations—can play an important bridging role by facilitating dialogue between producers and policymakers, supporting incentive-based approaches to waste reduction and sorting, and promoting sequencing-oriented reforms aligned with sector conditions. However, translating pilot results and advocacy into scalable circular solutions often remains constrained by weak linkages to investment mechanisms and market demand.

International partners and donors play a disproportionately influential agenda-setting and catalytic role in Armenia's CE transition. Through funding, technical assistance, and policy alignment requirements, they can mobilize pilot projects, infrastructure upgrades, and legislative development, often compensating for domestic capacity gaps. Their influence is particularly visible in sectors where systemic reform requires coordinated investments and regulatory modernization, such as plastics waste management and broader environmental governance.

To structure stakeholder analysis consistently, this study applies a power–interest lens, distinguishing between actors with high influence over the system and those with high motivation to advance circular outcomes. In Armenia's context, a recurring pattern is that high-interest actors (recyclers, NGOs, some sector intermediaries) often have limited structural power, while high-power actors (regulators, major producers/importers, and in some sectors large industrial players) may demonstrate mixed or conditional interest depending on the perceived economic case and regulatory pressure. Addressing this misalignment—through regulatory clarity, coordinated implementation mechanisms, and market-based incentives—emerges as a cross-cutting prerequisite for shifting from fragmented, project-based circular practices toward scalable and commercially viable circular value chains.

Against this economy-wide stakeholder landscape, the subsequent sector chapters present sector-specific stakeholder mappings that reflect differences in value chain structure, waste-stream characteristics, and the feasibility of circular interventions. These mappings are intended to identify leverage points for targeted action within each sector, while remaining anchored in the broader institutional and market dynamics described above.

1. GARMENTS AND TEXTILE SECTOR: VALUE CHAIN ANALYSIS IN ARMENIA

1.1 Sector Overview and Context

1.1.1 Global Value Chain Structure

The global garments and textiles industry operates through a multi-stage value chain spanning raw material production, manufacturing, distribution, consumption, and disposal. At the start of the chain are raw materials like cotton, wool, and synthetic fibers (polyester, nylon) produced through agriculture or petrochemical processes. These inputs feed into textile mills that spin yarn and weave or knit fabrics, which are then dyed and finished. Garment manufacturers cut and sew fabrics into finished apparel, often in large factories in emerging economies. Brands and retailers distribute the clothing worldwide to consumers. The prevailing model has long been linear – a “take-make-waste” system in which resources are extracted, used to make products, and after a short use are discarded as waste[1]. This linear fashion model has led to massive waste: **over 92 million tonnes of textile waste are generated globally each year**, equivalent to a garbage truck of clothes burned or landfilled every second[2]. Fast fashion trends have accelerated these issues – between 2000 and 2015, global clothing production doubled even as garment use time dropped by 36%[3]. As a result, **87% of material used for clothing ends up incinerated or in landfills** after use[4]. This wasteful chain also carries steep environmental costs: the sector consumes an estimated 215 trillion liters of water per year and causes 2–8% of global carbon emissions[5]. In economic terms, an estimated **$500 billion in value is lost annually due to clothing being under-utilized and not recycled**[6]. These statistics underscore that the traditional apparel value chain is environmentally unsustainable and rife with inefficiencies, prompting a global push toward circular economy approach.

1.1.2 Sector in Armenia – Background and Economic Role

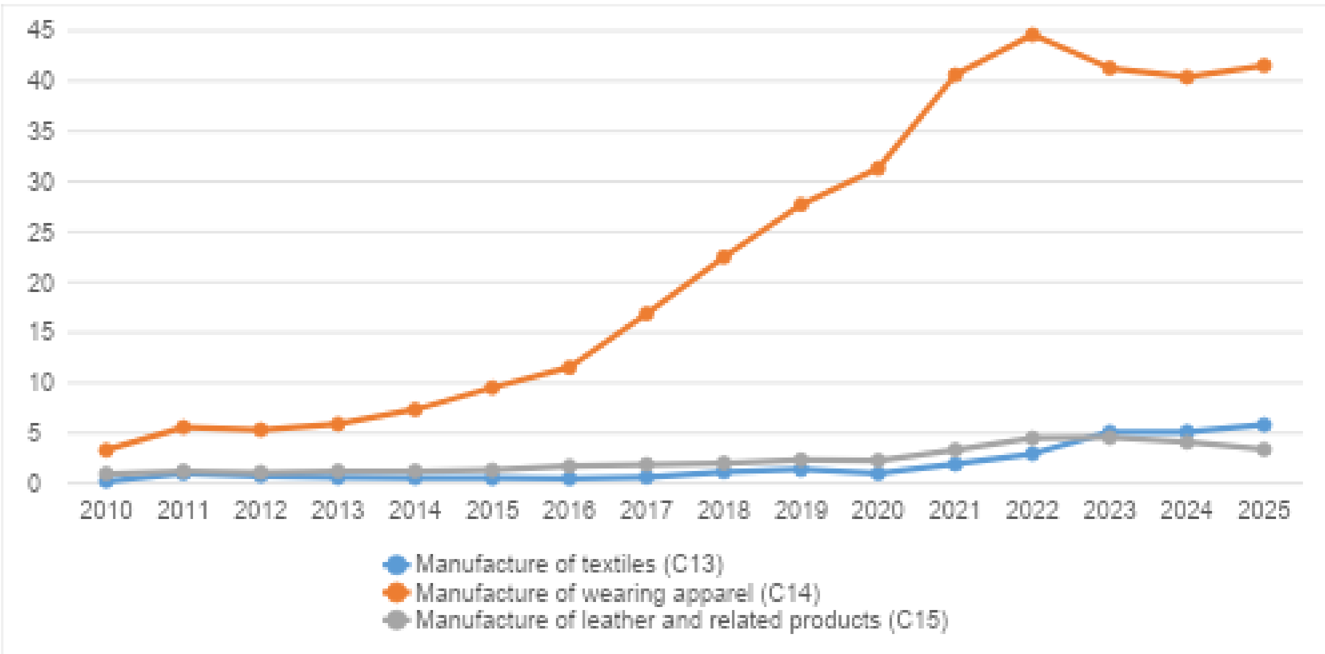
For the purpose of this report, Armenia’s garments and textile sector is defined as all economic activities in Armenia involved in fiber production, fabric manufacturing, textile finishing, garment production (NACE: C13-14, particularly C13.1x, C13.2x, C13.9x, C14.1x, and HS: 50–63 for products of that sector in international trade). Armenia’s garments and textile sector is a small but growing part of the economy with a rich historical legacy. During Soviet times, Armenia had a substantial textile industry, which declined in the 1990s. In recent years, the sector has rebounded as a promising export-oriented industry. Today, it comprises a broad base of mostly small and medium enterprises

[1] From “take-make-waste” to circular economy: paving the path to a sustainable future https://circulup.am/wp-content/uploads/2024/11/CircularStartupGrants-Guidelines-CircularEconomy-ENG.pdf
[2] Sustainable fashion to take centre stage on Zero Waste Day https://www.unep.org/technical-highlight/sustainable-fashion-take-centre-stage-zero-waste-day
[3] Sustainable fashion to take centre stage on Zero Waste Day https://www.unep.org/technical-highlight/sustainable-fashion-take-centre-stage-zero-waste-day
[4] How much do our wardrobes cost to the environment? https://www.worldbank.org/en/news/feature/2019/09/23/costo-moda-medio-ambiente
[5] Sustainable fashion to take centre stage on Zero Waste Day https://www.unep.org/technical-highlight/sustainable-fashion-take-centre-stage-zero-waste-day
[6] How much do our wardrobes cost to the environment? https://www.worldbank.org/en/news/feature/2019/09/23/costo-moda-medio-ambiente

focusing on apparel manufacturing. **As of 2024, 366 companies were active in the sector**, employing approximately **13,120 workers**, of whom nearly **78 percent are engaged in garment production** and around **90 percent of workers are women**[7]. Despite its social and employment significance, the sector's macroeconomic footprint remains modest, accounting for about **2.3 percent of total industrial output** and **1.6 percent of manufacturing output** in 2024.

At the same time, the sector's growth trajectory has been **strong but highly concentrated**. Between 2010 and its peak in **2022–2023**, **wearing apparel production increased more than twelvefold**, consistently accounting for **around 80–85 percent of total textile-sector output**. In **2022 alone**, apparel manufacturing represented approximately **84 percent** of combined textile, apparel, and leather production, underscoring its role as the dominant driver of expansion. However, following rapid growth driven largely by favorable external conditions, the sector entered a period of stabilization: between **2022 and 2025**, apparel output declined at a **compound annual growth rate of –7.4 percent**, signaling a slowdown after years of accelerated growth rather than a structural contraction. Overall, during the **2012–2022 period**, clothing production accounted for an average of **84.3 percent** of Armenia's textile output, with **leather and other textile products comprising the remaining 15.7 percent**, confirming the sector's persistent specialization in downstream garment manufacturing (Figure 1).

Figure 1. Manufacturing of clothing, leather, and textile products in Armenia, 2012–2025 (billion AMD)



Source: Armstat, Socio-Economic Situation reports

Garment manufacturing has become an important source of jobs, especially for women in regional towns, aligning with the government's goal to boost employment and inclusive growth. Major

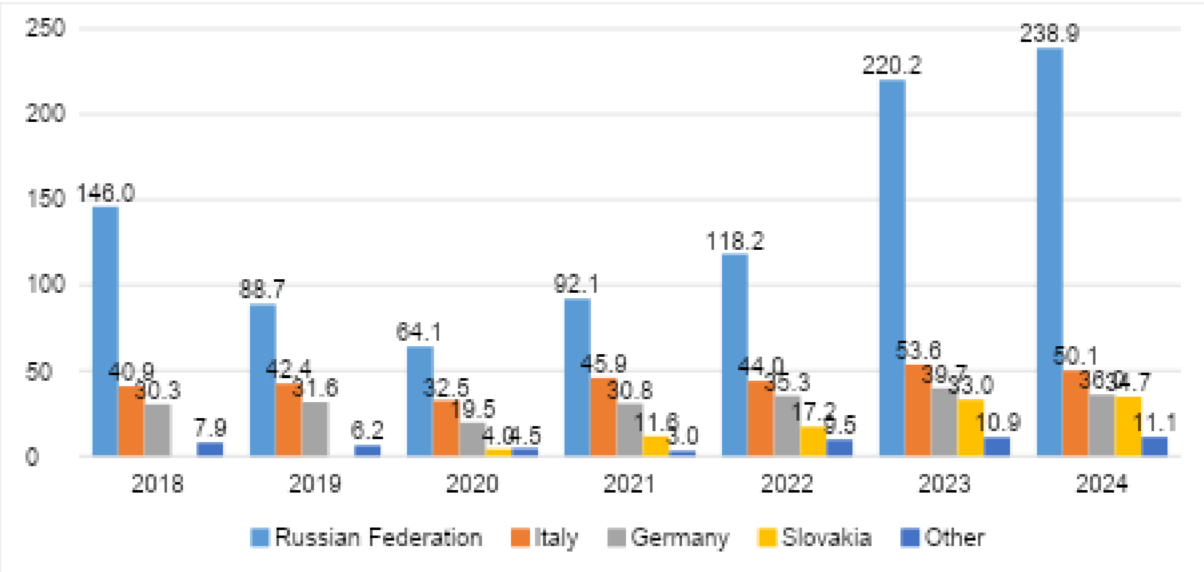
[7] The data provided by the State Revenue Committee of Armenia

products include cotton knitwear, uniforms, work gloves, lingerie, bed linens and other sewn goods. Notably, Armenia's apparel industry largely operates on a **cut-make-trim (CMT) basis for foreign brands** – local factories receive fabrics and materials from abroad, assemble garments, and re-export the finished products. For example, Armenian firms have produced jackets and uniforms for brands like Prada, Zara, Moncler and Max Mara. This implies high integration into global value chains but also heavy dependence on imported inputs.

1.1.3 Main Markets and Trade

Given its CMT model, Armenia sends much of its apparel output to export markets. The Eurasian Economic Union (EEU) countries (especially Russia) and the European Union are the primary destinations for Armenian-made clothing. While 2018, **Russia received 64% of Armenia's textile/apparel exports**, it reduced to 50% in 2020, but returned to 64% by 2024: followed by EU buyers in Italy, Germany and beyond. Armenian producers have found niche success in Russia despite competition from lower-cost countries like Uzbekistan and Vietnam. For instance, Tavush Textile specializes in work gloves and Alex Textile in children's knitwear for the Russian market.

Figure 2. Armenia's Export structure of HS50-63 in 2018-2024 period (million USD)

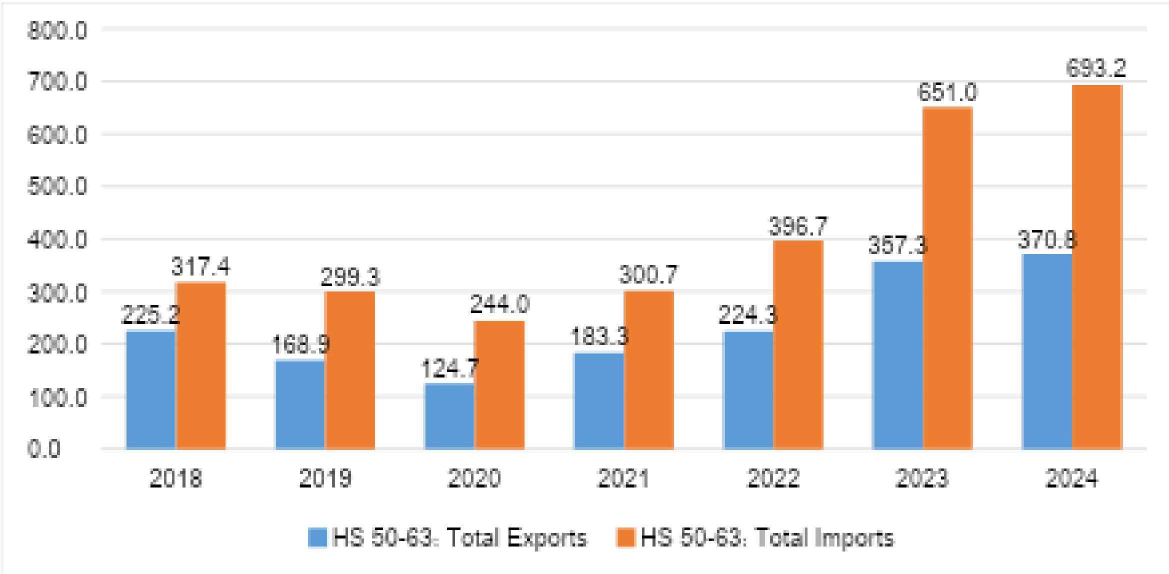


Source: UN Comtrade database

Since 2020, Slovakia emerged as one of the leading importers of Armenia's textile products. A more detailed examination of the trade structure indicates that this increase was largely driven by exports classified under HS 6210.40. Given that this HS category covers protective garments made from coated or laminated fabrics—often used in military, security, and industrial applications—the observed trade pattern may suggest the involvement of Armenia in the production of specialized or protective apparel destined for Slovakia. However, while military uniforms can fall under this classification when made from such materials, the HS code alone does not allow for a definitive conclusion regarding end use, and the exports may also reflect demand for non-military protective or industrial garments. EU accounted for 33.8% of Armenian clothing export value in 2024, even though the share was higher in 2019-2021 (47.2% on average for the period). However, Armenia's share in EU textile imports remains very small compared to giants like China, Bangladesh, and Turkey. It's worth noting that Armenia lost its EU GSP+ preferential trade status in 2022 (due to its classification as upper-middle-income) – meaning a 12% customs duty now applies to Armenian apparel exports to the EU. This could challenge Armenian exporters in the highly competitive EU market.

On the import side, Armenia brings in substantial volumes of both textile inputs and finished apparel. According to UN Comtrade / WITS (2024) data, total imports of textiles and textile articles (HS 50–63) approached USD 693.2 million. Imports of raw and semi-processed textile inputs are essential to sustain domestic garment production, while imports of finished clothing supply domestic consumption. China, Russia and Turkey remain the dominant suppliers across many textile and apparel categories.[8]

Figure 3. Armenia's Imports and Exports of HS 50-63 in 2018-2024 period (million USD)

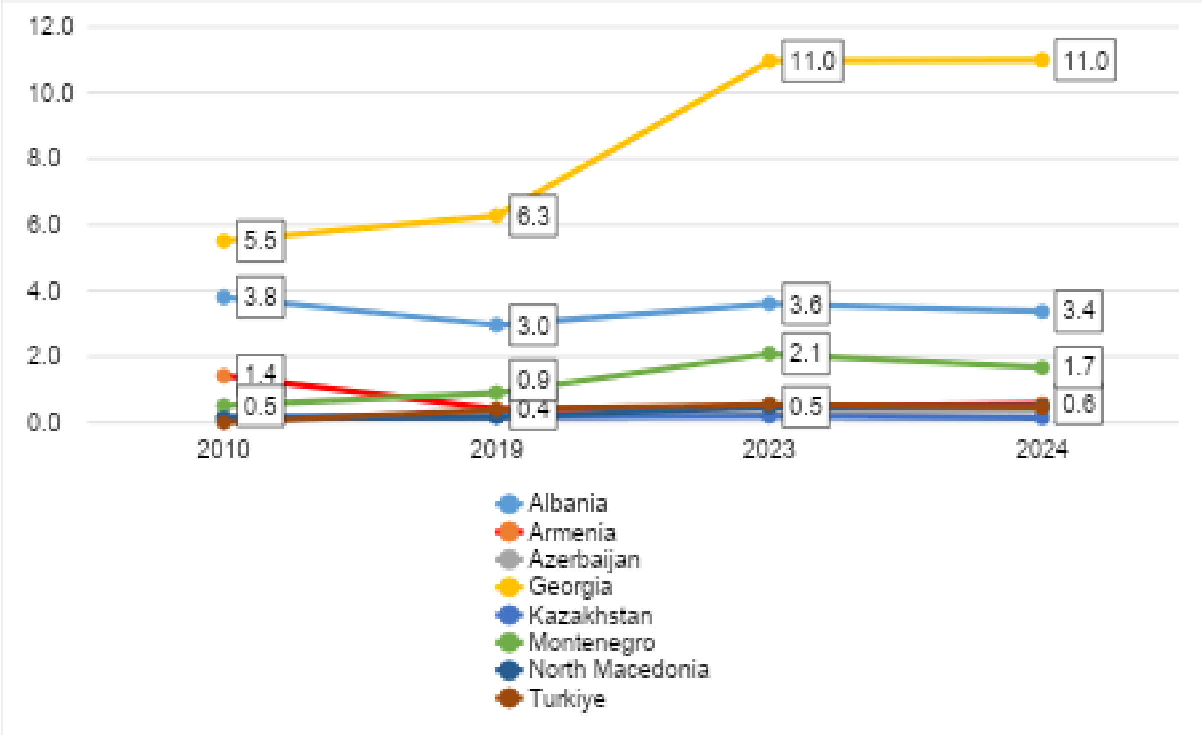


Source: UN Comtrade data

Additionally, Armenia maintains an established second-hand clothing market, though its scale is more limited than is often assumed and has shown a declining tendency over time. Per capita imports of used clothing (HS 6309) decreased from approximately USD 1.4 in 2010 to around USD 0.4–0.6 in 2019–2024, indicating a gradual reduction in reliance on imported second-hand garments. Armenia's average level of imports, at roughly USD 0.7 per capita, remains well below both the global average (USD 2.1) and the average for upper-middle-income countries (USD 2.3). In comparative perspective, Armenia's import intensity is significantly lower than in countries such as Georgia, where per capita imports reached around USD 11 in 2023–2024, and Albania, where levels consistently exceed USD 3. By contrast, Armenia's figures are closer to those observed in Azerbaijan and Kazakhstan, where second-hand clothing imports remain marginal.

[8] UNComtrade database

Figure 4. Per capita imports dynamics of HS6309 (Used clothes) of different upper-middle income countries (USD per capita)



Source: Estimated by Ameria, based on UN Comtrade data.

While the second-hand trade continues to provide affordable clothing options and contributes to extending the use phase of garments originally consumed elsewhere, it does not constitute a dominant source of apparel supply in Armenia. Nevertheless, these imports still add to the overall volume of textiles circulating in the domestic consumption system and, over time, enter the national textile waste stream.

1.1.4 Relevant National Policies

The Armenian government has recognized textiles as a priority industrial sector and introduced policies to support its development. In 2023, it adopted the **Program for the Development of the Textile Industry (2023–2026)**, along with an Action Plan, aiming to upgrade technology, improve skills, and boost the competitiveness of the sector. The strategy emphasizes higher value-added production and creating Armenian brands, as well as improving labor productivity and working conditions (e.g. through training and wage incentives). This reflects an understanding that while the sector is growing, productivity and value addition remain challenges – the government noted the value-added index of the textile sector had actually declined in recent years, partly due to poor working conditions and skill gaps. To tackle the workforce shortage, the Ministry of Economy is proposing incentives for companies to hire and train inexperienced workers (such as refunds of income tax for trainees in their first year).

On the waste management and circular economy front, Armenia is at an early stage of policy development. Historically, **no specific policies addressed textile waste** or circularity, and waste management has been largely linear – about **90% of all waste in Armenia ends up in landfills or dumpsites** with minimal recycling[9].

However, momentum is building for change. After the EU-Armenia Comprehensive and Enhanced Partnership Agreement (CEPA) came into force in 2018, Armenia has been aligning with European waste and environmental standards. Within this context, in **2025** the Armenian government published a draft **Law on Extended Producer Responsibility (EPR)** for public consultation. The draft law establishes a general framework for producer responsibility, including mechanisms for financing waste collection, sorting, recycling, and disposal through Producer Responsibility Organizations. The initial scope of the draft legislation focuses on selected priority waste streams such as packaging, electrical and electronic equipment, tires, oils, and batteries. Notably, **textiles are not included as a regulated category** in the current draft. Official explanatory notes emphasize the need for a phased and economically proportionate approach, taking into account Armenia's SME-dominated industrial structure and the limited financial margins of domestic producers and importers.

Additionally, Armenia's **Solid Waste Management Strategy** 2017–2036 (adopted 2016) and EU technical assistance have spurred investments in basic sorting infrastructure – for example, Yerevan has begun installing color-coded recycling bins in districts (for paper, plastic, glass), with some initial plans to add a **fourth bin for textile waste** in the future. This would allow residents to separate unwanted clothing/textiles for recycling instead of landfilling.

The first-ever **"CirculUP!" Circular Economy forum** was held in Armenia in 2025 with EU support, signaling high-level commitment to circularity. Experts at the forum highlighted textile manufacturing as one of the high-potential sectors for circular economy in Armenia (alongside agriculture and tourism). Moreover, over 20 local companies and NGOs have already received EU grants (totalling €500,000) to kickstart circular business initiatives, and an **Armenian Circular Economy Coalition (ACEC)** has been formed to coordinate stakeholders and advise on policy development.

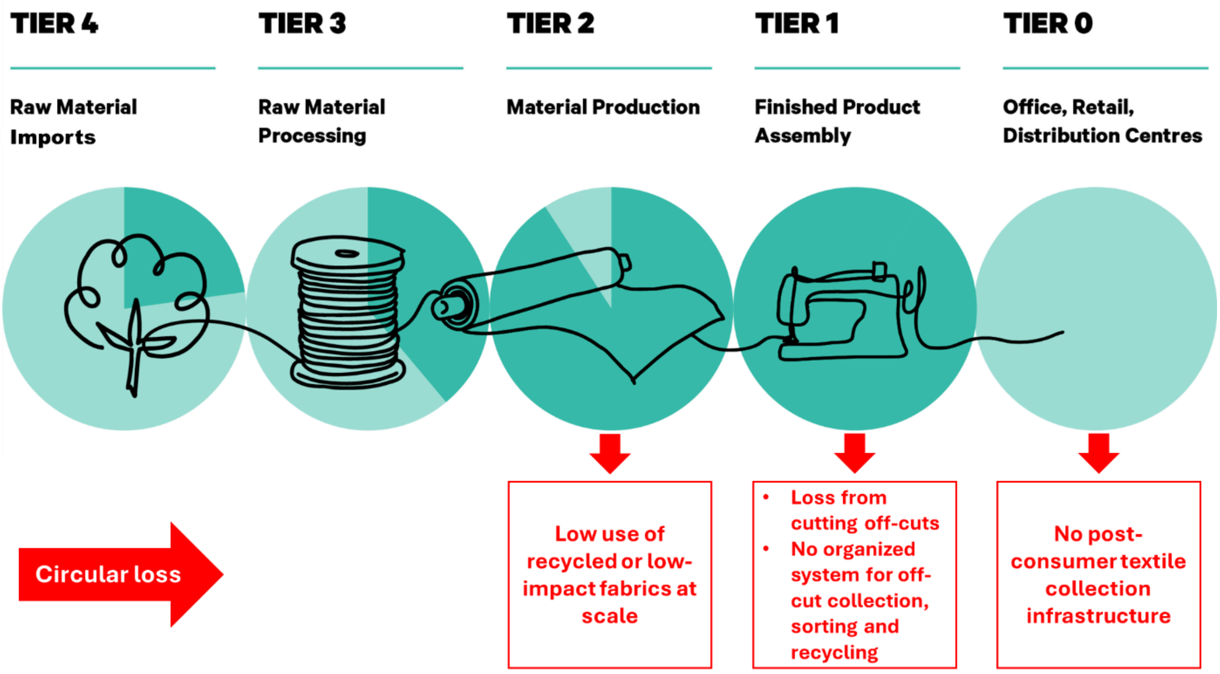
In summary, while **Armenia currently lacks specific textile circularity regulations**, it is laying groundwork through broader waste management reforms, industrial upgrade programs, and stakeholder engagement to eventually move the garments sector toward a more sustainable, circular model.

[9] Challenges and Development Pathways for Circular Economy in Armenia in Context of International Forum https://www.ecolur.org/en/news/waste/16046

1.2 Value Chain Mapping and Material Flow

The garments and textile value chain in Armenia mirrors the global structure but with certain local specificities. It can be mapped as a linear sequence from raw material supply through production, distribution, consumption, and waste management. **Figure 5** below provides a simplified map of this value chain, highlighting the main stages and flows in the Armenian context. As shown, the current system is predominantly linear: raw materials are imported, transformed into apparel, and after use most textiles exit as waste with very limited recycling or recovery. In other words, it largely follows the "take–make–waste" paradigm.[10] Key actors at each stage and the approximate material flows (inputs/outputs) are described following the diagram.

Figure 5. Simplified linear value chain for garments and textile waste in Armenia[11]



Note: Most raw materials (fibers, fabrics) are imported, as domestic textile fiber production is negligible. Local factories perform cut-and-sew production, and finished garments are distributed to export markets or domestic consumers. Post-consumption, the vast majority of textile waste is disposed in landfills (dotted red line), with minimal recycling or circular reuse currently in place.

In addition to material inputs, textile production relies on a range of other resources, including water, electricity, chemicals, and energy, the use of which can be reduced through technological investment and process optimization. Improvements in equipment efficiency, production technologies, and resource management can therefore contribute to lowering the overall environmental footprint of the sector.

[10] From "Take-Make-Waste" To Circular Economy: Paving The Path To A Sustainable Future -circulup.am

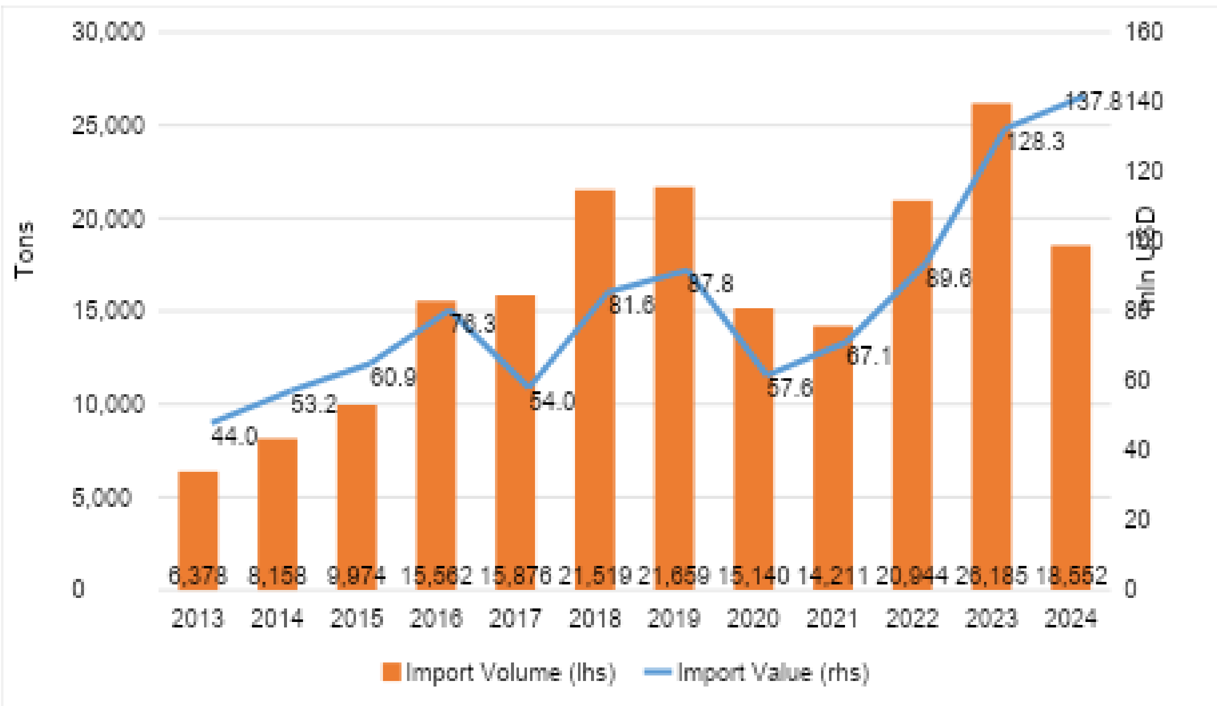
[11] Picture is taken from "What is textile processing? Understanding the fashion supply chain and its environmental impact" – Article from "Fashion For Good" https://www.fashionforgood.com/our_news/what-is-textile-processing-understanding-the-fashion-supply-chain-and-its-environmental-impact/

However, this analysis focuses specifically on textile product circularity, rather than the broader circularity of production processes and resource inputs. The emphasis is placed on material flows, product life cycles, and end-of-life management, as these elements are most directly linked to waste reduction and value retention within the textile sector.

1.2.1 Raw Material Supply

Armenia has **negligible domestic production of textile raw materials**, so it relies heavily on imports at the start of the value chain (Tier 4 in Figure 5). Nearly all fabrics, yarns, thread, and accessories used by Armenian garment manufacturers are sourced from abroad. For textile products used as raw materials and intermediate inputs for downstream manufacturing, which is classified under HS codes 50 to 55 (*Silk; Wool*; *Cotton*; *Other vegetable textile fibers*; *Man-made filaments*; *Man-made staple fibers etc*) official **UN Comtrade** data indicate sustained growth in both import value and volume over the past decade.

Figure 6. Total Imports of Textile Raw Materials and Intermediate Inputs (HS50-55) For Downstream Manufacturing in Value and Volumes (2013-2024)

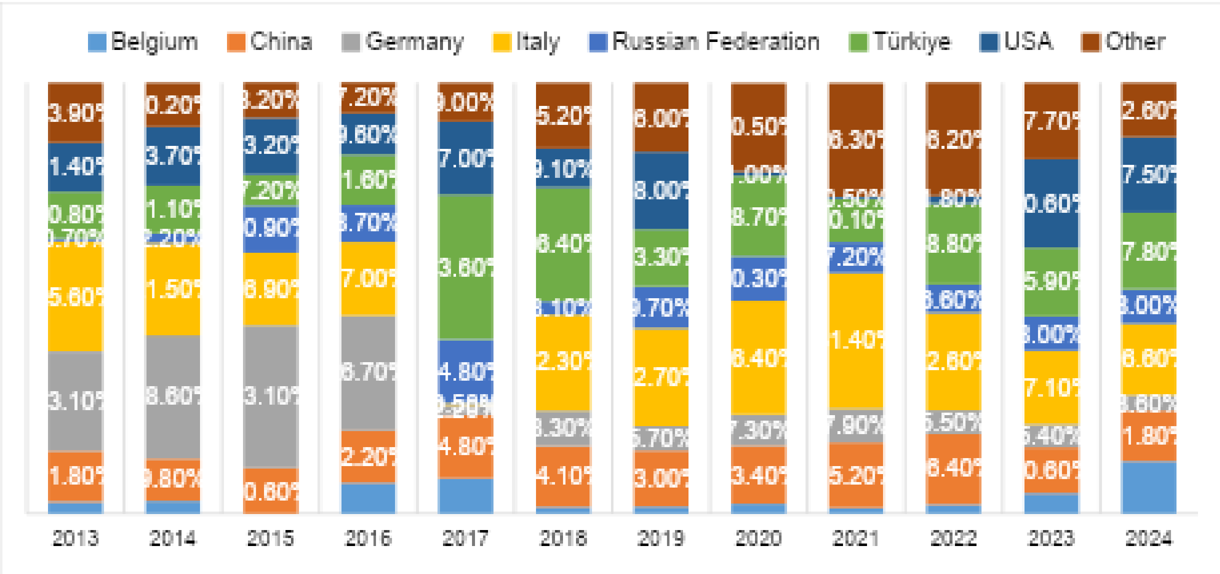


Source: Estimated by America, based on UN Comtrade data.

Armenia's imports under mentioned categories increased in value from **USD 44.0 million in 2013** to **USD 137.8 million in 2024**. Import volumes rose from **6,378 tons** in 2013 to their peak at **26,185 tons in 2023** before declining to **18,552 tons** in 2024. Despite lower import volumes in 2024, the continued increase in import value is most probably conditioned by rising global raw material prices, which have escalated over the period and potentially affected the cost structure and competitiveness of Armenia's textile industry. At the same time, the trend may also indicate a gradual shift toward higher unit-value textile inputs, rather than a simple contraction in overall demand.

The **geographical structure of imports** reveals a diversified and evolving supplier base. **Italy** has consistently remained one of the principal sources of textile raw materials, particularly for higher-quality and specialized fabrics, accounting for between **17% and 32%** of imports over most of the period and **17% in 2024**. **Türkiye** has become the main source in 2017 reaching 34%, later stabilized at around **18% in 2024**.

Figure 7. Structure of Armenia's Imports of Textile Raw Materials (HS 50–55) by Country (2013–2024).



Source: Estimated by America, based on UN Comtrade data.

China has maintained a stable share throughout the period, supplying between **9% and 17%** of imports, largely in standardized cotton and synthetic fabrics and yarns. The **United States** shows a marked increase in recent years, accounting for **21% in 2023** and **18% in 2024**, likely reflecting sourcing of specific fiber types or contract-based supplies rather than broad-based textile imports. **Germany** and **Belgium** appear as intermittent but important suppliers of specialized materials, with Belgium's share rising notably to **12% in 2024**. The **Russian Federation** maintains a moderate but persistent share, fluctuating around **6–10%** in recent years.

In-depth interviews with sector experts reinforce this picture of high import dependence and limited domestic value addition. According to Ruben Sarukhanyan (Certified EFQM Assessor, National Expert in the Textile Sector), Armenia's textile value chain is heavily reliant on imported raw materials and imported finished garments, with domestic activity concentrated largely in garment assembly. While second-hand clothing imports do exist, he assessed their role as non-significant in overall market terms, emphasizing that the domestic market is primarily supplied by new imported garments from multiple countries rather than reused clothing.

A key structural weakness identified is the persistence of relationship-based sourcing practices. Many Armenian producers continue to import raw materials from long-standing suppliers—often for

decades—regardless of whether product quality, specifications, or innovation levels align with current global standards. These "friendly relationship" dynamics tend to discourage quality upgrading and adaptation to international market trends. In contrast, companies that actively monitor and respond to global developments in materials, design, and production standards tend to be smaller and less influential within the sector.
This structure creates two interconnected challenges: high exposure to external supply shocks and a substantial embedded carbon footprint associated with imported materials. From a circularity perspective, a long-term opportunity lies in gradually introducing recycled fibers or fabrics, potentially sourced from domestic recycling efforts as capacity develops, to reduce reliance on virgin material imports and increase domestic value addition.

However, alongside imports, Armenia does have limited domestic production of wool, derived from sheep farming. This wool is used primarily in artisanal and semi-artisanal activities, including carpet weaving, felt products, and small-scale yarn production. While culturally and historically significant, domestic wool production does not supply industrial garment manufacturing at scale and has minimal integration with export-oriented apparel production. Beyond this artisanal segment, Armenia has a single industrial activity focused on the recycling of textile waste, Artiki PHK, operating under the CircullarTex brand in Maralik, which mechanically processes production off-cuts from local garment manufacturers and imported textile waste into secondary raw materials. Although limited in scale, roughly 150 tons of waste acquired from Armenian sources, this represents the only domestically available source of recycled textile input currently connected to industrial production.[12]

In effect, the **material inflow** at this stage is almost entirely composed of imported textiles. For example, large factories like Alex Textile import fabric from Turkey or Asia for their knitwear; high-end producers might import Italian material for suits or uniforms. On average, hundreds of tons of fabric enter Armenia annually for the garment sector (exact tonnage data is scarce, but the trade value indicates the scale). By contrast, **outflows** of waste at this raw material stage are minimal locally (the pollution and waste from fiber production happen abroad). One challenge is the **carbon footprint and cost of importing materials**, which raises final product costs and embeds significant resource use upstream. A circular opportunity here would be to **source recycled fibers or fabrics** (potentially in the future from domestic recycling efforts) to reduce new material imports.

1.2.2 Production (Manufacturing) and Post-Production

From a value chain perspective, production activities in Armenia's textile sector are **highly concentrated at the downstream end** of the chain. **Tier 3 (raw material processing)** and **Tier 2 (material production)**—including spinning, yarn processing, fabric manufacturing, dyeing, and finishing—are largely absent domestically. As a result, Armenian manufacturers rely almost entirely on **imported yarns, fabrics, and accessories**, which enter the country as semi- or fully processed inputs. This structural feature limits opportunities for upstream value addition and constrains circular interventions at earlier stages of the chain.

[12] https://circullartex.com/

Against this backdrop, Armenia's role in the textile value chain is concentrated in **Tier 1: finished product assembly**. Production activities focus on cutting, sewing, and assembling garments under predominantly cut–make–trim (CMT) arrangements. The sector is composed of a small number of larger manufacturers—such as **Alex Textile, Tavush Textile, and Gloria**—operating sizable production facilities, alongside dozens of smaller workshops and subcontractors serving niche orders. Manufacturing activity is geographically concentrated in **Yerevan, Lori, and Shirak**, particularly in **Vanadzor**, where Gloria and several other large factories are located.

The defining material characteristic of this stage is the generation of **post-production textile waste**, primarily in the form of cutting off-cuts and fabric remnants. These arise during pattern layout and fabric cutting and are an inherent by-product of garment manufacturing. According to in-depth interviews with experts, depending on garment type, fabric width, and pattern complexity, approximately **10–20 percent of fabric input** is typically lost as cutting waste. Importantly, this waste stream is **relatively homogeneous, uncontaminated, and generated in predictable quantities**, making it technically suitable for mechanical recycling, downcycling, or secondary use.

In terms of output, Armenia's clothing production was valued at approximately 40.4 billion AMD in 2024, slightly lower than in previous years, while textile production (distinct from garment assembly) accounted for around 5.1 billion AMD, reflecting the relatively modest scale of upstream textile output within overall manufacturing.[13] It's important to note the dependency of production on foreign inputs means **supply chain disruptions** (e.g. higher import costs or delays) directly affect this stage. Likewise, because production is predominantly assembly, the **value added in-country is lower** (mainly labor) and the profit margins are thin, leaving little incentive or capacity for factories to invest in waste reduction technology without external support.

1.2.3 Distribution and Export

Following manufacturing, finished garments produced in Armenia enter distribution channels that are largely shaped by the sector's export-oriented and contract-based production model. For export orders, distribution is typically integrated into buyer-led logistics arrangements: once garments are assembled and quality-checked, they are shipped directly to foreign clients or distribution centers designated by the contracting brand. Transport is primarily carried out by road (via Georgia) and, for higher-value or time-sensitive orders, by air freight. Exports remain the dominant outlet for domestically manufactured garments. The EAEU, and Russia in particular, continues to be the principal destination, reflecting both historical trade ties and regulatory alignment that lowers non-tariff barriers. The European Union constitutes the second major export market, with shipments directed mainly to Germany, Italy, Slovakia and several other EU member states. Export flows are typically concentrated in specific product categories—such as uniforms, knitwear, workwear, and selected fashion items—produced under subcontracting arrangements rather than under Armenian-owned brands.

[13] Finport. Government textile industry fund to be established in Armenia - https://finport.am/full_news.php?id=53087&lang=3

Distribution to the domestic market plays a secondary role. A limited share of locally manufactured garments is sold within Armenia through company-owned outlets, specialized shops, open markets, and procurement contracts (e.g. uniforms and workwear). However, domestic retail demand is largely met through imports of finished apparel, reflecting price sensitivity, brand preferences, and the scale limitations of local producers. Imported new garments originate mainly from Türkiye, China, and Russia, while the domestic market also appears to be supplied by a flow of second-hand clothing. The second-hand trade has traditionally constituted a parallel distribution channel, with used garments imported in bulk, sorted, and sold through specialized second-hand shops and informal retail points in Yerevan and regional towns.

While this segment seems to be declining in relative importance amid rising incomes and the increasing availability of low-cost new apparel, it likely continues to play a role in extending the functional life of textiles already placed on the global market. In this sense, second-hand clothing contributes to informal life-extension and may help reduce immediate pressure on local waste disposal systems, even if its impact is limited in scale and diminishing over time.

At the same time, unsold or low-quality fractions from this stream eventually enter the waste management system, linking distribution activities to end-of-life challenges discussed later in the value chain. This highlights the need to balance the life-extension benefits of second-hand trade with the risk of low-quality imports accelerating textile waste generation.

1.2.4 Consumption and Use Phase

In the consumption phase, garments—whether domestically manufactured or imported—are used by Armenian households and organizations. Consumption patterns are shaped by income levels, price sensitivity, and long-standing cultural practices related to clothing use. As confirmed also by the in-depth interviews with experts, a significant share of consumers rely on imported apparel, while locally produced garments account for a relatively small portion of household clothing purchases, mainly in specific segments such as uniforms, knitwear, and workwear.

At the household level, clothing use in Armenia appears to be characterized by relatively longer wearing periods compared to fast-fashion-dominated markets, although comprehensive data remains limited. Repair and alteration services are still present and commonly observed, particularly for higher-quality garments, children's clothing, and workwear, suggesting the persistence of informal life-extension practices. Informal tailoring and mending practices contribute to extending garment lifespans and delaying disposal, particularly among older generations and in regional communities.

At the same time, consumption patterns are gradually changing. Increased access to low-cost imported apparel and online retail platforms has led to higher purchase frequency and shorter use cycles for some consumer groups, especially younger urban residents. As a result, the volume of garments entering the disposal phase is increasing, even though reuse and repair practices continue to moderate this trend.

Once garments are no longer considered usable, disposal decisions are largely individual and uncoordinated. Some clothing is passed on to relatives, donated informally, or resold through second-hand channels, but the majority of end-of-use garments eventually enter the municipal waste stream. The absence of organized take-back schemes or systematic textile collection means that the consumption phase remains weakly connected to formal reuse or recycling pathways.

1.2.5 Waste Management (End-of-Life)

At the end-of-life stage, textile waste in Armenia is managed almost entirely through disposal rather than recovery. Worn-out clothing and household textiles are typically discarded together with mixed municipal solid waste and collected through standard municipal services. There is currently no nationwide system for separate textile waste collection, and no dedicated textile recycling infrastructure operating at scale.

Available evidence indicates that Armenia's textile waste generation per capita is significantly lower than that observed in OECD and Western European countries, reflecting lower overall consumption levels, longer garment use cycles, and the widespread practice of reuse and repair. In the absence of national waste composition studies specific to textiles, estimates must rely on conservative assumptions aligned with regional consumption patterns rather than developed-country benchmarks. Based on household consumption levels, reuse intensity, and comparisons with Eastern Partnership and upper-middle-income countries, annual post-consumer textile waste generation in Armenia is more plausibly in the range of **1–2 kg per capita**, rather than the 3–5 kg typical of high-income economies. This would correspond to approximately **3,000–6,000 tonnes of textile waste per year nationwide**, acknowledging that the true figure remains uncertain due to data gaps. The majority of this waste is landfilled. Armenia's disposal sites are largely unsanitary landfills or open dumps lacking engineered liners, leachate control, or gas capture. Natural fibers such as cotton and wool decompose anaerobically under landfill conditions, contributing to methane emissions, while synthetic fibers persist in the environment and contribute to microplastic pollution over time. Occasional informal burning of waste, including textiles, further exacerbates local air pollution risks. Diversion from disposal currently occurs only through informal and semi-formal channels. Some garments deemed still usable are passed on within households, donated through churches or community networks, or resold via second-hand markets. These practices delay disposal but are not systematically organized and do not apply to worn-out or low-quality textiles. Once textiles fall below reuse quality thresholds, they almost invariably enter the waste stream.

Industrial textile waste follows a similar pattern. Production off-cuts generated during garment assembly are typically disposed of as industrial waste, although a limited share is reused informally (e.g. as cleaning rags) or sold to a single domestic recycler capable of mechanically processing textile waste into secondary raw material. This activity remains small in scale relative to total waste generation and does not yet constitute a structured recovery system.

Armenia's garment value chain is highly dependent on imported textile inputs, focused on export-oriented garment assembly, and largely linear at the end-of-life stage. Textile raw materials are sourced almost entirely from abroad, while domestic textile production is limited to small-scale artisanal activity and a single, small industrial recycling operation. Locally assembled garments are distributed mainly to export markets, with a smaller share sold domestically. Material flows remain predominantly one-directional. Reuse through second-hand markets and informal practices delays disposal for some garments but does not constitute a structured recovery loop. Once garments reach the end of their usable life, most textile materials exit the value chain through disposal rather than recovery, resulting in the loss of material value. The mapping highlights clear intervention points at the production and end-of-life stages, where improved use of secondary raw materials and organized collection could reduce the system's linearity.

1.3 Mapping of Circular Economy Stakeholders and Initiatives

1.3.1 Stakeholders of circular economy practices in Textile and Garments Sector

In addition to the general circular economy stakeholders operating across the economy, the textile and garments sector involves a more narrowly defined set of sector-specific actors whose roles are shaped by the structure of Armenia's apparel value chain.

Garment manufacturers and apparel producers

Garment manufacturers constitute the core productive actors in the textile value chain. The sector is dominated by export-oriented firms operating under CMT arrangements for foreign buyers, alongside numerous small and medium-sized workshops serving both export and domestic markets.

This production model limits firms' autonomy over material choice, product design, and end-of-life responsibility. While manufacturers generate relatively clean and homogeneous textile waste in the form of cutting off-cuts, most currently treat this waste as a disposal cost rather than a recoverable resource. Larger factories have greater capacity to participate in pilot initiatives or partnerships, whereas smaller producers face tighter financial and organizational constraints.

Textile recycling operators

The textile recycling segment remains extremely limited. Currently, only one industrial operator—**Artiki PHK**, operating under **Circular Tex**—engages in mechanical recycling of textile waste. The company sources production off-cuts from local manufacturers and imports textile waste from abroad for processing into secondary raw materials.

While this activity represents the only existing industrial link between textile waste and material reuse in Armenia, it remains small in scale and does not constitute a sector-wide recovery solution. Expansion depends on reliable feedstock supply, regulatory clarity, and economic incentives for recycled textile materials.

Textile Industry Operator

The Textile Industry Operator plays an institutional coordination role within Armenia's textile and garment sector, acting as an interface between producers, policymakers, and other ecosystem actors. As an entity responsible for sector-level organization and dialogue, its mandate extends beyond individual firm performance to broader issues of competitiveness, capacity building, and structural development.

Insights from the in-depth interview conducted with Erik Minasyan, Acting Executive Director of the Textile Industry Operator, highlight key structural constraints shaping the feasibility of circular economy interventions in the sector. From a systemic perspective, the sector was assessed as not yet ready for comprehensive circular transformation, particularly in light of declining production volumes and limited changes in prevailing business models. At the same time, the interview confirmed the presence of partial and uneven adoption of waste-reducing technologies among larger producers and Operators participation in the cordination process. These include laser or knife-based cutting systems and lekal programming solutions that reduce raw material losses at the cutting stage.

Overall, the Textile Industry Operator emerges from the interview as a critical enabling stakeholder with a realistic and sequencing-oriented view of circularity. Its potential contribution lies in facilitating coordination, supporting incentive-based approaches to waste reduction and sorting, and aligning circular economy objectives with the sector's current economic conditions and production structure, rather than promoting capital-intensive solutions that exceed the sector's present capacity.

Designers, fashion brands, and creative industry actors

Designers, small fashion brands, and creative industry actors play a niche but potentially catalytic role. Their influence lies primarily in product design, upcycling initiatives, and awareness-raising rather than volume production. While their material impact is limited, they contribute to experimentation with circular concepts such as reuse, repair, and design for longevity.

Industry associations and sectoral networks

Organizations representing garment producers, designers, and creative industries act as intermediaries for the textile sector. Their activities focus on skills development, promotion of Armenian apparel and fashion, and participation in policy dialogue. Their influence on circularity is indirect and depends on their ability to translate sustainability narratives into sector-relevant business incentives.

Municipalities and waste service providers (textile-relevant role)

Although municipalities are general waste management actors, their role is particularly critical for textiles because any future system for post-consumer clothing collection, sorting, or reuse would depend on municipal collection infrastructure. At present, textiles are treated as residual waste, and municipalities lack dedicated systems or incentives to separate or recover them.

Civil society initiatives focused on clothing reuse

Several NGOs and social enterprises operate small-scale initiatives related to clothing donation, reuse, and upcycling. These activities are often donor-supported and socially oriented, with limited integration into formal waste management or industrial recycling systems. Their contribution is primarily social and educational rather than systemic.

Consumers and households (textile-specific dimension)

Consumers influence textile circularity through purchasing decisions, participation in second-hand markets, informal clothing exchange, and repair practices. In Armenia, these behaviors are largely driven by affordability rather than environmental considerations. Consumer awareness of textile waste and recycling remains low, but household behavior would be decisive for any future post-consumer textile collection system.

Synthesis

Taken together, textile circularity in Armenia is shaped by a narrow production structure, a single small-scale recycling operator, weak post-consumer collection systems, and limited coordination between actors. Sector-specific stakeholders operate within the broader circular economy governance framework but face additional constraints related to export-driven business models, low material prices, and the absence of dedicated textile policy instruments. Recognizing these constraints is essential for designing feasible and sector-appropriate circular economy interventions.

1.3.2 Circular Economy Practices in the Textile Value Chain (Current State)

Circular economy practices in Armenia's textile and garment value chain are currently driven less by formal systems and more by **everyday practices, niche initiatives, and small-scale experimentation**. While these practices do not yet form an integrated circular system, they provide concrete evidence of how circularity already manifests on the ground.

Second-hand clothing plays a limited and supplementary role in Armenia's textile system. Imported used garments are present mainly in price-sensitive niches such as winter wear and children's clothing, but volumes remain modest relative to overall apparel consumption. As a result, second-hand trade contributes to limited life extension of garments but does not significantly affect aggregate material flows or waste outcomes; its relevance lies primarily in demonstrating basic acceptance of reuse rather than in large-scale circular impact. In addition, there are indications that the Armenian Apostolic Church and church-affiliated charitable initiatives also play a role in the redistribution of used clothing, providing support to vulnerable groups. While these practices are primarily social in nature, they can also be viewed as a form of informal circularity, as they contribute to extending the usable life of garments through reuse.

Repair and alteration practices continue to play a tangible role in extending garment lifespans. Neighborhood tailors routinely alter trousers, jackets, and dresses, repair zippers and seams, and adapt adult clothing for children. In regional towns, repair is often preferred over replacement for workwear and uniforms, where durability and fit matter more than fashion cycles. These practices are largely invisible in official statistics but remain widespread and culturally embedded, especially among older generations.

Informal reuse of production off-cuts can be observed within garment factories and surrounding micro-economies. Cutting waste from garment assembly is often retained by workers or sold informally as cleaning cloths, padding material, or inputs for small workshops. Some small producers and artisans source remnants directly from factories to produce bags, accessories, or household textiles. While these flows are unrecorded and inconsistent, they demonstrate that production waste is already recognized locally as a usable material rather than pure waste.

Industrial textile recycling, although limited to a single operator (Artik PHK under Circullar Tex), represents the only structured attempt to close the material loop. This operator mechanically processes textile waste sourced from Armenian garment manufacturers and imported streams into secondary raw materials. While volumes remain modest, the activity demonstrates that textile recycling is technically feasible in Armenia and that local manufacturers are willing to supply clean production waste when an outlet exists. The operation's reliance on imported textile waste further highlights the absence of organized domestic collection rather than a lack of processing capability.

Upcycling and circular design practices are most visible in the creative sector. Designers such as **Natacha Kalfayan** have built collections around the transformation of discarded materials, including textile remnants, explicitly framing waste as a design resource. Similar approaches are seen among small studio-based designers and concept brands that use deadstock fabrics, factory leftovers, or second-hand garments to create limited-edition pieces. These initiatives are small in volume but influential in shaping discourse around sustainable fashion and demonstrating alternative value propositions beyond mass production.

Social-enterprise and community-based initiatives provide further anecdotal evidence of circularity in practice. Small workshops—often employing women or vulnerable groups—produce accessories, toys, or home décor items from textile remnants. In these settings, waste textiles are not framed as an environmental problem but as an accessible and low-cost input for income generation. While material throughput is limited, these initiatives show how circular practices can align with social objectives in Armenia's context.

Short-term collection and awareness initiatives illustrate both interest and limitations. NGO-led textile collection drives and donation boxes placed in schools or community spaces have periodically attracted public participation, suggesting latent willingness to separate textiles when convenient options exist. However, the temporary nature of these initiatives and the absence of downstream recycling or reuse capacity mean that their impact has not been sustained.

Finally, **coordination platforms**, most notably the **ACEC**,[14] provide a space where these disparate practices are discussed, documented, and connected to policy dialogue. While ACEC does not implement projects or manage textile flows, it plays an important role in making such anecdotal practices visible to policymakers and donors, helping to translate scattered initiatives into a shared understanding of circular economy potential.

[14] Natacha Kalfayan: Celebrate the Problem, Then Make a Choice
https://evnreport.com/lifestyle/salt-natacha-kalfayan-celebrate-the-problem-make-a-choice

Examples of Circular Businesses in Armenia include only a handful of businesses explicitly positioning themselves as circular in fashion. One example is **ZGEST**, a local sustainable brand noted on the Fashion & Design Chamber site for its upcycling initiative[15]. ZGEST and a few concept stores in Yerevan offer products made from repurposed garments. Additionally, **social enterprises** are emerging – for instance, some refugee women-led cooperatives create handicrafts from textile remnants, marrying social impact with waste reduction. While these operations are small, they demonstrate the viability of circular business models even in Armenia's context.

Taken together, these examples show that circular economy practices in Armenia's textile value chain are **not absent**, but **fragmented, informal, and small-scale**. They demonstrate existing behaviors, skills, and acceptance that could support more systematic circular interventions if enabling infrastructure, policy incentives, and coordination mechanisms were introduced.

[15] Fashion & Design Chamber
https://www.fdc.am/

1.4 Circularity Gaps and Pain Points

Despite the early initiatives mentioned, Armenia's textile value chain faces significant gaps when measured against international best practices for circularity. These gaps span technological, market, regulatory, and financial dimensions, and they result in missed economic opportunities as well as environmental costs. Below is a breakdown of the key circularity gaps and associated pain points.

1.4.1 Technological Gaps

On the technology and infrastructure side, Armenia currently lacks the core facilities needed for a circular textile economy. There are no automated sorting systems for textile waste, no fiber-to-fiber recycling plants, nor even a textile shoddy (downcycling) operation. In contrast, advanced circular economies have developed facilities such as Sweden's Siptex plant, which uses near-infrared optical sorting to process up to 24,000 tonnes of textiles annually. However, Siptex was established as a government-funded and publicly supported initiative, reflecting strong policy backing and subsidized infrastructure rather than purely market-driven investment. In this context, the gap for Armenia is not solely technological but primarily economic and institutional, as large-scale automated sorting systems typically require public financing, guaranteed feedstock volumes, and regulatory frameworks to be viable.
Armenia's absence of such technology means that even if textiles are collected, there is no local means to process them into recycled fiber or products. Furthermore, manufacturing technology in use is somewhat outdated among many Armenian apparel factories – machinery is geared toward basic sewing, not innovative processes that minimize waste (like 3D knitting or made-to-measure digital cutting that reduces scraps). This leads to higher material waste during production. The lack of modern waste treatment facilities is also an issue: landfills have no capability to capture or neutralize the pollutants from decomposing textiles (dyes, microplastics, etc.), so environmental harm is higher. The technological gap extends to know-how: few specialists in Armenia have experience with textile recycling techniques or circular design methods, which hampers adoption of even low-tech solutions.

Consequence: Without recycling tech, valuable materials are lost – all post-consumer clothing goes to dumps, meaning the embedded water, energy, and fiber value is wasted. For instance, the global norm is 87% of clothes end up burned or landfilled[16]; Armenia likely aligns with this or worse (possibly ~90%+). This is an economic loss (materials that could be worth money if recycled or reused) and an environmental burden (landfill space usage and pollution). Essentially, Armenia is forfeiting the chance to turn waste into resource due to technology unavailability.

1.4.2 Market and Demand Gaps

From a market perspective, Armenia's textile value chain currently has weak market pull for circular products or services. Domestically, consumer awareness and demand for sustainable or recycled textiles are low – most shoppers prioritize cost, and there is little branding of apparel as eco-friendly

[16] How Much Do Our Wardrobes Cost to the Environment?
https://www.worldbank.org/en/news/feature/2019/09/23/costo-moda-medio-ambiente

to create differentiation. Internationally, Armenia's main export market (Russia) has not imposed sustainability-related requirements on textile products, so producers have faced limited external pressure to change practices. In the EU market, such pressure is gradually emerging through eco-design and due-diligence initiatives, but Armenian exporters are only beginning to encounter these expectations and largely through indirect buyer requirements rather than regulatory obligations.

The resulting gap is a lack of incentives for companies to invest in circularity; firms do not see immediate profitability in using higher-cost recycled fabrics or establishing take-back logistics, particularly given thin margins and contract-based production models where material choices are often determined by foreign buyers.

Consequences: Without demand signals or functioning markets for recycled content, the business case for circular innovation remains weak. Companies continue to rely on linear models because the market does not reward circularity, and virgin materials and disposal remain cheaper and simpler options. This perpetuates a low-equilibrium system of high waste and limited value recovery. While global estimates suggest that circular models could generate substantial economic value in the textile sector, these projections largely reflect conditions in large consumer markets and are not directly transferable to Armenia's context. Nevertheless, Armenian producers may face future market-access constraints in higher-value segments, particularly in the EU, if durability, recyclability, or sustainability criteria become embedded in buyer specifications.

1.4.3 Regulatory and Policy Gaps

Although Armenia is taking initial steps, there are still considerable regulatory gaps. There is no specific policy mandating textile waste reduction or producer responsibility for apparel. Unlike the EU, where the Waste Framework Directive requires member states to introduce separate textile collection and is promoting textile-specific EPR schemes, Armenia's waste legislation does not currently single out textiles as a priority stream. The draft EPR law establishes a general framework, but it remains unclear whether and when textiles will be included as an obligated category. Additionally, standards or incentives for using recycled materials are absent. The government has not set recycled-content targets or introduced tax incentives for eco-friendly textile inputs. There is also limited regulatory pressure on retailers or importers, such as requirements for take-back schemes or differentiated disposal fees for clothing. Overall, the current policy environment does not actively encourage businesses to adopt circular practices.

Another regulatory gap relates to trade and customs controls. Imports of second-hand clothing and low-quality textile products may enter without specific screening or differentiated regulation, which could over time place additional pressure on domestic waste management systems. Institutional fragmentation further complicates policy implementation, as responsibilities related to waste management, industrial development, and skills formation are distributed across different ministries. While coordination mechanisms are emerging, including through platforms such as the ACEC, an integrated approach to textile circularity is still at an early stage.

Consequences: In the absence of strong policy drivers, the linear production and disposal model persists by default. Environmental externalities associated with textile waste, including pollution and greenhouse gas emissions, are not reflected in prices, reducing incentives for behavioral change. At the same time, international experience indicates that textile EPR schemes are administratively complex and financially demanding. In small economies dominated by SMEs with narrow margins, premature introduction of full, fee-based EPR systems risks placing disproportionate burdens on producers without ensuring effective collection or recycling outcomes. The regulatory gap therefore contributes to continued waste generation and delays sectoral modernization. It also creates uncertainty for potential investors in recycling or circular textile ventures, who lack clarity on future regulatory obligations, feedstock availability, or long-term policy support.

1.4.4 Financial and Economic Gaps

Implementing circular solutions often requires upfront investment and new financing models, which remain limited in Armenia's textile sector. Most local manufacturers are small and medium-sized enterprises with constrained capital; upgrading to more efficient machinery or investing in textile recycling equipment would require financial resources that firms often cannot access or justify given low margins and short production contracts. While access to finance for green projects in Armenia has improved in recent years—partly through credit lines supported by international financial institutions—these instruments are primarily oriented toward energy efficiency and renewable energy investments rather than circular material flows or waste reduction in manufacturing processes.

On the waste management side, municipalities are underfunded and face persistent challenges in maintaining basic collection and disposal services. As a result, allocating budgetary resources to textile-specific collection, sorting, or treatment is currently difficult. There is also a lack of economic incentives supporting circular behavior: there are no subsidies for the use of recycled textile inputs, no differentiated landfill fees for textile waste, and no pricing mechanisms that would make recycling economically preferable to disposal. Under these conditions, virgin materials remain cheaper than recycled alternatives, and landfilling remains the lowest-cost option for end-of-life textiles. Another financial constraint relates to scale. Armenia's domestic market is small, and the volume of recoverable textile waste alone may be insufficient to support commercially viable recycling facilities unless supplemented by regional sourcing or imports. This limits economies of scale and discourages private investment, as potential investors face uncertainty regarding feedstock availability, operating costs, and long-term profitability.

Consequences: Promising circular interventions may fail to materialize due to financing constraints. For example, even relatively basic investments such as mechanical textile shredding for rags or insulation materials require upfront capital that local entrepreneurs may be unwilling or unable to commit given uncertain returns. In the absence of financial incentives, the cost of "business as usual" practices—such as landfilling—does not reflect their broader social and environmental impacts. These externalized costs are ultimately borne by the public through landfill remediation, environmental degradation, and public health impacts. At the same time, Armenia foregoes potential economic benefits of circularity, including reduced reliance on imported raw materials and job creation in collection, sorting, and recycling activities, which remain unrealized without initial investment support.

1.4.5 Economic consequences

As noted above, the persistence of a linear model results in the loss of economic value embedded in textile products at end of life. International studies estimate that globally hundreds of billions of dollars' worth of value is lost each year due to underutilization of clothing and the absence of recycling. While Armenia represents only a small share of the global textile system, the same dynamic applies proportionally at the national level, as garments and production off-cuts are disposed of rather than reused or recovered.

There is also a missed opportunity in terms of employment and enterprise development. Circular activities such as collection, sorting, repair, reuse, and basic material recovery are typically more labor-intensive than landfill disposal and are often well suited to small-scale and local economic contexts. Even modest diversion of textile waste could support new forms of employment, particularly for women and low- to medium-skilled workers, but these opportunities remain unrealized due to the absence of enabling conditions.

In addition, Armenian textile producers face potential long-term competitiveness risks. As international buyers gradually integrate sustainability, durability, and traceability requirements into procurement practices, firms operating exclusively under linear models may face higher compliance costs or reduced access to higher-value market segments. Without gradual adaptation, producers risk reacting to external regulatory or buyer-driven changes under time pressure rather than through planned and cost-effective transition.

In summary, the gaps in technology, market, policy, and finance keep Armenia's textile value chain locked in a linear mode with significant environmental damage (landfill waste, pollution) and economic inefficiencies (loss of materials, missed business opportunities). Addressing these gaps – through investment, policy reform, and capacity building – is imperative to unlock circular benefits. The next section will outline some of the opportunities and interventions that could bridge these gaps, drawing on international examples of what has worked elsewhere.

1.5 Opportunities for Circular Interventions

Despite the challenges, there are opportunities for Armenia to introduce circular economy interventions in its garments and textile value chain. By drawing selectively on international experience and adapting it to local institutional and market conditions, Armenia can begin to reduce material losses and environmental pressure associated with textile waste. The following opportunities reflect incremental, scale-appropriate interventions rather than comprehensive system transformation.

1.5.1 Establish Organized Textile Collection and Sorting Systems

A foundational opportunity lies in capturing textile waste before it enters mixed municipal landfills through dedicated collection and basic sorting. This could involve limited pilot initiatives in urban areas, such as designated textile collection points, voluntary take-back arrangements with selected retailers, or periodic collection drives implemented in cooperation with municipalities, NGOs, or educational institutions. While international experience demonstrates the effectiveness of mandatory separate textile collection, Armenia's immediate opportunity lies in piloting small-scale, voluntary systems that can be tested and adjusted before wider rollout.

Collected textiles could be sorted into broad categories such as reusable items, recyclable production off-cuts and household textiles, and residual waste. Even basic manual sorting would support reuse and potential downstream processing while improving understanding of material flows. At an early stage, the objective would be learning and capacity building rather than high capture rates.

Quantified projections based on high-income countries should be treated cautiously. Armenia's lower consumption levels and informal reuse practices suggest that achievable diversion volumes are likely to be more modest in the short term. Nonetheless, even limited diversion could reduce pressure on landfills and support small-scale employment in sorting and logistics.

Key success factors include ease of participation for households, clear communication, and coordination with existing waste services. Engagement of civil society organizations and Armenian Apostolic Church with experience in donation and redistribution can help build trust and operational capacity.

1.5.2 Promote Reuse, Repair, and Second-Hand Activities

Reuse and repair represent low-capital entry points to circularity. Armenia already has informal repair practices and tailoring services, which can be strengthened through targeted skills support and visibility rather than large-scale formalization. Small interventions such as vocational training for tailors, support for repair services linked to local manufacturers, or community-based repair events could extend garment lifespans without requiring new infrastructure.

The second-hand clothing market exists but remains limited in scale and does not currently represent a major structural component of textile material flows. Its relevance lies primarily in life-extension rather than waste reduction at scale. Policy attention should therefore focus on preventing low-quality second-hand imports from becoming waste rather than expanding the market itself.
Extending garment lifespans through repair and reuse reduces demand for new imports and delays disposal. While international studies quantify significant environmental benefits from prolonged use, in Armenia the primary benefit is incremental waste reduction combined with local employment support.

At the same time, the long-term scalability of reuse and repair in Armenia faces structural constraints. Rising household incomes and the continued availability of low-cost imported garments—particularly mass-produced apparel from Asian markets—are likely to reduce incentives for repair and second-hand use over time. As consumption patterns shift toward affordability and convenience, informal life-extension practices may gradually decline. This suggests that reuse and repair should be viewed as complementary and transitional elements of circularity rather than a standalone solution, requiring realistic expectations and careful alignment with broader economic and consumer trends.

1.5.3 Develop Local Textile Recycling and Upcycling Ventures

A longer-term opportunity lies in developing small-scale textile recycling or material recovery activities linked to existing manufacturing waste streams. Rather than advanced fiber-to-fiber recycling, initial efforts could focus on mechanical processing of clean production off-cuts or post-consumer cotton textiles into secondary products such as insulation materials, padding, or industrial wipes.

Given Armenia's market size, any recycling activity would need to operate at modest scale and potentially integrate regional sourcing over time. Upcycling enterprises - producing functional goods from textile waste - may be more viable initially than material recycling and can be supported through design incubators or SME grant programs.

International examples from middle-income countries demonstrate that gradual formalization of textile waste reuse can reduce reliance on imported raw materials. For Armenia, the opportunity lies less in export-oriented recycled fibers and more in partial substitution of imported inputs and waste reduction.

1.5.4 Extended Producer Responsibility (EPR) for Textiles

Extended Producer Responsibility is often cited as a key policy instrument for textile circularity. However, international experience shows that textile EPR systems are administratively complex, cost-intensive, and most effective in high-consumption economies with strong enforcement capacity.

For Armenia, immediate implementation of a full, fee-based textile EPR scheme would likely impose disproportionate costs on small producers and importers without guaranteeing effective outcomes. A more appropriate opportunity lies in phased or voluntary approaches, such as pilot take-back agreements with major importers, reporting obligations without fees, or gradual inclusion of textiles at a later stage once collection and processing capacity exists.

Any future consideration of EPR should be preceded by data collection, cost-benefit analysis, and consultation with domestic producers to avoid unintended competitiveness impacts.

1.5.5 Encourage Circular Design and Sustainable Production Practices

Within existing production structures, opportunities exist to reduce waste and improve resource efficiency. Manufacturers can gradually adopt improved cutting techniques, better fabric utilization practices, and internal reuse of off-cuts. Access to fabrics with recycled content is already available through international suppliers, and selective uptake can occur where buyer specifications allow.

Design for durability and simplified material composition can improve reparability and future recyclability without requiring radical changes to production models. Skills development for designers and production managers is a low-cost intervention with long-term benefits, particularly as international buyer expectations evolve.

Public programs supporting technology upgrades or production efficiency improvements can integrate waste-reduction criteria without framing them explicitly as circular economy mandates.

1.5.6 Leverage International Partnerships and Regional Cooperation

International cooperation can help mitigate scale and financing constraints. Armenia can engage with development partners to pilot textile-related circular initiatives, particularly where climate mitigation and waste reduction objectives align. Regional cooperation with neighboring countries facing similar constraints could support shared facilities or knowledge exchange.

Before positioning Armenia as a regional hub, the immediate opportunity lies in learning, piloting, and building institutional capacity through externally supported projects.

1.6 International Benchmark Cases

Case 1 – France: Circular Cooperation between HoReCa and Textile Services (ELIS Group)

A practical and relatively low-capital example of textile circularity through HoReCa cooperation can be found in France, where the textile services company ELIS has developed a circular model linking hotels, hospitals, and catering facilities with textile reuse and recycling streams. ELIS operates large-scale linen rental and laundering services for the HoReCa sector, managing items such as bed sheets, towels, bathrobes, table linens, and staff uniforms. These textiles are standardized, used intensively, and replaced on predictable cycles, creating a stable and homogeneous waste stream.

When HoReCa textiles reach the end of their service life, they are not immediately disposed of. Instead, they are sorted by material type, stripped of non-textile elements where needed, and redirected into secondary uses. High-quality cotton and cotton-blend textiles are mechanically recycled into cleaning cloths, insulation materials, or padding for furniture and automotive uses. In some cases, textiles are upcycled into new hospitality-related products, such as reusable laundry bags or staff accessories, extending material value without complex processing technologies.

The key circular advantage of HoReCa textiles lies in their material simplicity. Unlike post-consumer clothing, hotel linens and towels rarely contain buttons, zippers, mixed fibers, or decorative elements, which significantly reduces sorting and preprocessing costs. This allows circular operations to function with relatively basic equipment and limited technological investment, relying instead on logistics coordination, contractual arrangements, and quality control.

Lessons for Armenia:

The French example demonstrates that circularity does not require full-scale textile recycling plants to begin delivering impact. For Armenia, structured cooperation between hotels, restaurants, hospitals, and local textile processors could unlock an accessible entry point into textile circularity. By targeting HoReCa textile waste—characterized by volume stability, fiber uniformity, and low contamination—Armenia could pilot circular solutions such as mechanical recycling, industrial wiping cloth production, or simple upcycling activities. The case also highlights the importance of service-based models and long-term contracts, rather than spot-market waste transactions, in making circular textile flows economically viable. For a small market like Armenia, this approach offers a realistic pathway to circular value creation without large upfront capital investments.

Case 2 – Türkiye: Cutting Optimization and Skills-Based Waste Reduction in Export-Oriented Apparel Manufacturing

Türkiye offers a highly relevant example of how textile circularity can begin at the production stage through **off-cut waste reduction**, without requiring large-scale recycling infrastructure. As a major apparel supplier to European brands, Turkish garment manufacturers have faced increasing pressure to improve material efficiency, reduce costs, and meet sustainability expectations embedded in buyer requirements.

In response, many Turkish factories—particularly small and medium-sized export-oriented producers—have focused on **cutting room optimization** as a primary intervention. Rather than investing immediately in advanced automation, firms adopted a combination of **operator training, improved marker planning, and affordable digital pattern-making tools**. These measures targeted the main source of production-stage textile waste: fabric losses generated during pattern layout and cutting.

Through structured training programs for cutting operators and pattern designers, factories improved the accuracy of fabric layout and reduced errors that lead to excessive off-cuts. At the same time, the introduction of relatively low-cost marker optimization software enabled better fabric utilization without altering the overall production model. As a result, participating manufacturers reported **reductions in cutting waste ranging from 5 to 12 percent**, with corresponding savings in raw material costs and improved production efficiency. In many cases, the financial payback period for these interventions was less than one year.

Importantly, this approach did not require changes to the export-oriented CMT model itself. Instead, it enhanced competitiveness within existing value chains by lowering input costs and improving compliance with buyer sustainability criteria. Waste reduction outcomes were also measurable and predictable, allowing firms to track improvements and justify further incremental investments over time.

Lessons for Armenia:

Türkiye's experience demonstrates that off-cut waste reduction can be a **practical and cost-effective entry point into textile circularity**, especially in countries where garment manufacturing is concentrated in assembly operations and raw materials are imported. For Armenia, similar gains could be achieved through targeted skills development for cutting-room staff, basic digitalization of pattern planning, and simple performance tracking, without requiring large capital expenditure. This case also highlights the importance of aligning circular interventions with competitiveness and export requirements, ensuring that waste reduction supports—not constrains—industrial growth.

2 PLASTICS PACKAGING VALUE CHAIN ANALYSIS IN ARMENIA

2.1 Sector Overview and Context

2.1.1 Global Plastics Value Chain

Plastics are a broad class of synthetic or semi-synthetic materials primarily composed of polymers, most commonly derived from fossil fuel–based feedstocks. In professional and policy-oriented literature, plastics are generally defined as materials made of high-molecular-weight polymers that can be molded or shaped under heat and pressure and retain their form upon cooling. These materials are valued for their durability, versatility, light weight, and low production cost, which has led to their widespread use across packaging, consumer goods, construction, automotive, and industrial applications[17].

Despite their ubiquitous use, there is no single universally accepted definition or classification of plastics across international institutions and regulatory frameworks. Different organizations emphasize different characteristics—such as chemical composition, functional use, polymer type, or end-of-life behavior—resulting in variations in how plastics are defined and categorized. Recent academic and policy discussions highlight the need for a harmonized definition and classification system for plastics, particularly in the context of environmental governance and circular economy policies, as inconsistencies complicate measurement, regulation, and international comparison[18].

In the context of this study, the term *plastics* is used in a clearly delimited and operational sense, with a primary focus on **plastic bottles used for beverages and liquid consumer products**. The analysis concentrates on bottles made predominantly of polyethylene terephthalate (PET), which represent the most common plastic bottle type globally and in Armenia. The scope covers the full lifecycle of plastic bottles—from polymer production and bottle manufacturing to consumption, collection, and recycling. Other plastic products and polymer types are considered only where they directly affect bottle-related flows, infrastructure, or policy design.

Building on this definition, the chapter examines the plastics value chain through a structured sequence of stages: raw material extraction and polymer production, product manufacturing and packaging conversion, distribution and consumption, and finally waste management (collection, recycling, or disposal). Globally, this chain remains largely linear in structure.

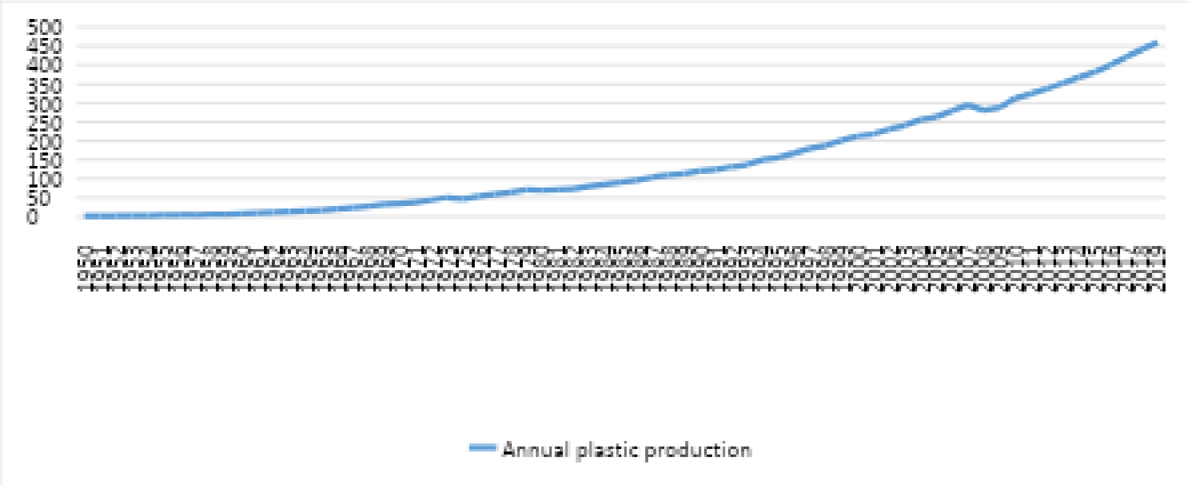
At the upstream stage, plastics originate from fossil fuel extraction and polymer production, particularly the manufacture of PET resin and other polymers by large petrochemical companies.

[17] Center for International Environmental Law (CIEL). 2023. Compilation of Key Terms Relevant for the Negotiation of a Treaty to End Plastic Pollution. Center for International Environmental Law. https://www.ciel.org/wp-content/uploads/2023/05/Compilation-of-Key-Terms-Relevant-for-the-Negotiation-of-a-Treaty-to-End-Plastic-Pollution_FINAL.pdf

[18] Zhu, X., et al. 2023. *The Need for a Unified Definition and Classification System for Plastics.* ACC Science Journal. https://api-journal.accscience.com/journal/article/preview?id=5106
Asia-Pacific Journal of Environmental Chemistry (APJEC). 2022. *Plastics Classification and Environmental Implications.* Asia-Pacific Journal of Environmental Chemistry. https://www.waocp.com/journal/index.php/apjec/article/view/1009

Global plastic production has expanded rapidly over recent decades, increasing from approximately 2 million tonnes in 1950 to about 460 million tonnes per year by 2019[19]. This dramatic scale-up reflects the growing role of plastics—especially packaging—in modern economies and reinforces a supply-driven system that places increasing pressure on downstream waste management systems.

Figure 8. Global annual plastic production between 1950 and 2019 (Millions)



Source: Geyer et al. (2017); OECD (2022) databases

The produced polymers are converted into packaging and other plastic products, many of which are designed for single-use applications. In the case of beverage bottles, PET resin is processed into bottles, which are then filled and distributed by beverage producers and brand owners through retail networks. After a typically short consumption phase—particularly for packaging—products quickly transition into waste.

Globally, the waste management stage represents the weakest link in the value chain. According to OECD estimates, plastic waste generation increased from 156 million tonnes in 2000 to 353 million tonnes in 2019. Although more than 300 million tonnes of plastic waste are generated annually, only around 9% is effectively recycled, while the remainder is landfilled, incinerated, or leaked into the environment. For plastic packaging specifically, collection rates for recycling are estimated at roughly 14%, and an even smaller share is ultimately recycled into new products due to contamination and economic constraints[20].

This predominantly linear throughput of materials generates significant environmental externalities and represents a loss of valuable resources. In response, global policy discussions and private-sector initiatives increasingly focus on transitioning toward circular economy models for plastics. Evidence suggests that even modest increases in reuse—for example, reusing 10% of plastic packaging— could

[19] Our World in Data. n.d. Global Plastics Production. Our World in Data.https://ourworldindata.org/grapher/global-plastics-production

[20] OECD. 2022. *Global Plastics Outlook: Economic Drivers, Environmental Impacts and Policy Options*. OECD Publishing. https://www.oecd.org/content/dam/oecd/en/publications/support-materials/2022/02/global-plastics-outlook_a653d1c9/Global%20Plastics%20Outlook%20l.pdf

cut the volume of plastic waste entering oceans by half[21], underscoring the impact potential of circular models.

In Armenia, nearly all raw plastic feedstock is imported and processed by local manufacturers into plastic products and packaging. In parallel, finished plastic products are also imported directly for domestic use. These materials enter distribution channels and reach consumers, after which plastic packaging becomes waste. While a small share—estimated at less than 10%—is collected and processed for recycling, the overwhelming majority is disposed of in landfills, resulting in only a limited circular feedback loop through secondary plastic materials.

2.1.2 Plastics Value Chains in Comparable Countries

In countries with economic and sectoral structures similar to Armenia —such as small developing or transition economies in Eastern Europe and the Caucasus—the plastics value chain often exhibits comparable structural patterns. In many cases, these countries have limited or no domestic oil refining or polymer production capacity, and therefore rely on imported raw materials and finished plastic goods. Where domestic manufacturing exists, it is typically concentrated in **downstream conversion activities**, such as processing imported resins into plastic products including bottles, bags, and household items.

This import-dependent and downstream-oriented production structure has important implications for the later stages of the value chain, particularly waste management and circularity outcomes. In the absence of strong upstream integration and dedicated recycling infrastructure, plastic products—especially short-lived packaging—tend to exit the economic system quickly after use. As a result, waste management systems in many of these countries remain underdeveloped, leading to low recycling rates and high reliance on landfilling.

For instance, according to a UNDP assessment, plastic recycling in **Moldova remains very limited, with the overwhelming majority of plastic waste being disposed of through landfilling, while only a small fraction-estimated at around 3%- is recycled**[22]. Georgia has similarly faced rising plastic pollution pressures; it introduced a ban on single-use plastic bags in 2018 and is currently working on the development of a national circular economy strategy[23].

Common characteristics in such peer countries include an **informal recycling sector** (individuals scavenging recyclables), nascent formal recycling businesses, and growing government attention due to environmental pressures. Typically, plastic packaging and single-use items make up a significant portion of municipal solid waste, straining landfill capacities. Without significant recycling

[21] Ingilizian, Z. 2023. How to bring back circular models of consumption. *World Economic Forum* https://www.weforum.org/stories/2023/01/how-to-bring-back-circular-models-of-consumption/

[22] UNDP. 2021. Study on Plastic Waste in the Republic of Moldova. United Nations Development Programme. https://www.undp.org/moldova/publications/study-plastic-waste-republic-moldova

[23] BTU AI. n.d. Georgia’s Advantages for Circular Economy Business Models. BTU AI. https://btuai.ge/en/georgias-advantages-for-circular-economy-business-models/

infrastructure, these countries see outcomes similar to Armenia: most plastic waste goes to dumps, and only a small fraction is recovered.

Experience from comparable countries suggests that progress toward circularity is usually driven not by upstream industrial development, but by targeted policy and institutional interventions at downstream stages of the value chain. According to analyses by the OECD[24] and the World Bank[25], small and transition economies that have achieved measurable improvements in plastic recycling have done so through a combination of extended producer responsibility schemes, deposit-return systems for beverage containers, and gradual formalization of collection and sorting activities. In the European neighbourhood, alignment with European Union waste directives[26] has played a particularly important role in shaping national policy reforms, even in non-EU countries.

One area where some peer countries have moved ahead is the early adoption of policy instruments affecting plastic bottles specifically. For example, **Moldova is preparing a nationwide deposit-return system for plastic bottles** and other containers[27], drawing on EU best practices to improve collection rates and material recovery. Overall, while the structure of the plastics value chain—from import-dependent supply to largely linear disposal—remains broadly similar across these countries, comparative experience indicates a clear trend toward policy-led interventions and regional cooperation to improve circularity outcomes.

2.1.3 Armenia: Sector Background and Policy Context

Armenia's plastics sector is focused mainly on downstream activities (product manufacturing and consumption) since the country lacks indigenous fossil fuel resources and polymer production. As a result, the Armenian plastics value chain is structurally **import-dependent**, relying on foreign suppliers for both **primary polymer granules** (such as polyethylene, polypropylene, PET, PVC, and engineering plastics) and a wide range of semi-finished and finished plastic products. These imports originate mainly from China, Russia, Iran, and European markets.

Within this constraint, a **modest but relatively mature local conversion industry** has emerged. Armenian firms process imported polymers into bottles, caps, pipes, sheets, household articles, and construction materials. Companies such as **Hytex Plastic CJSC**, which produces PET bottle preforms, have become dominant players in their niche—supplying approximately **65% of Armenia's PET preform market** and exporting to neighboring countries. Similarly, firms such as **Narplast** manufacture bottles and caps for food and beverage applications, confirming Armenia's functional capacity in **packaging conversion**, even in the absence of upstream polymer production.

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[24] OECD. n.d. Improving Markets for Recycled Plastics: Trends, Prospects and Policy Responses. OECD Publishing. https://www.oecd.org/environment/waste/policy-highlights-improving-markets-for-recycled-plastics.pdf

[25] World Bank. 2018. What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. World Bank. https://openknowledge.worldbank.org/entities/publication/d3f9d45e-115f-559b-b14f-28552410e90a

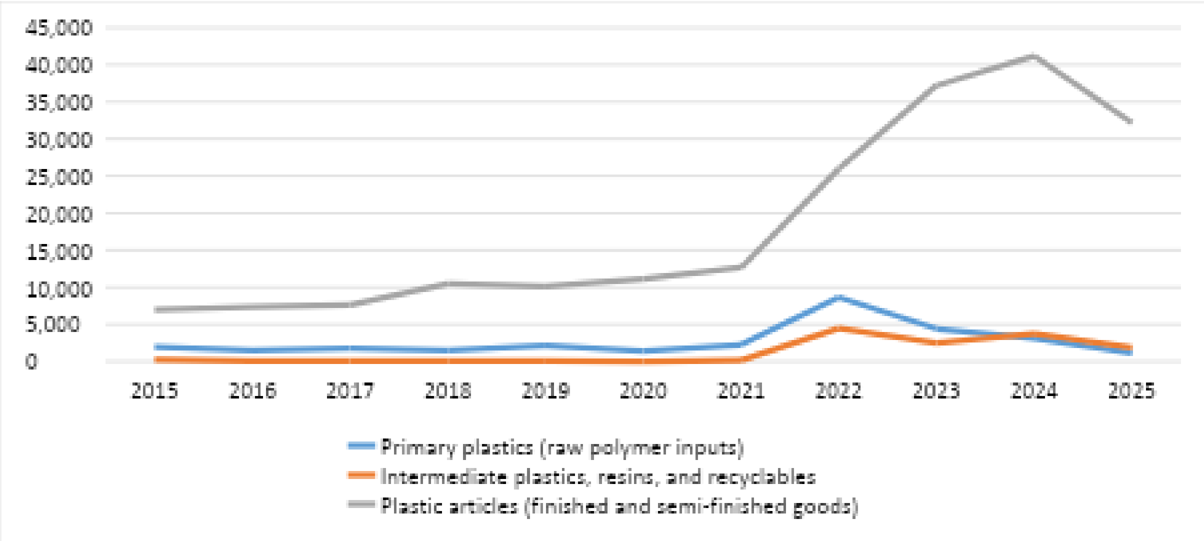
[26] European Union. 2008 (amended 2018). Directive 2008/98/EC on Waste (Waste Framework Directive). European Union. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0098

[27] Moldova 1. n.d. How Moldova Plans to Recycle Plastic, Glass, and Aluminum Packaging. Moldova 1. https://moldova1.md/p/46681

Trade data strongly reinforces Armenia's downstream-oriented positioning within the plastics value chain. Across HS Chapter 39, Armenia records **consistently high import values** for both **primary plastics** (HS 3901–3907) and **plastic articles** (HS 3916–3926), while **exports remain comparatively small, volatile, and episodic**, and are largely concentrated in downstream or semi-processed product categories rather than raw polymers.

Figures 2 and 3 present Armenia's exports and imports of plastic materials and products over the period 2015–2025, disaggregated into three value-chain segments: primary polymers, intermediate plastics and resins (including waste), and finished or semi-finished plastic articles. This decomposition allows a clear assessment of Armenia's position within the plastics value chain and the relative balance between upstream material dependence and downstream manufacturing activity.

Figure 9. Armenia's Exports of Plastics by Value-Chain Segment (HS Chapter 39), 2015–2025 (Thousand USD)

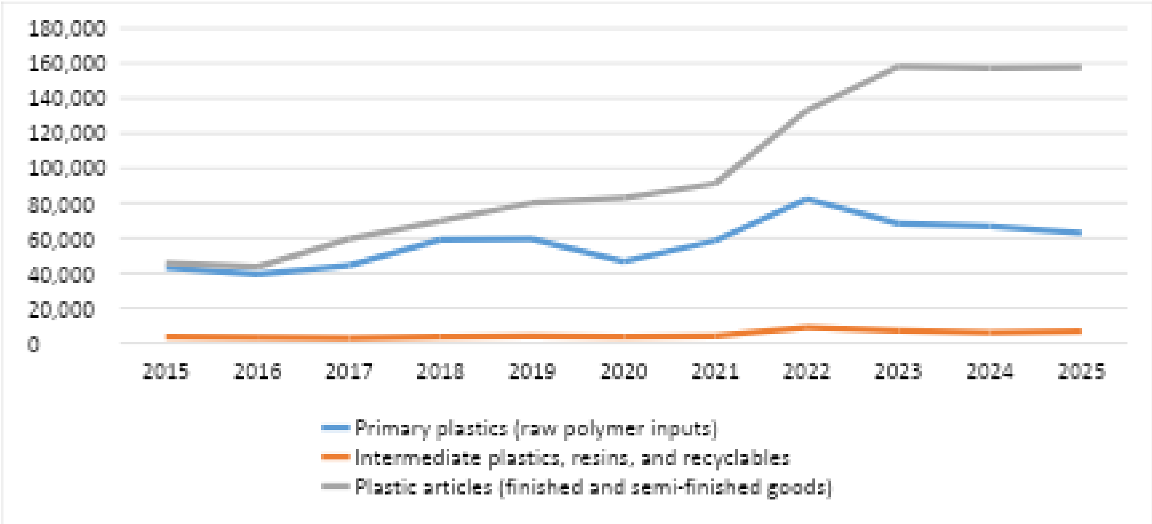


Source: Armstat, External Trade Database (HS 4-digit level)

Figure 2 shows that Armenia's plastic exports are overwhelmingly concentrated in **plastic articles (HS 3916–3926)**, while exports of **primary polymers (HS 3901–3907)** and **intermediate plastics and resins (HS 3908–3915)** remain minimal throughout the period. Export values for plastic articles increase markedly after 2021, peaking around 2023–2024, before a slight decline in 2025. This pattern reflects the expansion of local downstream manufacturing capacity—particularly in packaging, construction plastics, and miscellaneous plastic products—rather than any shift toward upstream polymer production.

The consistently negligible export levels of primary plastics confirm the **absence of domestic polymer manufacturing**, while the limited and volatile exports of intermediate plastics suggest that Armenia's participation in regional plastic trade is driven primarily by **conversion and re-processing activities**, rather than by the supply of raw or semi-raw materials.

Figure 10. Armenia's Imports of Plastics by Value-Chain Segment (HS Chapter 39), 2015–2025 (Thousand USD)



Source: Armstat, External Trade Database (HS 4-digit level)

Figure 10 highlights the dominant role of imports across all segments of the plastics value chain. Imports of **plastic articles (HS 3916–3926)** and **primary polymers (HS 3901–3907)** are consistently high and exhibit a strong upward trend, particularly from 2021 onward. On the other hand, imports of **intermediate plastics, resins, and recyclable materials (HS 3908–3915)** remain comparatively modest but show gradual growth, indicating limited domestic availability of specialty inputs and reinforcing the dependence on foreign suppliers even for mid-stream production stages. Overall, import values exceed exports by a wide margin in every year, underscoring Armenia's role as a **net importer of plastic materials and products**.

Despite this, the overall economic role of plastics manufacturing in Armenia remains relatively limited. Employment data show that the sector is highly concentrated in downstream plastic product manufacturing (NACE 22.2), which employed around **3.2 thousand workers in 2024**, while **primary plastics production (20.16)**[28] is nearly absent, with single-digit employment levels recorded in recent years and no activity reported in 2024. Within plastics manufacturing, packaging-related activities (22.22) account for a significant but not dominant share of employment, reflecting the sector's orientation toward meeting domestic demand for packaging materials such as bottles, bags, and containers. There is little in the way of plastic product exports, as domestic production primarily serves local demand for packaging (bottles, bags, containers) and some regional export of packaging materials.

Official production statistics by detailed NACE classification provide a clear picture of the evolution of Armenia's plastics sector over the past decade. Total plastic product manufacturing (**Manufacture of plastic products, C22.2**) expanded rapidly from **AMD 27.3 billion in 2016** to **AMD 46.5 billion in 2021**, reflecting strong growth across all major downstream segments. Following this expansion phase, output stabilized at a relatively high level, amounting to **AMD 47.8 billion in 2022**, **AMD 50.2**

[28] State Revenue Committee of the Republic of Armenia (SRC). n.d. SRC Database.

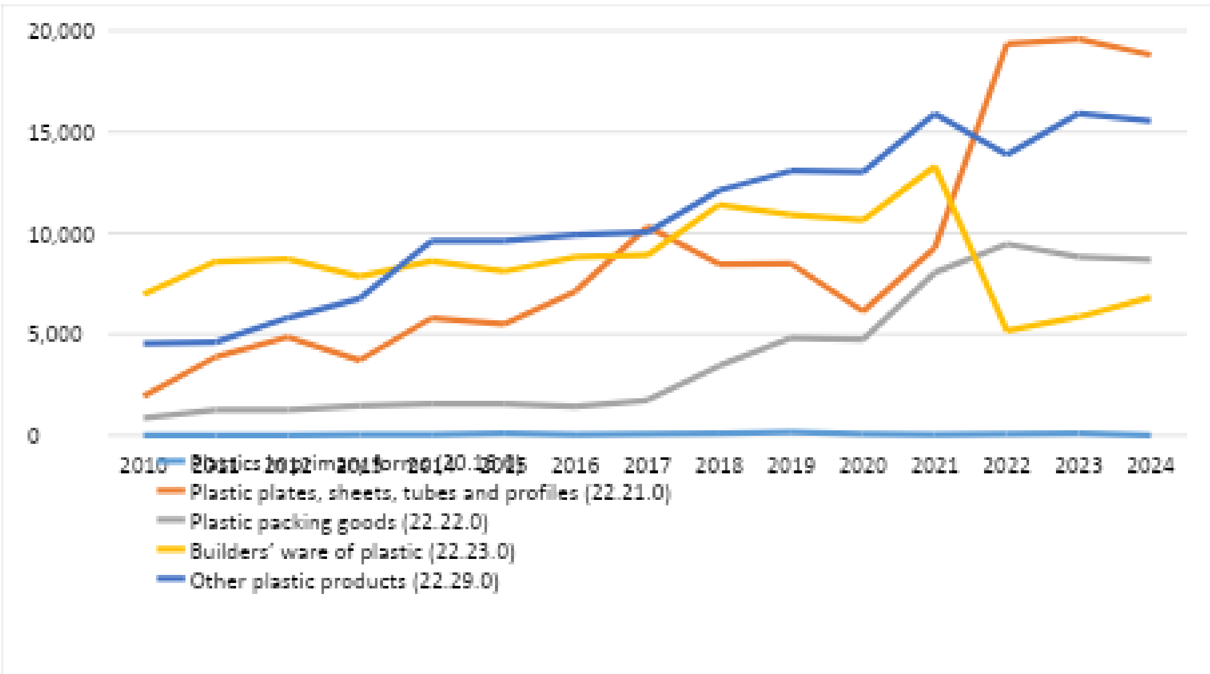
billion in 2023, and **AMD 49.9 billion in 2024**, indicating consolidation rather than continued rapid growth.

Within plastics manufacturing, **manufacture of plastic packing goods (22.22.0)** has been one of the most dynamic subsectors. Output increased more than fivefold between **2016 (AMD 1.43 billion)** and **2021 (AMD 8.05 billion)** and has since remained structurally high, fluctuating between **AMD 8.7–9.5 billion during 2022–2024**. This reflects sustained domestic demand for plastic packaging used in food, beverages, and consumer goods.

By contrast, **manufacture of builders' ware of plastic (22.23.0)** followed a more cyclical trajectory. Production expanded steadily up to **2021, peaking at AMD 13.3 billion**, before contracting sharply in **2022 (AMD 5.2 billion)** in line with shifts in construction activity and investment cycles. A partial recovery is observed thereafter, with output reaching **AMD 6.8 billion in 2024**, although remaining well below its pre-2022 peak.

Other downstream activities grouped under **manufacture of other plastic products (22.29.0)** represent the largest and most stable segment of the sector. Output increased from **AMD 9.9 billion in 2016** to **AMD 15.9 billion in 2021**, and remained broadly stable at **AMD 15.5–15.9 billion during 2023–2024**, underscoring the resilience of diversified plastic product manufacturing.
On the other hand, upstream production remains marginal. **Manufacture of plastics in primary forms (20.16.0)** exhibits high volatility and a very limited scale.

Figure 11. Volume of Industrial Production in Plastics Manufacturing by Product Group, Armenia (2010–2024, current prices)



Source: Ameria team calculations based on Armstat data

Taken together, these production trends highlight a plastics sector that is structurally downstream-oriented and domestically focused, which in turn shapes the scope and intent of public policy interventions aimed less at industrial transformation and more at managing the environmental impacts of plastic consumption and waste.

In terms of sector policies and regulations, Armenia has taken **gradual and selective steps** to address plastic waste, with a primary focus on reducing environmental leakage rather than transforming material circularity. From **January 1, 2022**, regulations came into force restricting the **sale and use of polyethylene plastic bags up to 50 microns thick** in retail and trade facilities, with exceptions for bags used for weighing goods and bags made from recycled materials. These changes stemmed from amendments to the **Law on Trade and Services**, intended to give businesses time to transition toward alternatives.[29] In practice, many plastic bags remain in circulation in 2025, especially thicker bags and in smaller retail settings, highlighting **limited enforcement and substitution effects** rather than elimination. Independent reporting notes that despite the 2022 restriction on thin bags, enforcement has been inconsistent and many sellers continue offering plastic bags of various thicknesses.[30]

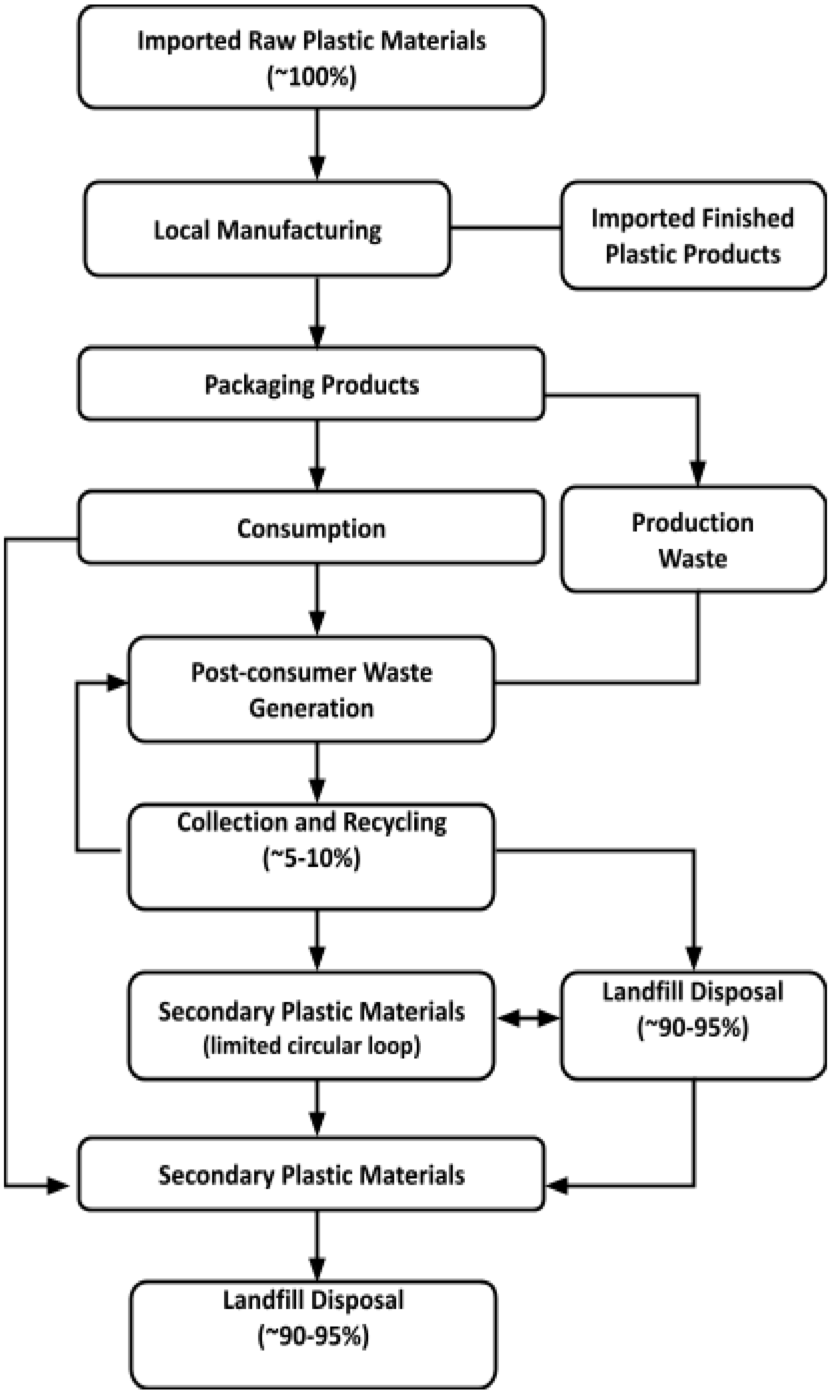
As such, Armenia's plastics sector is largely oriented toward downstream manufacturing and relies heavily on imports for raw materials. While local production plays a role in meeting domestic demand, the country remains structurally dependent on foreign suppliers. As a result, current policy efforts are focused more on managing plastic use and environmental impacts than on transforming the sector's position in the global value chain.

[29] Republic of Armenia. 2022. Law on Trade and Services. Article 9 – Rules of Trade Organization. Republic of Armenia. In force from 1 January 2022.
[30] JAMnews. (2019). Armenia's battle with plastic bags. https://jam-news.net/armenias-battle-with-plastic-bags/

2.2 Value Chain Mapping and Material Flow

Building on the definition and scope set out earlier in the report, this section provides a concise overview of the plastics packaging value chain in Armenia, with a particular focus on plastic bottles. The mapping highlights the main stages of material flow, key actors, and points of leakage and recovery across the lifecycle. The current structure of the value chain is illustrated in the figure below.

Figure 12. Simplified material flow in Armenia's plastics value chain (focused on packaging and single-use plastics)



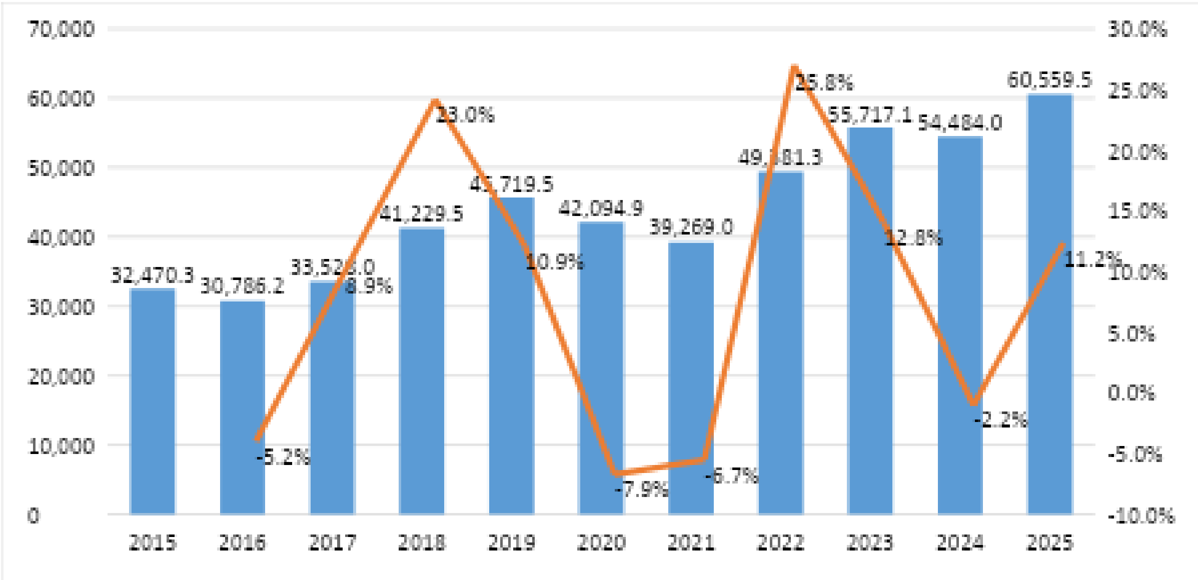
Source: Ameria team analysis based on stakeholder consultations with industry representatives and public institutions, and review of sector statistics.

Overall, Armenia's plastics system is largely linear, with most raw materials and finished products imported, processed, and consumed locally, and only a small fraction recovered for recycling, resulting in limited material circularity. Each stage of the value chain is discussed in detail below to provide a clearer understanding of flows, actors, and processes.

2.2.1 Raw Material Supply

Armenia has no domestic production of primary plastics, making the sector **entirely dependent on imports** of polymer raw materials supplied as resins, granules, and semi-processed inputs. Core materials used in packaging include polyethylene (Polymers of ethylene, in primary forms, PE, HS 3901), polypropylene (Polymers of propylene, other olefins in primary forms, PP, HS 3902), polystyrene (Polymers of styrene, in primary forms, PS, HS 3903), polyvinyl chloride (Polymers of vinyl chloride, other halogenated olefins, PVC, HS 3904), and other plastics. Between 2015 and 2024, the value of Armenia's plastic raw material imports (HS 3901-3907) fluctuated between approximately **USD 30–45 million** in most years, before peaking at **about USD 82 million in 2022** amid global polymer price shocks, and then easing to **around USD 66 million in 2024**. Import volumes in tonn followed a different trajectory: after declining to below 31 thousand tons in 2016, volumes expanded steadily and exceeded 60 thousand tons by 2025, reaching the highest level observed in the period. This divergence between value and volume trends points to partial normalization of global polymer prices alongside rising physical demand in the domestic market.

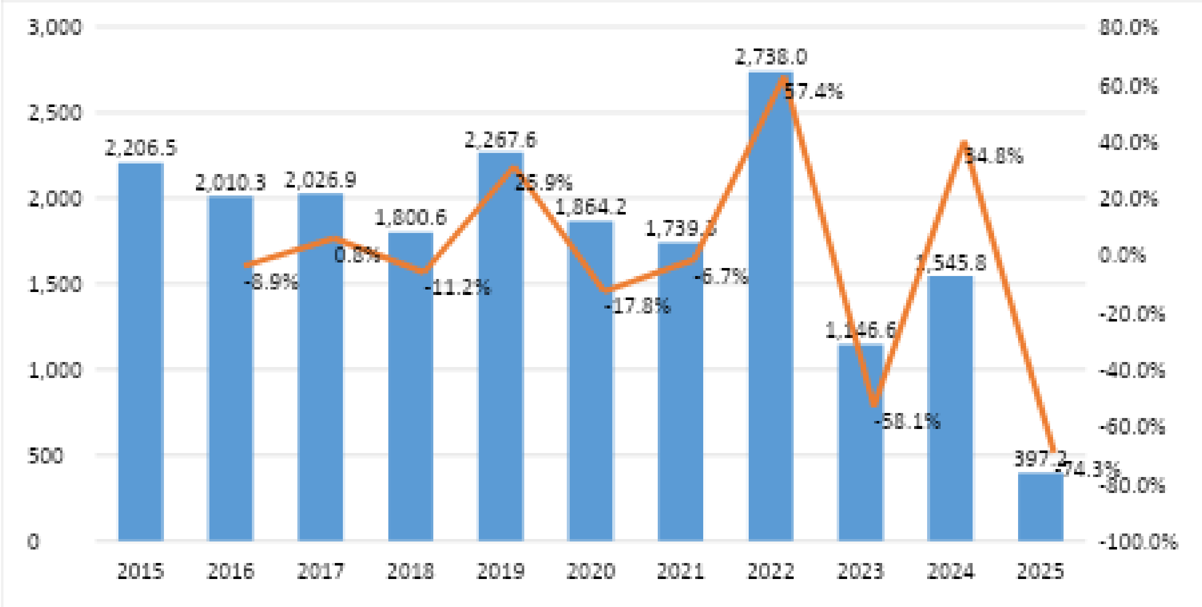
Figure 13. Total imports (in tonn) of primary plastic raw materials classified under HS 3901-3907 (2015-2025).



Source: Armstat, External Trade Database (HS 4-digit level)

Exports of primary plastic raw materials remained limited in absolute terms and showed notable year-to-year variation over the period shown in Figure 7. Export volumes ranged between approximately 1.7 and 2.3 thousand tons in most years between 2015 and 2021. In 2022, exports increased to about 2.7 thousand tons, the highest level observed in the period. This was followed by a decline to around 1.1 thousand tons in 2023, a partial recovery to approximately 1.5 thousand tons in 2024, and a further decrease to about 0.4 thousand tons in 2025.

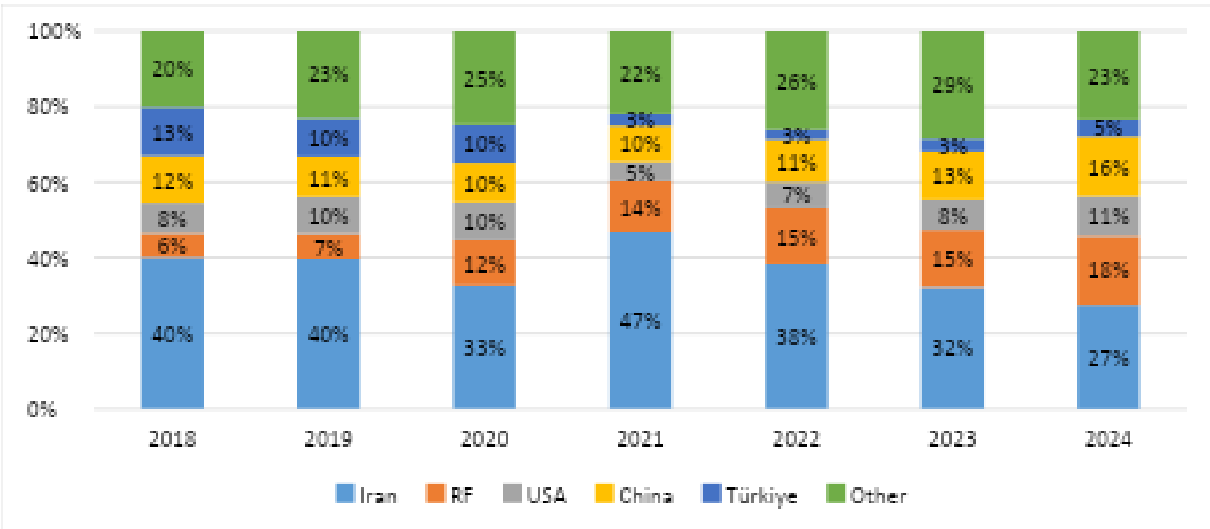
Figure 14. Total exports (in tonn) of primary plastic raw materials classified under HS 3901-3907 (2015-2025).



Source: Armstat, External Trade Database (HS 4-digit level)

Armenia's plastics import structure is concentrated among a small group of suppliers. Iran remains a leading partner in value terms throughout the period, while the Russian Federation's importance increased sharply after 2020, reaching over USD 12 million by 2024. China and the United States play steadily growing roles, with the US emerging as a higher-value supplier in 2024. Türkiye's contribution declined after 2019 and remained comparatively volatile, with only partial recovery in recent years.

Figure 15. Top five source countries for Armenia's primary plastic raw materials imports classified under HS 3901, 3902, 3903, 3904, 3905, 3906 and 3907 (2018-2024)



Source: Ameria team calculations based on UN Comtrade data.

In relative terms, supplier shares reveal clear structural shifts over time. Iran remained the dominant supplier throughout the period, accounting for around 40% of imports in 2018–2019 and peaking at 47% in 2021, before its share declined steadily to 27% by 2024. The Russian Federation's role strengthened after 2020, with its share rising from 6–7% in 2018–2019 to 18% by 2024, reflecting a sustained post-2020 reorientation of trade flows.

China and the United States both gained importance in the import mix, with China's share increasing from 11–12% in the late 2010s to 16% in 2024, and the United States rising from 8–10% to 11% over the same period. Together, these two suppliers accounted for roughly 27% of imports by 2024, indicating gradual diversification toward non-regional sources.

Türkiye's relative importance declined markedly, falling from around 10–13% in 2018–2019 to just 3–5% after 2021, while the share of other suppliers remained sizeable, fluctuating between 20% and 29%, underscoring continued fragmentation beyond the main partners.

2.2.2 Local Manufacturing and Imports of Products

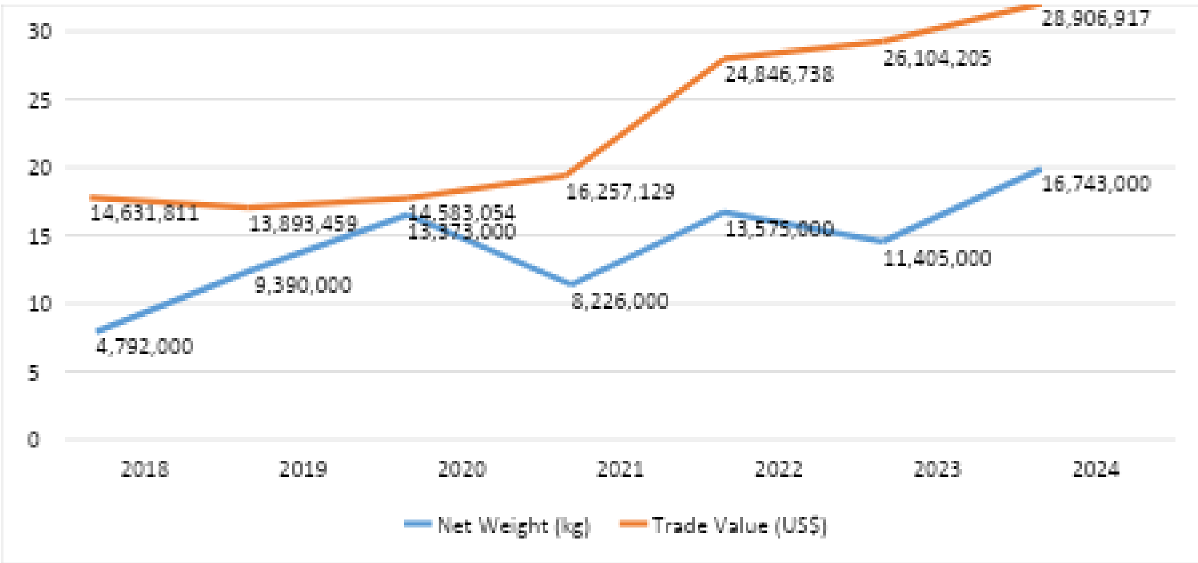
Armenia's plastic packaging market is supplied through a combination of domestic production and imports of finished products. On the manufacturing side, a network of local firms converts imported polymer raw materials into a wide range of plastic packaging and related goods, including plastic bags and films, bottles and PET preforms, household items, as well as pipes and fittings.

At the same time, part of domestic demand is met through imports of finished plastic packaging products. While this channel is discussed in more detail in the sector overview, it is important to note here that imported finished articles complement local production and play a role in meeting market needs alongside domestically manufactured packaging.

This dual structure of local manufacturing alongside imports of finished products is reflected in the size, composition, and segmentation of firms operating across the plastics value chain in Armenia.
Based on registered economic activity data, around 800 entities operate across plastics manufacturing, packaging production, and related waste and recycling activities in Armenia, reflecting a fragmented sector dominated by small and medium-sized firms. The largest concentration is in **manufacturing of plastic products (NACE C22)**, particularly **C22.29 (other plastic products; ~280 entities)** and **C22.23 (plastic builders' ware; ~230 entities)**, followed by **C22.22 (plastic packaging goods; ~80 entities)** and **C22.21 (plastic plates, sheets, tubes and profiles; ~50 entities)**. A smaller number of firms operate in **polymer production and compounding (C20.16; ~25 entities)** and **plastic waste collection and recycling (E38.32; ~100 entities)**.

Within this landscape, firms such as Hytex and Narplast produce PET preforms and bottles domestically, alongside companies manufacturing disposable plastic tableware, packaging films, and polymer pipes and fittings. Armenia's market for plastic packaging products is also supplied through an **imports of finished packaging articles**, classified primarily under **HS 3923**, which covers plastic articles used for the conveyance or packing of goods. This category includes **plastic sacks and bags, bottles and containers, boxes and crates, caps and closures, and other rigid or flexible plastic packaging**.

Figure 16. Imports of Plastic Packaging Products (HS 3923) to Armenia, 2018–2024 (Value in USD and Volume in kg)



Source: UN Comtrade

Imports of HS 3923 products have risen markedly in recent years, reflecting growing demand for packaged goods and continued reliance on imported plastic packaging. Import values increased from around USD 14 million in 2018–2020 to nearly USD 28 million by 2024.

Import volumes, however, were more volatile, rising from about 4.79 million kg tons in 2018 to nearly 13.37 million kg in 2020, falling in 2021, and recovering to over 16.74 million kg by 2024. **The widening gap between value and volume points to fluctuations in unit values**, driven by global polymer prices, transport costs, and changes in the product mix (see Figure 8).

Implicit average import price of HS 3923 products (price per ton) decreased over the considered period reaching about 1,700 USD per ton in 2024 (about 3,000 USD per ton in 2018).

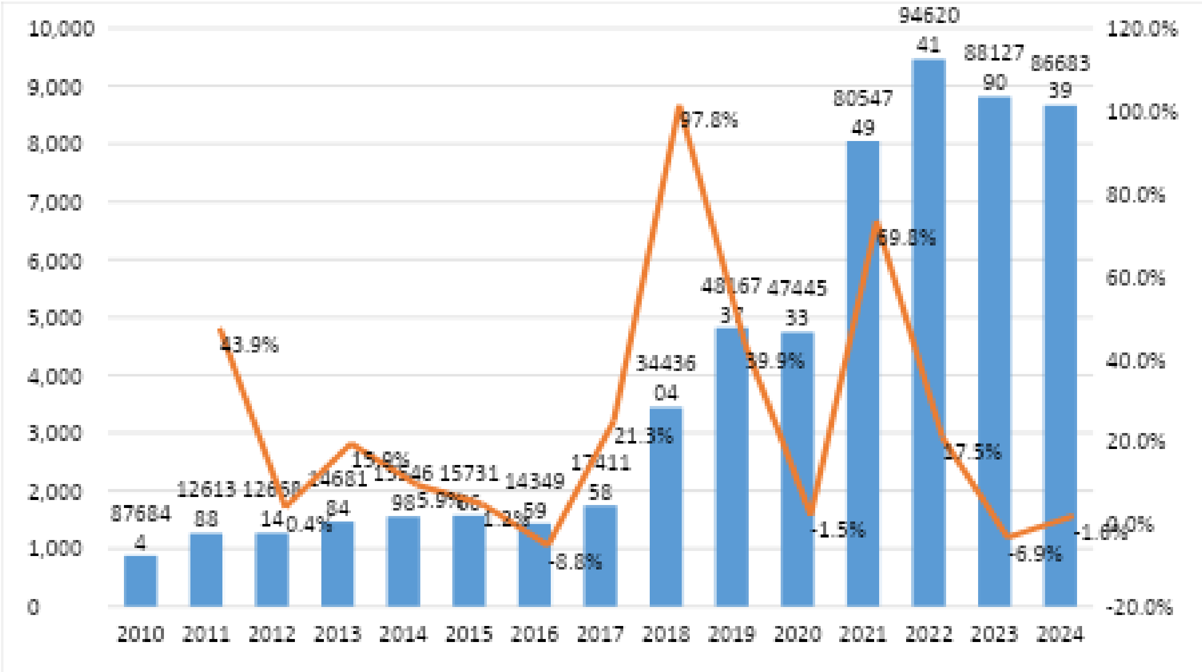
Table 1. Import Volumes, Values, and Implicit Unit Prices of Plastic Packaging (HS 3923), Armenia

Row Labels	Net Weight (ton)	Trade Value (US$)	Price per ton (US$)
2018	4,792	14,631,811	3,053
2019	9,390	13,893,459	1,480
2020	13,373	14,583,054	1,090
2021	8,226	16,257,129	1,976
2022	13,575	24,846,738	1,830
2023	11,405	26,104,205	2,289
2024	16,743	28,906,917	1,726

Source: Ameria team calculations based on UN Comtrade database

Alongside imports, local manufacturing of plastic packaging has expanded significantly over the past decade, making it one of the fastest-growing segments of Armenia's plastics industry. Output in plastic packaging production (NACE 22.22) increased steadily from about AMD 877 thousand in 2010 to around AMD 1,741 thousand by 2017, before accelerating sharply from 2018 onward. Production more than doubled between 2018 and 2019, rising from approximately AMD 3,444 thousand to AMD 4,817 thousand.

Figure 17. Manufacture of plastic packing goods (HS 22.22.0) (millions, AMD)

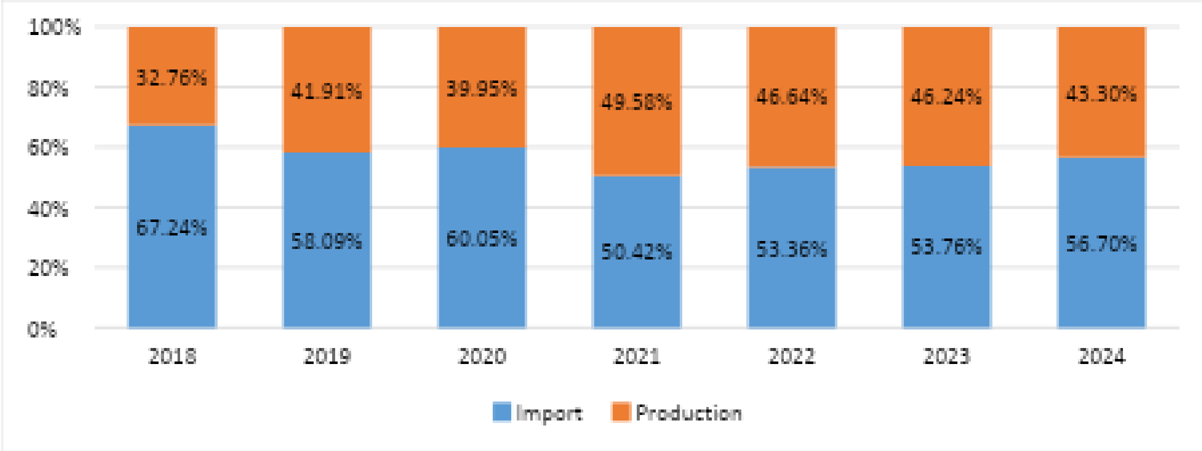


Source: Ameria team calculations based on Armstat data

After a brief slowdown in 2020, growth resumed strongly, with output reaching about **AMD 8,055 thousand** in 2021 and peaking at around **AMD 9,462 thousand** in 2022. Production then stabilized at a high level of roughly **AMD 8,813–8,668 thousand** in 2023–2024, equivalent to about **USD 22–24 million** at an exchange rate of AMD 385 per USD.

When domestic production is assessed together with imports, a clearer picture of Armenia's overall plastic packaging supply (HS 3923) emerges. Despite the rapid expansion of local manufacturing, imports continue to account for the majority of total supply. In 2018, imports represented about 68% of total plastic packaging supply, with domestic production covering the remaining 32%. As local manufacturing expanded, the production share increased to 42% in 2019 and peaked at around 48% in 2021, reflecting the strong growth of domestic capacity during this period.

Figure 18. Structure of Plastic Packaging Supply (HS 3923) in Armenia: Imports vs. Domestic Production



Source: Armstat, External Trade Database (HS 4-digit level)

However, in subsequent years the balance shifted back toward imports. By 2024, imports accounted for approximately 57% of total plastic packaging supply, while domestic production represented around 43%. This evolution indicates that, although local manufacturers have secured a meaningful and stable share of the market, imports remain the dominant supply channel, particularly for standardized packaging formats and packaging embedded in imported consumer goods.

Beyond quantitative growth trends, stakeholder consultations indicate that parts of the domestic industry are already pursuing material-efficiency strategies within existing production structures. Several leading producers have introduced packaging "lightweighting" measures, meaning thinner bottles and caps that require less resin per unit. Representatives of Coca-Cola HBC Armenia explained that a standard 0.5-liter carbonated beverage bottle that previously weighed about 28 grams has been reduced to around 21 grams in summer conditions and around 18 grams in winter, reflecting gradual optimization while maintaining functionality and product safety. Additional reductions have been achieved through design adjustments such as narrowing bottle necks and reducing cap weight.

Similarly, Oval Plastic reported that it has modernized the majority of its product range and introduced material-saving improvements across roughly 95% of its 1,000–1,200 plastic packaging products. These examples demonstrate that upstream waste prevention through improved design and thinner packaging is already occurring in Armenia and can complement future downstream recycling reforms.[31]

2.2.3 Distribution and Consumption

Plastic packaging enters Armenia's economy through a combination of domestically produced packaging and imported finished packaging, as well as packaging embedded in imported consumer goods. As outlined in the previous subsection, total packaging supply is determined by the sum of domestic production and imports, net of exports. This balance provides a basis for estimating the volume of plastic packaging that ultimately remains available for use within the domestic market.

[31] Stakeholder consultations—Coca-Cola HBC Armenia CJSC (16 Jan 2026);
Stakeholder consultations—"OVAL PACK" ("OVAL" Plastic LLC), Varuzhan Khalatyan (19 Jan 2026).

Given that the vast majority of this packaging is designed for short life cycles, single-use plastic items are structurally embedded in everyday consumption, particularly in urban areas.

From a functional perspective, plastic packaging used in Armenia can be broadly divided into single-use and multiple-use applications. Single-use packaging, such as PET bottles, plastic bags, films, and disposable food-service items, dominates consumption flows and typically becomes waste shortly after purchase. Multiple-use packaging—including refillable containers, reusable crates, and durable household packaging—exists but represents a much smaller share of total volumes and is concentrated in specific commercial or logistics applications. As a result, overall consumption patterns are heavily skewed toward short-lived plastic items.

When production, imports, and exports are assessed jointly, **apparent domestic consumption** of plastic packaging can be approximated as production plus imports minus exports. On this basis, domestic consumption[32] increased steadily over the period, rising from around **USD 17.9 million in 2018** to over **USD 44.7 million in 2024**. This growth reflects both the expansion of local manufacturing capacity and sustained reliance on imported packaging products.

Table 2. Structure of Plastic Packaging Supply and Apparent Domestic Consumption (HS 3923), Armenia (USD)

	Import	Production	Export	Consumption
2018	14,631,811	7,129,763	3,820,653	17,940,921
2019	13,893,459	10,025,574	3,580,205	20,338,828
2020	14,583,054	9,702,346	3,161,476	21,123,924
2021	16,257,129	15,988,941	3,185,365	29,060,705
2022	24,846,738	21,718,367	4,105,646	42,459,459
2023	26,104,205	22,454,112	5,815,008	42,743,309
2024	28,906,917	22,072,006	6,228,717	44,750,206

Source: Ameria calculations based on Armstat and UN Comtrade databases

From a distribution perspective, plastic packaging reaches end users through **multiple channels**. A portion of domestically produced packaging is supplied **directly to final consumers**, for example in the form of shopping bags, household containers, or disposable tableware. Another portion is used in **intermediate consumption**, where packaging is applied by food and beverage producers, personal-care manufacturers, and other firms that package their own products before sale. The final consumption of plastic packaging therefore includes both packaging purchased as a standalone product and packaging embedded in domestically produced goods.

In practice, the boundary between intermediate and final consumption is not always clearly observable in statistics. As discussed during expert consultations, some large producers may internally supply or source their own packaging, reducing the visibility of intermediate transactions. This issue will be further clarified through stakeholder interviews. Nevertheless, from a material-flow

[32] Apparent domestic consumption = Imports + Domestic production – Exports

perspective, **all packaging used at intermediate stages ultimately enters final consumption**, either through retail purchases of packaged goods or through food and beverage services.

In addition to domestically sourced packaging, a significant share of plastic packaging reaches consumers **indirectly through imports of packaged goods**, such as bottled beverages, processed food, and household products. This packaging is not captured under HS 3923 in trade statistics, as it enters the country under the HS codes of the contained products (e.g. beverages or food items). As a result, the total volume of plastic packaging circulating in the domestic market is **higher than what is observed through direct packaging imports alone**, reinforcing the importance of considering embedded packaging in distribution and consumption analysis.

Because packaging at the consumption stage is overwhelmingly **single-use**, most items transition into waste shortly after purchase. In the absence of widespread reuse schemes or deposit-return mechanisms, this reinforces a predominantly one-way material flow from distribution to disposal. The implications of these consumption patterns for waste generation, collection, and recycling are examined in detail in the following section.

Stakeholder consultations suggest that, among household waste streams, plastic packaging—especially beverage bottles—tends to be more recognizable to consumers and is therefore more likely to be separated informally compared to paper or mixed waste. However, both public and private stakeholders noted that separation behaviour is inconsistent and often breaks down in practice, including cases where households mix waste even when color-coded bins are available.[33]

2.2.4 Waste Collection and Disposal

Currently, Armenia's waste collection and disposal system remains **predominantly linear**, with landfilling as the default outcome for household and commercial waste, including plastic packaging. Municipal waste services collect mixed waste streams from households, retail outlets, food services, and industrial facilities, with no nationwide system of mandatory source separation. Collected waste is transported directly to disposal sites, limiting opportunities for material recovery at earlier stages.
According to official statistics, municipal solid waste generation per capita ranges between approximately 150 and 210 kg per person per year over 2018–2024.[34] While these levels are moderate by international standards, they are consistent with a consumption model increasingly shaped by packaged goods, particularly in urban areas. The data also indicate year-to-year variation rather than a sustained upward trend, suggesting relative stability in overall waste generation intensity at the population level.

In practice, waste management outcomes remain heavily shaped by disposal practices. Armenia's waste disposal system is largely centered on landfilling and other forms of final disposal, with mixed

[33] Coca-Cola HBC Armenia CJSC. 2026. Stakeholder Consultation. 16 January 2026.
Ministry of Economy of the Republic of Armenia, Armen Yeganyan. 2026. Stakeholder Consultation. 15 January 2026.
[34] ArmStat. *Environmental Statistics – Waste generation by indicators (EE-i1-1)*. ArmStatBank database. https://statbank.armstat.am/pxweb/hy/ArmStatBank/ArmStatBank__8%20Environment__(I)%20Waste/EE-i1-1.px

municipal waste collection serving as the predominant management pathway. Many disposal sites operate with limited technical controls and without comprehensive environmental protection measures, such as engineered liners, leachate management, gas capture, or systematic monitoring. These characteristics were consistently confirmed during consultations with sector professionals, who highlighted that landfilling functions not only as the dominant but also as a weakly controlled end-of-life option, with potential implications for soil, water, and air quality.

This system design has particularly strong implications for plastics. Plastic packaging—especially lightweight items such as PET bottles, polyethylene films, and disposable food-service containers—typically enters mixed municipal waste streams immediately after consumption. Once combined with organic waste and moisture, much of this material loses its practical recyclability, despite being technically recyclable in principle. As a result, most post-consumer plastic packaging is effectively directed toward disposal rather than recovery, reinforcing the predominantly linear character of plastic material flows.

Although small quantities of plastic waste are recovered through informal and semi-formal collection, particularly in urban areas, these activities operate outside the formal municipal system and remain limited in scale. In the absence of integrated sorting infrastructure, economic incentives, extended producer responsibility (EPR) schemes, or deposit-return systems, such recovery does not materially alter the overall waste management structure.

As a result, waste collection and disposal function as a terminal stage in Armenia's plastics value chain, reinforcing its predominantly linear character. This disposal-oriented model constitutes one of the main structural barriers to increasing plastics circularity and directly constrains progress toward relevant Sustainable Development Goals, particularly SDG 11.6 (reducing the environmental impact of cities) and SDG 12.5 (substantially reducing waste generation through prevention, reduction, recycling, and reuse)[35]. While Armenia reports on aggregate waste indicators under the SDG framework, the absence of plastic-specific tracking and source-separated collection limits the effectiveness of policy interventions targeting plastics in particular.

2.2.5 Recycling and Recovery

Recycling and material recovery currently play a limited and structurally marginal role in Armenia's plastics value chain. Existing recycling activity captures only a small share of total plastic waste and operates largely outside a coordinated national system. From a material-flow perspective, plastic waste suitable for recycling originates from two distinct stages of the value chain: **waste generated during production processes** and **waste arising from final consumption**, commonly referred to as post-consumer plastic waste.

Production-stage plastic waste consists primarily of industrial and commercial scrap, including production offcuts, defective packaging, trimming residues, and post-commercial waste generated by

[35] United Nations. n.d. Sustainable Development Goal 11: Make Cities and Human Settlements Inclusive, Safe, Resilient and Sustainable. SDGs Platform. https://sdgs.un.org/goals/goal11

manufacturers and distributors. These material streams are relatively clean, homogeneous, and predictable, making them economically viable for recycling under current market conditions. As a result, most formal recycling activity in Armenia is concentrated on this segment of the waste stream, where collection, sorting, and processing costs are lower and material quality is more consistent.

In contrast, **post-consumer plastic waste**—generated after products are used by households, retail outlets, and food-service establishments—poses significantly greater challenges for recovery. This waste enters mixed municipal waste streams immediately after consumption and is typically contaminated with organic waste and moisture. Once contaminated, even theoretically recyclable plastics lose much of their practical and economic recyclability. As a result, only a very small fraction of post-consumer plastic packaging is recovered, while the vast majority is directed toward disposal.
Producers also stressed that their current recycling capability is limited to clean and sorted plastics; they do not have capacity to separate plastics from mixed household waste streams, which further narrows practical recovery of post-consumer packaging.[36]

Overall, Armenia has no nationwide mandatory source-separation requirement, no deposit-return system, and no large-scale material recovery facilities capable of processing mixed municipal waste into clean plastic fractions. Recycling activity is therefore structurally constrained and limited in scale. Available evidence from official statistics, sector studies, and stakeholder consultations consistently suggests that only a few percent of plastic waste generated in Armenia is recycled, with the remainder disposed of in landfills.

Recycling operations that do exist are concentrated among a small number of private operators and focus almost exclusively on high-value, easily identifiable polymers—primarily PET bottles and HDPE containers. Feedstock is sourced through two main channels: relatively clean industrial scrap and informal or semi-formal collection of post-consumer plastics from dumpsters, collection points, and landfill sites. Informal collection plays a particularly important role for PET bottles, which retain resale value and have established downstream markets. However, these activities operate under unsafe conditions and remain weakly integrated into municipal waste-management systems.

Collected plastics are typically processed using relatively basic technologies, including manual sorting, washing, and shredding into flakes or granules. Recycled material is either reused domestically in low-grade applications—such as plastic pipes, trash bags, or non-food packaging—or exported as recyclable plastic scrap. Armenia currently lacks facilities capable of producing food-grade recycled polymers, which effectively prevents closed-loop recycling for packaging applications and limits the value added that can be captured domestically.

Recycling as a Structural Bottleneck and the Case for Circularity

[36] OVAL Plastic LLC (OVAL PACK). 2026. Stakeholder Consultation (Varuzhan Khalatyan). 19 January 2026.

The limited recovery of plastics—particularly post-consumer packaging—has broader implications for the performance of Armenia's plastics value chain. Plastic waste therefore represents not only an environmental challenge but also a structural inefficiency, reflecting the loss of material value at the end of the product lifecycle. Under current conditions, recycling and recovery do not function as integral components of the system but rather as marginal activities at its periphery. This reinforces the predominantly linear character of plastic material flows and underscores the need for a transition toward a more circular plastics value chain.

Emerging Circular Economy Practices in the Plastics Value Chain

Despite the predominantly linear structure of Armenia's plastics value chain, a limited but growing set of circular economy practices and initiatives has emerged in recent years. These activities remain fragmented and small in scale, but they provide insight into where circularity is technically and institutionally feasible under current conditions.

Private-sector recycling and recovery activities. A small number of private companies are engaged in plastic recycling, focusing primarily on PET bottles and HDPE containers, which offer the most stable demand and resale value. These operations rely heavily on informal and semi-formal collection networks and employ basic processing technologies. Output is used mainly for low-grade domestic applications or exported as recyclable plastic scrap. The absence of food-grade recycling capacity remains a critical limitation.

Pilot collection and sorting initiatives. Donor-supported and municipal-level pilot projects have tested separate collection of plastic waste in selected locations, such as neighborhoods, schools, or institutions. These initiatives demonstrate that higher recovery rates are technically achievable when separation at source is combined with targeted awareness-raising and logistical support. However, such pilots remain geographically limited, project-based, and difficult to scale in the absence of stable financing and institutional backing.

Multi-stakeholder coordination platforms. Armenia has also seen the emergence of dialogue and coordination platforms aimed at advancing circular economy concepts and waste-management reform. The Armenian Circular Economy Coalition, established under the EU-funded *CirculUP!* programme[37], brings together experts, businesses, civil-society organizations, and public officials to exchange knowledge and develop policy and pilot ideas related to circularity. While these platforms do not exercise formal decision-making authority, they play an important role in agenda-setting, capacity-building, and early consensus formation.

Policy-oriented working groups and preparatory mechanisms. Circular economy principles are also being explored through policy working groups linked to forthcoming waste-management reforms, particularly in relation to Extended Producer Responsibility. These processes involve government bodies, academic institutions, and business associations and have helped clarify technical options and stakeholder positions. However, they remain consultative and have not yet resulted in operational, system-wide circular arrangements.

[37] Circul'Up. *Promoting Circular Economy in Armenia.* Circul'Up Initiative. https://circulup.am/hy/home-hy/

2.3 Mapping of Circular Economy Stakeholders and Initiatives in the Value Chain

The transition toward a circular plastics value chain in Armenia involves a **diverse set of stakeholders** with differing levels of influence, incentives, and capacity to act. While interest in circular economy concepts has increased in recent years, **effective implementation remains uneven**, reflecting misaligned incentives and institutional constraints across the stakeholder landscape.

Government and Regulatory Authorities: Key public actors include the Ministry of Environment (waste policy and environmental regulation), the Ministry of Territorial Administration and Infrastructure (municipal services), and sectoral agencies involved in trade and industry oversight. These institutions possess **high formal power**, as they define regulatory frameworks, enforcement mechanisms, and public investment priorities. However, their **effective influence on circular outcomes has been constrained** by limited enforcement capacity, fragmented mandates, and competing policy priorities. While alignment with international commitments has increased government engagement with circular economy concepts, implementation has so far focused on **incremental measures** rather than systemic restructuring of material flows.

Producers and Importers of Plastic Products and Packaging: This group includes local manufacturers of plastic packaging and products, as well as importers of packaged goods and plastic materials. Collectively, they have **significant market power**, as they determine what materials and packaging formats are placed on the Armenian market. However, their **direct economic interest in circular practices has historically been low**, given the absence of binding recovery obligations, low disposal costs, and easy access to inexpensive virgin plastics through imports. Engagement with circularity has therefore been selective and largely reactive, driven by anticipated regulation, international supply-chain requirements, or reputational considerations rather than intrinsic business incentives.

Municipalities and Waste Management Operators: Municipal authorities, particularly in Yerevan and other large cities, are responsible for waste collection and disposal services. They hold **moderate operational power**, controlling infrastructure and service delivery, but face **significant budgetary and technical constraints**. While municipalities have a clear interest in reducing landfill pressure and service costs, their ability to initiate circular practices—such as separate collection or local recycling systems—has been limited by financing gaps and the absence of national-level coordination mechanisms.

Recycling Companies and Circular Economy Entrepreneurs: Private recycling firms and circular-economy startups represent the **core operational actors** capable of closing material loops. These actors exhibit **very high interest** in expanding circular practices, as their business models depend directly on access to recyclable feedstock and stable markets for secondary materials. However, they currently possess **low structural power**, operating at small scale and facing unstable material supply, limited demand for recycled plastics, and exposure to volatile scrap prices. Without regulatory support or guaranteed feedstock streams, their ability to scale remains constrained.

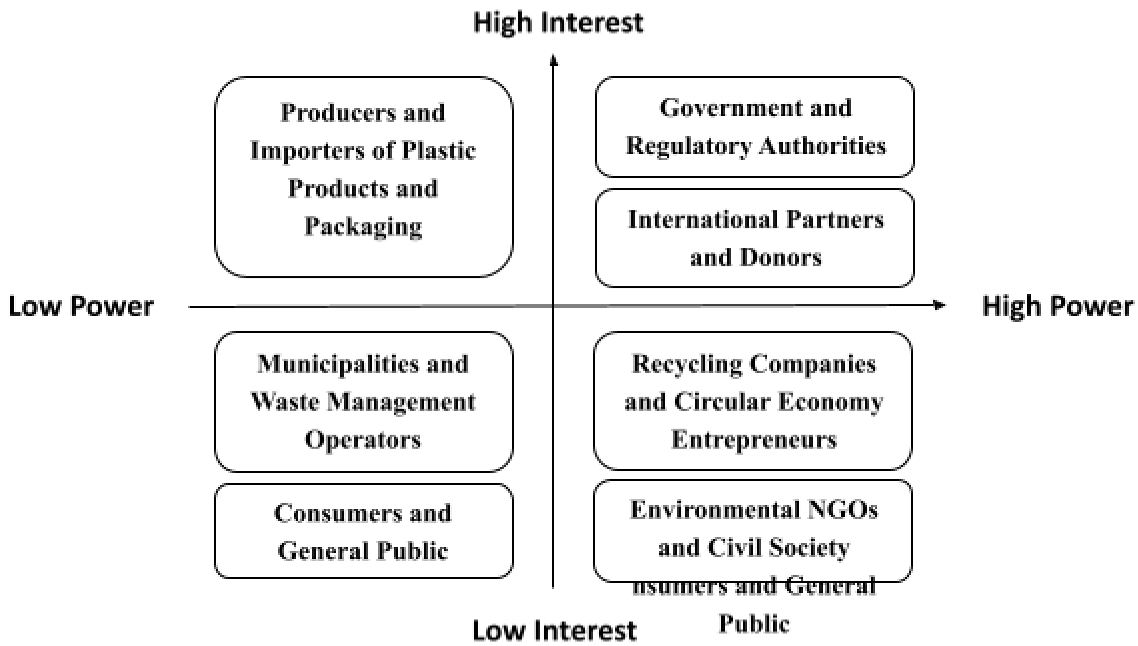
Environmental NGOs and Civil Society: Environmental NGOs, community groups, and advocacy organizations play an important role in **raising awareness, piloting initiatives, and maintaining public pressure** on waste and plastics issues. Their **formal power is limited**, but they exert indirect influence through public discourse, donor engagement, and policy dialogue. These actors have been instrumental in keeping plastics pollution on the agenda and in supporting pilot collection and recycling initiatives, though their impact on system-level material flows remains indirect.

Consumers and General Public: Households are the end users of plastic packaging and the primary generators of post-consumer plastic waste. As a stakeholder group, consumers hold **low individual power and fragmented collective influence**. While public awareness of environmental issues has increased, **behavioral incentives for waste reduction and separation remain weak**, due to the lack of convenient infrastructure, economic rewards, or enforcement mechanisms. Consumer participation in circular practices is therefore largely opportunistic rather than systematic.

International Partners and Donors: International organizations and development partners—including the EU, UN agencies, international financial institutions, and bilateral donors—play a **disproportionately influential role** in Armenia's circular economy agenda. Through funding, technical assistance, and policy alignment requirements, they exert **high agenda-setting power** and maintain strong interest in advancing waste and plastics reforms. In practice, international partners often compensate for domestic capacity gaps by financing pilot projects, infrastructure upgrades, and legislative development, making them key catalysts of progress in the circular plastics space.

A useful way to visualize these stakeholders is through a **power–interest grid**, which maps each actor's level of influence against their level of vested interest in circular economy outcomes:

Figure 19. Stakeholder power–interest grid for circular plastics economy in Armenia



Note: Stakeholders in the top-right quadrant (high power, high interest) – such as international donors/EU and, potentially, government regulators – are critical champions who can drive policy and investment. Top-left (low power, high interest) includes NGOs and recycling companies that advocate and pilot solutions but need support. Bottom-right (high power, low interest) includes large producers/importers whose buy-in is essential; they may need regulatory push to act. Bottom-left are stakeholders with low influence and currently low engagement (e.g. the general consumers), who require education and empowerment to play a bigger role.

2.4. Circularity Gaps and Pain Points

Despite growing awareness and a proliferation of pilot initiatives, plastics circularity in Armenia remains constrained by a set of **structural, economic, and institutional gaps** that limit the ability of existing practices to scale or materially alter national plastic flows. These constraints operate across the value chain and reinforce the predominance of landfill disposal.

Fragmented and low-quality feedstock supply: The most fundamental constraint is the **absence of systematic source separation** for municipal waste. Plastic packaging enters mixed waste streams contaminated with organic material, significantly reducing its recyclability and economic value. Armenia lacks nationwide requirements or infrastructure for separate collection, resulting in highly inconsistent and low-quality plastic feedstock for recyclers. This structural deficiency forces recycling companies to rely on **informal recovery networks**, particularly for PET and HDPE, which constrains scale, predictability, and material quality.

Weak economics of plastic recycling: The economic case for plastic recycling in Armenia remains fragile. Virgin plastic polymers—imported at international market prices—often remain **cheaper and more consistent in quality** than recycled alternatives. At the same time, landfill disposal costs are low and do not internalize environmental externalities, undermining incentives to divert plastics from disposal. Without mechanisms to stabilize demand for secondary plastics or to correct price distortions, recycling remains **opportunistic rather than systemic**.

Institutional fragmentation and limited enforcement capacity: Responsibility for plastics and waste management is distributed across multiple public institutions and levels of government, with **weak coordination and limited enforcement capacity**. Municipalities are responsible for waste collection but lack the resources and mandates to introduce circular practices independently. National authorities set policy direction but have limited capacity to ensure consistent implementation on the ground. These governance challenges are repeatedly identified in international reviews of Armenia's waste sector. This fragmentation dilutes accountability and slows the transition from policy intent to operational change.

Policy instruments not yet translated into operational systems: While policy discussions around Extended Producer Responsibility and restrictions on certain single-use plastics are well advanced, these instruments have **not yet translated into operational systems** that alter material flows. In the absence of binding recovery targets, financing mechanisms, or producer-led collection schemes, circularity remains dependent on voluntary initiatives and donor-supported pilots rather than enforceable market structures. This gap between policy design and implementation reinforces uncertainty for private investors and recyclers.

Stakeholders highlighted that deposit-return mechanisms could be a practical early instrument for high-value, standardized packaging (e.g., beverage bottles), including through reverse-vending machines installed in supermarkets or public spaces—provided that rollout is phased and operational responsibilities are clearly assigned.[38]

Behavioral constraints at the household level: Public awareness of plastics pollution has increased, but **behavioral change among households remains limited**. In the absence of convenient infrastructure, financial incentives, or enforcement mechanisms, consumers have little practical ability or motivation to separate waste or reduce single-use plastic consumption.

Taken together, these gaps indicate that Armenia's plastics system is constrained less by **lack of awareness or pilot activity**, and more by **structural failures in feedstock capture, market economics, and institutional design**. Without coordinated interventions that address these constraints simultaneously, existing circular economy practices will remain **isolated and marginal**, unable to shift the system away from landfill-centered disposal.

[38] Ministry of Economy of the Republic of Armenia (Armen Yeganyan). 2026. Stakeholder Consultation Conducted on 15 January 2026.

2.5 Opportunities for Circular Interventions

While Armenia's plastics system is constrained by structural and economic barriers, the analysis above points to sequenced entry points where targeted interventions could generate incremental circularity gains. These opportunities should be understood as pragmatic steps rather than a rapid shift to full circularity.

Focusing on high-capture plastic streams. The most immediate opportunity is to concentrate interventions on plastic streams that are already being collected and traded in practice—most notably PET bottles and rigid HDPE containers. These materials are easier to identify and sort, have clearer resale pathways, and therefore offer higher recovery potential than low-value films or composite plastics. Prioritizing these polymers can increase recovered volumes without dispersing limited institutional and investment capacity across streams with weak economics.

Scaling separate collection gradually. Although nationwide source separation is not currently in place, phased expansion of separate collection—starting in dense urban areas and large institutions—can improve the cleanliness of collected plastics and increase the share that is practically recyclable. This approach is more realistic than attempting immediate nationwide rollout and helps build operational routines (collection logistics, contamination control, communications) before scaling further.

Using upcoming policy instruments to finance recovery systems. Planned reforms such as Extended Producer Responsibility (EPR) can support more stable financing for collection and sorting, reduce reliance on project-based initiatives, and improve feedstock reliability for recyclers—provided that governance roles, reporting systems, and cost coverage are clearly designed.

Strengthening domestic demand for secondary plastics. Recycling becomes more viable when there are predictable local outlets for recycled outputs. Non-food applications—such as pipes, construction materials, household goods, and low-grade packaging—are more feasible near-term destinations for secondary plastics, especially where food-grade standards are not required.

Incremental integration of informal recovery activities. Plastic recovery in Armenia includes both formal and informal actors. Rather than attempting to eliminate informal collection channels, there is scope to gradually improve coordination, aggregation mechanisms, and material traceability within existing recovery practices. Enhancing working conditions and improving material sorting and consolidation processes could increase the quality and reliability of recovered plastics without requiring abrupt structural changes.

Positioning plastics circularity within fiscal planning. Improving plastic recovery can also be framed within broader waste-management planning considerations. As disposal remains the dominant pathway and infrastructure investments are required over time, reducing the volume of materials sent to disposal may contribute to more efficient use of municipal waste-management resources.

Presenting plastics recovery not only as an environmental objective but also as part of long-term system efficiency planning may support broader institutional engagement.

Taken together, the proposed interventions indicate that advancing plastics circularity in Armenia requires a coordinated and phased approach grounded in practical implementation realities. Progress depends on combining material-focused actions, gradual improvements in collection and recovery systems, and the effective use of emerging policy instruments. By strengthening institutional coordination, improving material capture, and supporting viable end-markets for recycled plastics, Armenia can begin shifting its plastics value chain toward greater efficiency and resource recovery within existing economic and governance constraints.

2.6 Case Examples and International Benchmark

Case 1: European Union's Circular Plastics Approach (EU/Germany)

The **European Union** offers a comprehensive benchmark for managing plastics in a circular economy. Over the past decade, the EU has implemented a series of policies that address plastics across their life cycle, yielding measurable results. Key elements of the EU's approach include: **strict targets, economic instruments, and innovative regulations**.

In January 2018, the European Commission published *A European Strategy for Plastics in a Circular Economy*[39], setting the direction for a "new plastics economy" and working towards the objective that, by 2030, all plastic packaging placed on the EU market is reusable or can be recycled in a cost-effective manner. In parallel, the revised EU packaging rules set binding recycling targets for plastic packaging of 50% by 2025 and 55% by 2030. Across the EU, extended producer responsibility (EPR) systems are widely used to finance the collection and treatment of packaging waste and to support higher recycling performance. Recycling outcomes have improved over time: in 2022, 40.7% of plastic packaging waste generated in the EU was recycled, and in 2023 the EU average increased to 42.1%. Performance varies significantly by country; in 2023 Belgium (59.5%) and Latvia (59.2%) recorded the highest recycling rates, followed by Slovakia (54.1%).[40]

A cornerstone of EU plastics policy is the **Single-Use Plastics Directive** (Directive (EU) 2019/904), adopted in 2019[41], which establishes a targeted legal framework to reduce the environmental impact of the most common single-use plastic products. The Directive combines market restrictions, product design requirements, consumption-reduction measures and extended producer responsibility obligations. Notably, it prohibits the placing on the market of selected single-use plastic items (such as cutlery, plates, straws and expanded polystyrene food containers), requires beverage containers to be designed so that caps and lids remain attached during use, and mandates minimum recycled content in plastic beverage bottles—at least 25% recycled plastic in PET bottles by 2025 and 30% in all plastic beverage bottles by 2030.

Germany, as an EU member, exemplifies best practices. Germany has a long-running **deposit-refund system on beverage containers (Pfand).**[42] Introduced in 2003 for most single-use beverage containers, the system applies a mandatory €0.25 deposit and is supported by a nationwide reverse-vending infrastructure that enables highly efficient collection and material recovery. As noted earlier, this system achieves an **approximately 98% return rate** for eligible single-use bottles and cans. This is the highest in the world, ensuring that almost all drink containers are collected and recycled. Additionally, Germany encourages **refillable bottles** (over 40% of beverages there are in

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[39] European Commission. 2018. A European Strategy for Plastics in a Circular Economy (COM (2018) 28 Final).https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52018DC0028

[40] Eurostat. 2025. Plastic Waste Generation and Recycling in the EU.https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20251022-1

[41] European Parliament & Council of the European Union. (2019). *Directive (EU) 2019/904 on the reduction of the impact of certain plastic products on the environment*. Official Journal of the European Union. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019L0904

[42] DPG Deutsche Pfandsystem GmbH. (n.d.). *The DPG one-way deposit system*. https://dpg-pfandsystem.de/index.php/en/

refillable containers which also have a deposit), extending the reuse loop[43]. The German Packaging Law also made **EPR fees modulated** – meaning companies pay less if their packaging is more easily recyclable or if it contains recycled content. The outcome is that companies are incentivized to innovate (e.g., some switched from multi-layer packaging to single-material packaging to lower fees).

Consumer participation in recycling is facilitated by a convenient bin system ("Gelber Sack" for packaging recyclables, etc.), which has been in place for years – a testament to sustained public education. Economically, these measures have spurred a robust recycling industry: Germany not only recycles domestic waste but even has excess capacity to import recyclables for processing.

Furthermore, EU and German policies address upstream impacts: the EU's chemicals regulations ensure that additives in plastics do not hinder recycling, and climate policies recognize that recycling plastics significantly cuts emissions compared to producing new plastics (the **plastics value chain in the EU was responsible for 193 million tonnes CO_2 in 2019**[44], and increasing circularity is a key strategy to reduce that).

For Armenia, the EU/German example provides multiple lessons.

- **First**, strong legislation with clear targets is essential – it mobilizes all actors towards common goals.
- **Second**, convenience and incentives for the public (like deposits or easy recycling bins) greatly improve participation.
- **Third**, involving producers via EPR ensures financing and also drives eco-design innovation.
- **Fourth**, complementary measures (like banning the worst offenders and requiring recycled content) push the system toward circularity from both ends (supply and demand of recycled materials).

The quantifiable success of EU policy implementation demonstrates that substantial diversion from landfill is achievable with the right regulatory framework. In 2022, the EU recycled 41% of all generated plastic packaging waste, marking a slight increase compared with 2012, when the recycling rate stood at 38%.[45]

The EU example also highlights the need for **continuous improvement** – Europe is still working to hit 55% recycling by 2030, acknowledging that issues like plastic film and multi-material packaging are challenging. Armenia can anticipate these challenges and choose solutions appropriate for its scale (for instance, focusing on PET and PE which are easier to recycle as low-hanging fruit). In sum, the EU provides a roadmap of progressively tightening measures and cross-sector collaboration that Armenia could emulate to overhaul its plastics economy.

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[43] TOMRA. (n.d.). *Germany's deposit return scheme*. https://www.tomra.com/reverse-vending/media-center/feature-articles/germany-deposit-return-scheme

[44] European Parliament. (2018). *Plastic waste and recycling in the EU: Facts and figures*. https://www.europarl.europa.eu/topics/en/article/20181212STO21610/plastic-waste-and-recycling-in-the-eu-facts-and-figures

[45] Eurostat. (2024). 41% of plastic packaging waste recycled in 2022. Eurostat News Articles, 24 October.41% of plastic packaging waste recycled in 2022

Case 2: Algramo's Refill Model (Chile)

As a second benchmark, **Algramo** illustrates an innovative, **industry-led solution** to plastic waste, relevant for Armenia's private sector and startup community. Algramo is a Chilean start-up that reinvented how everyday products are delivered to consumers by enabling **refillable, smart packaging**. Traditionally, low-income consumers in Santiago would buy small sachets or bottles of things like detergent or cooking oil – convenient but generating a lot of plastic waste (and a "poverty tax" where smaller quantities cost more per unit).[46] Algramo addressed this by creating a system where people buy a durable container once and then refill it "by the gram" (hence the name) at dispensing machines or via electric tricycle delivery, paying only for the product. The container has an RFID chip linked to a mobile app for payment and tracking. This model turns packaging into a service – the company maintains ownership of the package, and consumers get product at bulk prices without single-use waste[47].

The results from Algramo's pilots are impressive and provide quantifiable evidence of impact: In one partnership with Unilever, some customers **refilled their liquid detergent bottles 15 times** over the course of a year. Each refill meant one less disposable plastic bottle produced; accumulated, those reuses **eliminated the need for over 2 kg of plastic per household just for that product**.[48]

Since its launch in 2013, Algramo's original refill model has expanded to approximately 2,000 stores in Santiago, reaching around 350,000 customers. The company reports that reuse rates increased substantially over time: while initial reuse levels were below 10%, they later rose to over 80% after adjustments to pricing and incentives. This indicates that a large majority of containers are returned and reused rather than discarded.

The case demonstrates how circular business models can combine environmental and social objectives. By allowing consumers to purchase products in reusable containers without increasing the price per gram, Algramo addresses the "poverty tax" associated with small packaging formats. In partnership with brands such as Unilever, some products offered through the refill system were reported to be around 30% less expensive than equivalent products sold at regular supermarket prices. This suggests that reuse-based systems can reduce packaging waste while also improving affordability for consumers.

Another important takeaway from the Algramo case is the role of convenience and technology in enabling reuse. The company introduced mobile refill services using electric tricycles equipped with dispensing machines, allowing customers to refill products directly at their homes. The system also incorporates RFID-enabled containers and digital payment mechanisms to facilitate transactions and

[46] Harvard Business School. (n.d.). Faculty & Research item. Harvard Business School Publishing. https://www.hbs.edu/faculty/Pages/item.aspx?num=59005

[47] World Economic Forum. (2021, April). Algramo: Reusable smart packaging can help tackle plastic waste. https://www.weforum.org/stories/2021/04/algramo-reusable-smart-packaging/

[48] Marchant, N. (2021). This Chilean start-up is revolutionizing reusable packaging. World Economic Forum, 21 April. https://www.weforum.org/stories/2021/04/algramo-reusable-smart-packaging/

encourage container returns. By making reuse both convenient and economically attractive, the model increases the likelihood of sustained consumer participation.

The case also demonstrates the importance of brand partnerships. In 2018, Algramo attracted the interest of major brands such as **Unilever**, and later **Nestlé**, leading to the development of the "Algramo 2.0" model. These collaborations suggest that large corporations are willing to engage in refill-based systems when a circular distribution model proves operationally feasible and commercially attractive.[49]

For Armenia, Algramo's experience may offer a relevant reference point for exploring refill-based models adapted to local economic conditions. A local equivalent could build on existing retail networks by introducing refill stations for staple foods, detergents, or other frequently used household products within supermarkets or neighborhood stores. Such systems would rely primarily on reusable containers, transparent pricing, and organized reverse logistics, rather than advanced technological infrastructure.

Importantly, the relevance of such a model in Armenia is not primarily cultural, but economic. In a context where household incomes remain constrained and price sensitivity is high, the opportunity to purchase products without paying for single-use packaging could create tangible savings. If refill systems demonstrably lower the effective price per unit—similar to the mechanism described in the Algramo case—they could appeal to cost-conscious consumers, making circular practices financially attractive rather than purely environmentally motivated.

Implementing such a system in Armenia would reduce single-use plastic sachets and bottles that often end up as litter. It could start in Yerevan and expand to other cities. A smaller pilot (perhaps with a local dairy or cleaning products cooperative) could test consumer response. Given that less than 15% of Armenia's plastic is recycled now, a reuse model like this prevents waste up front – each reuse is one fewer item needing collection or recycling.

It's a reminder that **circular economy is not only about recycling, but also about reducing and reusing**. The success of Algramo on another continent shows that these models are transferable and can be adapted – indeed, Algramo has expanded pilots to New York City and Jakarta, proving its global relevance. Armenia could be the next frontier, especially if supported by innovation grants or impact investors. Ultimately, an Algramo-style case study reinforces that the private sector can lead in solving the plastic problem by rethinking how products are delivered, in a way that benefits everyone.

[49] Perella, M. (2019). *Chilean startup eliminating packaging waste, 'poverty tax' in Latin American product market*. Sustainable Brands, 29 October.
https://sustainablebrands.com/read/chilean-startup-eliminating-packaging-waste-poverty-tax-in-latin-american-product-market

2.7 Conclusions

The analysis of Armenia's plastics value chain shows a system that is strongly import-dependent, downstream-oriented, and largely linear. Armenia produces few primary plastics and relies on imported polymers and finished plastic products. Domestic manufacturing has expanded, especially in plastic packaging, but most products are designed for short use and quickly become waste. At the end of the chain, landfilling remains the dominant outcome, while recycling plays only a small and fragmented role.

Stakeholder meetings confirmed that the main problem is not lack of production technology. Leading companies already recycle their own production waste and have reduced plastic use through lightweighting. The biggest weakness lies in the collection stage. Household plastic waste is mixed with other waste, becomes contaminated, and loses its recycling value. There is no nationwide source separation system, and collector networks are weak. As a result, a large amount of recyclable plastic is lost before it can reach recyclers.

Recycling companies operate at small scale and depend heavily on clean industrial scrap or informal collection of PET bottles. There is no food-grade recycling capacity, which limits the possibility of closed-loop recycling for beverage bottles. At the same time, imported virgin plastic often remains cheaper and more stable in quality than recycled material. This weak economic incentive makes recycling difficult to expand under current conditions.

Based on the value chain analysis and stakeholder feedback, Armenia should follow a gradual and realistic approach. Full replication of EU-level circular economy systems is not feasible in the short term due to Armenia's smaller market, limited number of producers, and institutional capacity constraints. Instead, reforms should focus on practical and achievable steps.

Extended Producer Responsibility (EPR) can be part of the long-term solution, but it should be introduced carefully. The current Producer Responsibility Organization provides a starting point, yet its impact remains limited. A large and complex EPR system similar to those in bigger EU countries may create high administrative costs without generating sufficient funds. Therefore, EPR should first focus on a small number of high-volume and standardized packaging types, such as PET beverage bottles. This would allow authorities to test the system, improve reporting, and build capacity before expanding to other plastic streams.

Improving waste collection is the most urgent priority. Without better collection and cleaner plastic waste, recycling cannot grow. Targeted source separation pilots in urban areas, large supermarkets, and institutions could help improve material quality. Strengthening organized collection networks is essential to prevent recyclable plastics from being lost to landfill. Stakeholders from both the public and private sectors emphasized that improving collection is the necessary first step for any meaningful circular progress.

A deposit-return system for beverage containers could also be considered as a focused intervention. Because beverage bottles are standardized and already partially collected informally, such a system may significantly improve capture rates. However, it must be designed according to Armenia's market size and retail structure to avoid excessive costs.

Circular efforts should prioritize plastics that are technically recyclable and already have some market demand. PET and rigid HDPE packaging represent the most realistic starting points. Trying to cover all plastic types at once would dilute limited resources and reduce effectiveness. Prioritization will allow Armenia to achieve visible results and gradually expand its scope.

At the same time, reducing plastic waste at the source is equally important. Industry representatives noted that significant lightweighting has already taken place, reducing the amount of plastic used per bottle. Further improvements may be possible through modernization and investment support. Refill and reuse models, such as those seen internationally, could be tested through small pilots, but stakeholder consultations indicate that consumer behavior and low sorting discipline remain challenges. Therefore, such models should be introduced gradually and in controlled settings.

In addition, policy frameworks could explicitly encourage further packaging optimization and lightweighting. Setting indicative material-efficiency guidelines, supporting investment in modern bottling and molding technologies, or introducing differentiated EPR fees that reward thinner and more recyclable packaging could reinforce existing industry efforts. Promoting the use of thinner, design-optimized packaging represents a practical upstream measure that reduces waste volumes before collection and recycling systems are expanded.

Another important step is strengthening demand for recycled plastics. Recycling can only work if there is a stable market for secondary materials. In the short term, non-food applications such as construction materials, pipes, and non-food packaging offer more realistic opportunities than food-grade closed-loop recycling. Supporting domestic use of recycled plastics would improve economic viability.

Finally, plastics circularity should be presented not only as an environmental goal but also as a waste-management efficiency measure. Landfills require land, maintenance, and future remediation costs. Diverting plastics from landfill can reduce long-term municipal costs and improve system performance. Framing reforms in terms of economic efficiency may increase political and institutional support.

In summary, Armenia's plastics system does not require a complete overhaul but rather a sequenced improvement of key weak points. The priority should be better collection, targeted producer responsibility, focus on high-value plastic streams, gradual integration of informal recovery, and development of markets for recycled materials. Through realistic and phased interventions, Armenia can progressively move from a landfill-centered model toward a more resource-efficient and circular plastics value chain.

3. METALS VALUE CHAIN AND CIRCULAR ECONOMY ANALYSIS – SCRAP, RESIDUES, AND RECYCLING

3.1 Sector Overview and Context

Circularity in Armenia's metals sector is shaped by two structurally distinct but interlinked subsectors, each characterized by very different material flows, waste profiles, and policy challenges. The first subsector relates to **primary metal extraction and processing**, dominated by mining and beneficiation activities that generate large volumes of metal-bearing residues. The second concerns **secondary metals**, namely the collection, trade, and recycling of metal scrap arising from end-of-life products, construction and demolition activities, vehicles, machinery, and industrial off-cuts. Together, these two subsectors define the boundaries of metal-related circularity in the Armenian economy.

From a statistical and analytical perspective, the chapter adopts a two-layer definition of "metals." At the economy-wide level, metals are treated as a broad material category comprising ferrous metals (iron and steel) and non-ferrous base metals (such as aluminium, copper, zinc, lead, and nickel), with limited reference to precious metals where relevant. In parallel, a clearly delineated **scrap metals boundary** is applied, focusing specifically on collected, traded, and consumed metal waste and scrap. In practice, circular flows are not uniform: ferrous scrap collection is weak/chaotic and less incentivized, while non-ferrous scrap is more organized due to higher value, leading to uneven recovery and leakage.[50] This approach allows the chapter to distinguish between largely linear primary material flows and partially circular secondary flows, while maintaining consistency with NACE classifications (mining under NACE B07; metal production and fabrication under NACE C24–C25; scrap recovery under NACE E38.32 and G46.77) and trade statistics based on HS chapters 72–81 and dedicated scrap headings (e.g. HS 7204, 7404, 7602).

The chapter therefore concentrates on two core circularity challenges. First, it examines the structural linearity of mining-related metal flows, where valuable metals remain locked in tailings and waste rock stored in tailings storage facilities, representing both environmental risk and lost secondary resource potential. Second, it assesses the functioning of the scrap metal system, where strong economic incentives drive recovery and recycling, but collection remains fragmented, partly informal, and weakly integrated into municipal waste management systems. Particular attention is paid to how policy instruments—such as export restrictions on scrap metal—have shaped domestic recycling outcomes.

Overall, this chapter does not aim to provide a comprehensive industrial analysis of the metals sector. Instead, it focuses explicitly on material flows, waste points, and circular practices that are most relevant for advancing circular economy objectives in Armenia. By separating primary metal extraction from secondary scrap-based loops, the chapter provides a clear analytical foundation for identifying where circular interventions are technically feasible, economically meaningful, and institutionally realistic within the Armenian context.

[50] In depth interview with Ministry of Economy representative

3.1.1 Global Metals Value Chain Overview

Structure and Material Flows: The global metals value chain is a complex system spanning primary resource extraction, material processing, product manufacturing, consumption, and end-of-life recovery. At the start of the chain, mining companies extract ores (iron, copper, aluminium-bearing bauxite, etc.), which are then processed and refined into metals (e.g. iron to steel, copper concentrate to refined copper). These primary metals enter manufacturing – from steel beams and aluminium parts to copper wires – forming components and final goods across industries (construction, automotive, electronics, etc.). After a period of use (consumption), products reach end-of-life and become sources of secondary raw materials. In a circular model, significant metal content can be recovered as scrap for recycling rather than disposed.

Globally, recycling already supplies a substantial share of metal demand – for example, about one-third of the world's copper supply is met by recycled scrap[51]. Steel, the most used metal, similarly relies on scrap: current projections indicate scrap will rise to 45–50% of total steel production by 2050 to meet climate targets[52] (up from roughly 30% today). However, circularity varies widely by metal. Less than one-third of 60 common metals have end-of-life recycling rates above 50%, and 34 elements have recycling rates below 1% – meaning many critical and specialty metals are hardly recycled at all[53]. This highlights significant untapped potential in closing material loops. Materials value chains currently account for about 20% of global greenhouse-gas emissions, underscoring the importance of recycling and circularity for decarbonization[54].

Key Stakeholders and Dynamics: The global metals value chain involves a broad set of stakeholders whose roles span extraction, processing, manufacturing, consumption, and end-of-life recovery. At the upstream stage, mining and primary processing companies extract metal-bearing ores and transform them into concentrates and refined metals. According to the OECD's Global Material Resources Outlook to 2060, metal extraction and processing account for a disproportionately large share of global material throughput and waste generation, particularly due to the production of waste rock, tailings, and other mining residues generated alongside primary metal output. These upstream actors therefore play a decisive role in shaping material efficiency and environmental pressures across the entire metals value chain.[55]

Midstream stakeholders consist mainly of manufacturers and industrial users who convert primary and secondary metals into semi-finished and finished products for construction, transport,

[51] The Role of Mining in the Circular Economy - https://internationalcopper.org/resource/the-role-of-mining-in-the-circular-economy/

[52] Unlocking potential in the global scrap steel market - https://www.oecd.org/en/publications/unlocking-potential-in-the-global-scrap-steel-market_d7557242-en.html

[53] Soaring Demand for Metals Calls for Rethink of Recycling Practices, Says International Resource Panel - https://www.unep.org/news-and-stories/press-release/soaring-demand-metals-calls-rethink-recycling-practices-says

[54] Looking upstream: A path to unlocking low-carbon, circular materials - https://www.mckinsey.com/industries/metals-and-mining/our-insights/looking-upstream-a-path-to-unlocking-low-carbon-circular-materials

[55] OECD, Global Material Resources Outlook to 2060 (2019) - https://www.oecd.org/content/dam/oecd/en/publications/reports/2019/02/global-material-resources-outlook-to-2060_g1g98d7d/9789264307452-en.pdf

machinery, and consumer goods. Both the OECD and UNEP identify this stage as a critical leverage point for circularity: decisions on material choice, product complexity, durability, and design strongly influence product lifetimes and the technical feasibility of metal recovery at end of life. Inefficient design and short product use cycles are highlighted as major drivers of material losses along metals value chains.[56]

Downstream, distributors and retailers supply metal-intensive products to end users. After use, these products become potential sources of secondary raw materials. At the recovery stage, scrap collectors, dismantlers, and recyclers transform end-of-life products and manufacturing off-cuts into secondary metals. These actors range from informal collectors to highly capital-intensive recycling firms and secondary smelters. The OECD documents that scrap metal has become an increasingly important **internationally traded commodity**, with cross-border flows driven by differences in processing capacity, industrial demand, and energy costs between regions.

From a production-system perspective, the steel sector illustrates the growing importance of secondary materials particularly clearly. Studies on low-carbon industrial pathways show that scrap-based steelmaking—primarily using electric arc furnaces—plays a central role in reducing energy use and emissions relative to ore-based routes. As a result, steel producers, scrap suppliers, and downstream users are becoming increasingly interconnected within global value chains structured around secondary feedstock availability.[57]

Public authorities and regulators influence the metals value chain indirectly by shaping framework conditions such as environmental standards, waste-management rules, and long-term climate and resource-efficiency objectives. The OECD outlook emphasizes that improving recycling rates and increasing the use of secondary metals are among the most effective strategies for decoupling economic growth from material consumption and environmental impact in metals-intensive economies.

Overall, global metals value-chain dynamics are increasingly shaped by stronger interaction between primary producers and secondary-material markets, rising international trade in scrap metals, and structural pressure to improve material efficiency and reduce emissions. These trends are driven by long-term resource constraints and climate objectives identified in both OECD and UNEP global material-flow assessments, rather than by country-specific policy measures.

[56] UNEP International Resource Panel, *Global Resources Outlook 2019*- https://wedocs.unep.org/items/3ec5991f-1ab2-4d54-9000-c9d3cee81d16

[57] Low-Carbon Pathways for the European Steel Industry toward 2050 (industry study) - https://www.wvstahl.de/wp-content/uploads/Schlussbericht-Studie-Low-carbon-Europe-2050_-Mai-20131.pdf

3.1.2 Metals Value Chains in Armenia and Peer Countries

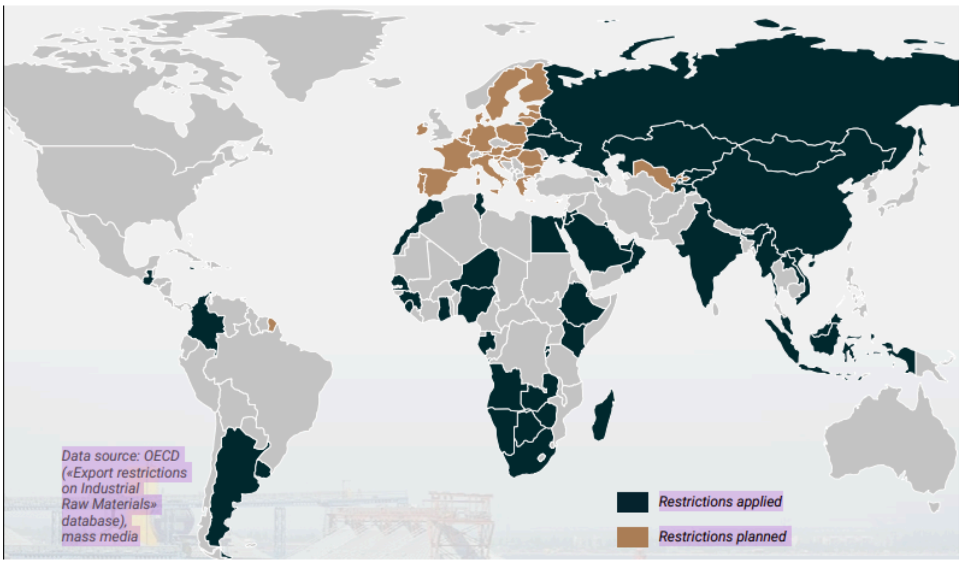
Common Structural Characteristics

Countries with economic structures similar to Armenia – typically small or mid-sized economies with significant mining activity but limited domestic metal processing – show common value chain characteristics. Often, these countries export raw or semi-processed metals and rely on imports for finished metal goods, with relatively nascent recycling systems. For example, many post-Soviet and developing economies historically exported scrap metal and mining outputs due to lack of local refining or steelmaking capacity. Georgia has no large steel mills, so for years most ferrous scrap collected domestically was exported (notably to Turkey, a major scrap importer), while Georgia imported finished steel such as rebar to meet construction needs. Moldova similarly collected ferrous scrap which supplied a single steel plant and export markets, but depended on imports for certain steel products. Mongolia and Kyrgyzstan – both rich in minerals – primarily export mineral concentrates or ores, as local smelting is limited; they generate scrap from obsolete equipment but have minimal metal manufacturing industries, so scrap has often been sold abroad.

A notable trend in such countries is the use of export restrictions on scrap metal to promote domestic value addition. For instance, Kazakhstan (which has some steelmaking capacity but is a major scrap source) has periodically banned or tariffed ferrous scrap exports to channel scrap to local mills. Kyrgyzstan introduced a ban in 2022 on exporting ferrous scrap and waste outside the Eurasian Economic Union and has repeatedly extended it. These policies echo Armenia's own scrap export ban, using trade levers to secure feedstock for domestic recycling.

The GMK Center's "Global Scrap Exports Restrictions 2025" report visualizes this trend with a map of countries restricting scrap exports[58].

Figure 20. Map of scrap exports restrictions (as of March 2025)



Source: The GMK Center's "Global Scrap Exports Restrictions 2025"

[58] Global Scrap Exports Restrictions 2025 - https://gmk.center/wp-content/uploads/2025/04/Scrap-Restrict-2025_eng-2.pdf

The map shows that more than forty countries had imposed some form of scrap export restriction by early 2025, highlighting that such measures are becoming a global norm. The same report includes a graph projecting global scrap demand and supply: it shows that global scrap demand is expected to rise nearly 50 % by 2050, driven by decarbonization policies and the expansion of electric-arc furnace capacity. The graph underscores that scrap availability on the global market will decline, making domestic scrap retention increasingly attractive for countries without iron-ore deposits.

Because many of these economies lack iron-ore resources, domestic steel production relies entirely or largely on scrap. Armenia and Kyrgyzstan, for instance, have no effective iron-ore mining; any steel manufacturing is via melting scrap. Export bans are therefore coupled with investment in electric-arc furnaces and mini-mills to create a local market for scrap. The early results across the region show modest but growing steel production capacity and nascent recycling industries.

Mining Residues and Circular Practices

In addition to scrap policies, peer countries face similar challenges in managing mining residues and implementing circular practices. Large volumes of mine tailings and waste rock are stockpiled with minimal reuse; tailings reuse is rare in Kazakhstan and other mining-driven economies. Regulatory frameworks often lag—for example, research shows that 99.6% of all waste generated in Armenia is mining waste, yet mining companies historically had no responsibility or taxation on it.[59] Comparable situations exist in other post-Soviet states: tailings impoundments and pollution in Georgia's Chiatura manganese mines and Kazakhstan's copper mines persist, with few initiatives to repurpose these wastes.

However, some peer countries are starting to adopt circular economy elements in the metals sector. Across the region, countries comparable to Armenia remain at an early stage of developing metals-circularity systems. Kazakhstan has begun exploring the use of mining and metallurgical waste for value-added production, including technologies that convert waste into functional materials,[60] while national strategies emphasise more resource-efficient and sustainable metallurgical practices.[61] The government has also announced plans to expand domestic fertilizer and chemical production as part of broader industrial upgrading efforts.[62] Uzbekistan has initiated safe battery-collection and disposal projects, and its national e-waste assessment confirms that recycling systems for batteries and electronics remain limited.[63] Georgia, with EU and UNDP support, has introduced Extended Producer Responsibility for Waste Electrical and Electronic Equipment (WEEE), batteries, tyres and

[59] Principal ecological threats of the mining industry in Armenia and its political and legal background -https://www.succowstiftung.de/fileadmin/Ablage/Projekte/ForschungWeiterbildung/AnnaVardanyanpaperMD.pdf
[60] Transformation of mining and metallurgical waste into functional materials: overview of technologies and applications - https://www.researchgate.net/publication/387173851_Transformation_of_mining_and_metallurgical_waste_into_functional_materials_overview_of_technologies_and_applications
[61] White Paper Decarbonization of The Metallurgical Sector of Kazakhstan - https://www.giz.de/en/downloads/giz2024-en-white-paper-on-decarbonization-of-the-metallurgical-sector-of-kazakhstan.pdf
[62] Kazakhstan Eyes Fertilizer Independence with Expanding Chemical Output - https://astanatimes.com/2025/05/kazakhstan-eyes-fertilizer-independence-with-expanding-chemical-output
[63] National Review of The Current Situation on Electronic Waste In The Republic of Uzbekistan https://www.itu.int/en/ITU-D/Environment/Documents/Publications/2022/others/National%20review%20of%20the%20current%20situation%20on%20electronic%20waste%20in%20UZ%5B2%5D.pdf

oils[64] and is expanding circular-economy infrastructure through new EU–UN programmes.[65] Ukraine, prior to 2022, also received EU technical assistance to improve waste and e-waste collection and recycling systems, recognising ongoing losses of valuable metals.[66]

Policy measures like scrap export bans and incentives for local recycling are common first steps to emulate more advanced circular economies. The experience of these peers suggests that Armenia's recent shift (retaining scrap for local use) aligns with a regional movement to capture more value domestically – but also that Armenia, like its peers, has substantial room to improve in areas like mining waste reuse, electronic-waste recycling, and creating markets for secondary metals.

[64] Waste Management: Extended Producer Responsibility (EPR): Business for the Environment - https://eu4georgia.eu/wastemanagement

[65] EU and UN Join Forces to Advance Circular Economy in Georgia - https://www.undp.org/georgia/press-releases/circular-economy

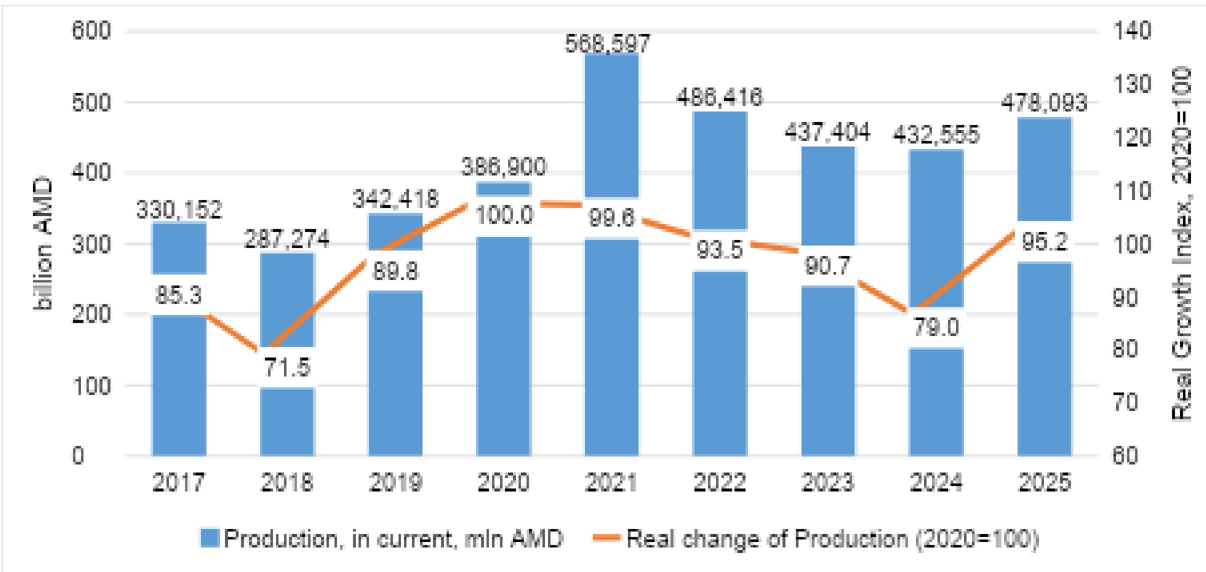
[66] Ukraine works to improve waste management - https://fiiapp.quentalstaging.com/en/noticias/ukraine-works-to-improve-waste-management/

3.2 Mapping Armenia's Metals Value Chain

3.2.1 Raw Material Supply – Mining and Scrap

Armenia has a long mining legacy and remains a significant producer of primary metals, particularly copper concentrate, molybdenum concentrate, and gold, along with smaller quantities of zinc, silver, and other by-products. Mining is one of the country's most strategic and export-oriented industries. Sector indicators in 2022 showed that metal mining accounted for approximately 3.8–4% of GDP, 28% of total exports, and about 6.8% of government revenues[67]. In 2022, the sector employed over 11,000 people and contributes more than $300 million annually to the state budget.[68] Armenia's metal ore mining production value shows growth from 2017 to its peak in 2021. Since then, the sector values in AMD indicated a gradual decline through 2024 with signs of recovery in 2025. While, the USD-denominated nominal values remain relatively stable over the same period (and increased in 2025), values in real term indicate that Subsector of Mining of metal ores in Armenia was at its peak in 2020, then during 2021-2024 registered significant reduction in actual production or sector performance.

Figure 21. Production of metal ore mining (NACE B07) in Armenia (2017-2025)



Source: Ameria calculations, based on Armstat data

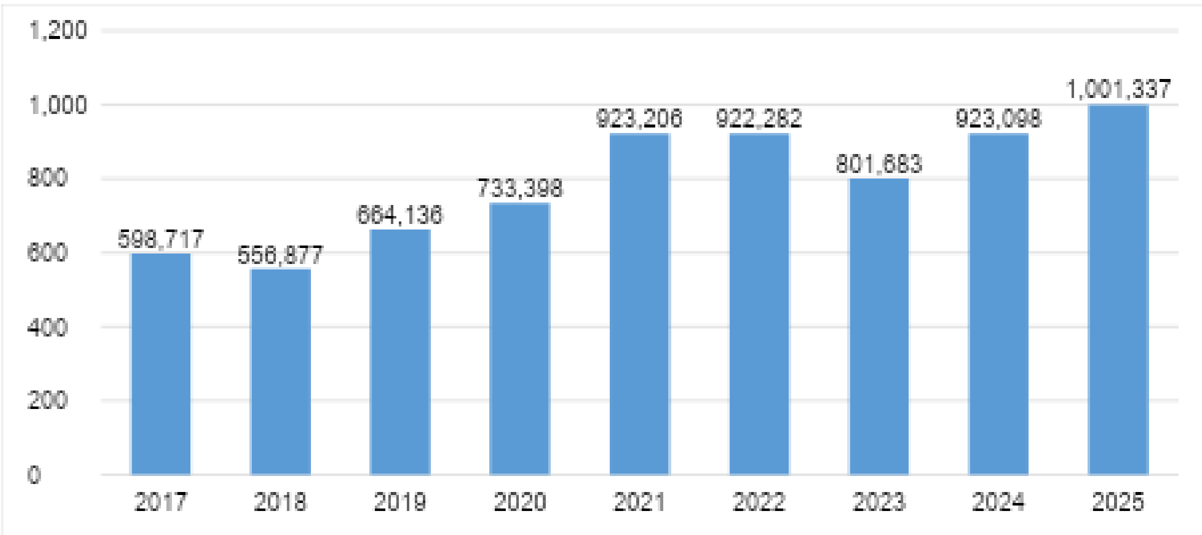
While this reflects a decline in value compared to the 2022 peak, when exports of copper, molybdenum, and gold exceeded USD 1.2 billion, the earlier surge was driven not only by higher global commodity prices and increased output but also significantly by the re-export of Russian-origin gold through Armenia.[69]

[67] Overview and role of the EITI - https://eiti.org/countries/armenia
[68] Armenia's mining sector: state of play and recent developments - https://www.german-economic-team.com/en/newsletter/armenias-mining-sector-state-of-play-and-recent-developments/
[69] Overview of the metals and mining sector in Armenia - https://www.german-economic-team.com/wp-content/uploads/2024/07/GET_ARM_PS_01_2024_EN.pdf

Mining is dominated by several major enterprises. The Zangezur Copper-Molybdenum Combine (ZCMC) is the country's largest mining operator, with the state holding a minority equity stake. The Teghut mine, the second-largest copper producer, has resumed stable operations under new ownership and exports to China, the UK, and the Netherlands. The Amulsar gold project, after years of disputes and stalled activity, became partially state-owned in 2023, though large-scale production has not yet restarted. Other important assets include the Kapan mine, producing copper, zinc, gold, and silver under mixed foreign ownership; the Agarak mine, one of Armenia's oldest, under Armenian–Russian ownership; the Akhtala enrichment plant, a smaller copper producer serving regional markets; and Meghradzor Gold LLC, exporting modest quantities of gold and copper concentrates to Europe.

Armenia primarily exports concentrates, not refined metals, due to limited domestic downstream capacity. The country has lacked industrial-scale smelting since the closure of the historic Alaverdi copper smelter in 2018 because of environmental violations. Consequently, nearly all copper, molybdenum, and gold concentrates are shipped abroad for smelting and refining, mainly to China, European markets, and Asian processing hubs, leaving higher value-added stages outside the Armenian economy.

Figure 22. Armenia's Metal Ores and Concentrates Exports (Copper, Zinc, Molybdenum, Precious Metals)



Source: Armstat (data on HS 2603; 2613; 2616; 2606)

Exports remain highly concentrated. In 2025, Armenia's exports of metal ores and concentrates, namely copper (58%), molybdenum (21%), precious metal-including gold ores (19%), and zinc (2%), amounted to 365,396 tons, with a total export value of approximately USD 1.0 billion.[70]

[70] Estimations based on Armstat data for Exports of HS 2603; 2613; 2616; 2606.

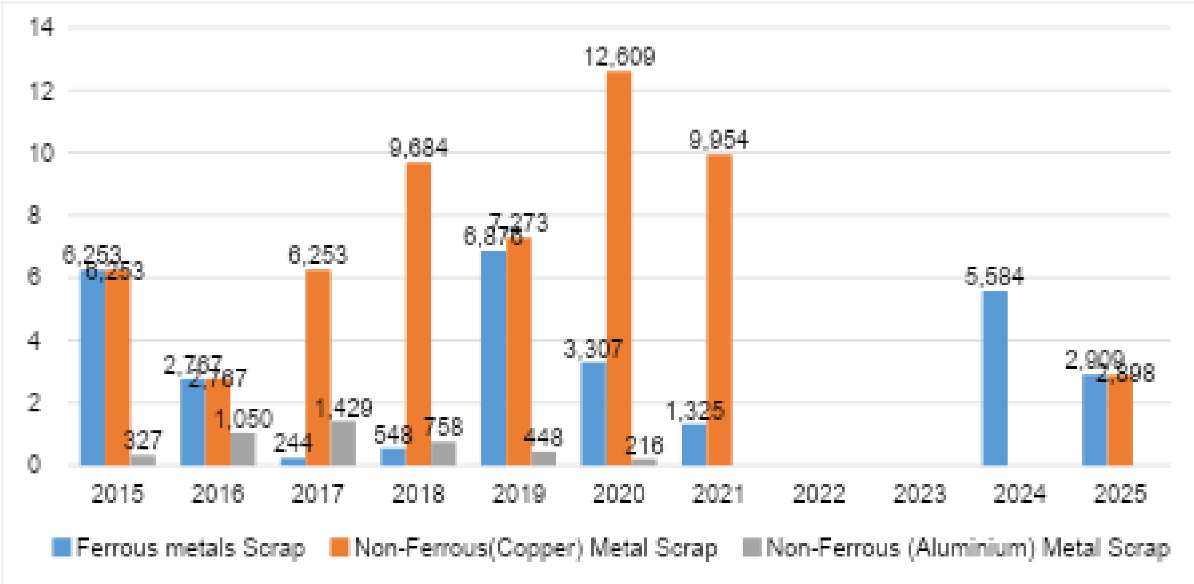
Alongside primary mining, secondary raw materials (scrap) form the other major supply pillar of Armenia's metals value chain (as imports level is negligible). Armenia's metallurgy is structurally dependent on locally collected scrap, but competition for available volumes is intensifying and the limits of domestic scrap supply are increasingly visible. ASCE operates a nationwide network of collection centers and purchases scrap both directly and through smaller independent collectors that aggregate and resell material. The domestic scrap market is segmented: ASCE primarily focuses on ferrous scrap, while companies such as Metexim are more active in non-ferrous scrap. A key concern is medium- to long-term scrap scarcity, as certain legacy streams are being depleted (for instance, cast iron scrap reserves are reportedly close to exhaustion), implying that domestic recycling growth may become constrained unless collection systems improve or alternative feedstock options are developed.[71]

Raw Material Market and Policy Context (Scrap): Prior to 2021, Armenia largely exported its metal scrap – ferrous and non-ferrous scrap was collected by traders and shipped to foreign markets (often to Turkey, Iran or within the Eurasian Economic Union) for processing. For example, it was noted that *"factory equipment, entire production lines, [and] skeletons of cars were exported from Armenia under the guise of scrap metal"* in the past.[72] This situation began to change in 2021, when the government introduced a ban on the export of ferrous and non-ferrous metal scrap in order to support domestic processing and strengthen local industry. Nevertheless, exports continued to be recorded, reaching approximately $5.5 million of ferrous scrap in 2024, and about $2.9 million each of ferrous and copper scrap in 2025, while imports of these products for last decade have remained negligible.

Figure 23. Armenia's Ferrous and Non-Ferrous (Copper, Aluminium) Metal Waste and Scrap Exports (Million USD)

[71] In depth interview with ASCE representative

[72] Armenian government establishes procedure for licensing import of finished metal products to protect local production - https://arka.am/en/news/economy/armenian-government-establishes-procedure-for-licensing-import-of-finished-metal-products-to-protect/



Source: Armstat (data on HS 7204; 7404; 7602)

As a result, scrap is now retained domestically as a raw material for Armenian metallurgy. According to government forecasts, following the introduction of the export ban, domestic utilization of scrap increased by approximately 65–70%, with authorities indicating a target level of up to 250,000 tonnes of scrap processed annually within Armenia. [73]The reorientation of scrap flows altered the functioning of Armenia's raw material markets. Scrap transitioned from being primarily an export commodity to a strategic input for domestic metallurgy, particularly for scrap-based steelmaking. This shift reduced the availability of ferrous scrap for export while increasing its role as an internal industrial feedstock.

End-of-Life Vehicles and Metal Losses: Armenia functions largely as a terminal destination for imported vehicles, many of which ultimately remain in private yards or informal "car cemeteries," leaving recoverable metals underutilized. ASCE management noted that vehicle scrap is technically challenging due to mixed material composition and the need for separation; however, ASCE is capable of processing virtually all ferrous scrap types, including car skeletons, provided vehicles arrive already dismantled. The company does not engage in dismantling operations and emphasized the need for regulation that obliges owners to surrender end-of-life vehicles to licensed collectors at the moment of deregistration, instead of retaining them on private property. As an indicative estimate, an average passenger car contains around **500 kg** of scrap metal, and Armenia may have approximately **10,000** potentially scrapable vehicles; even if fully mobilized, this stream would remain modest compared to total ferrous scrap throughput but would improve recovery discipline and environmental outcomes.[74]

3.2.2 Production – Metal Processing and Manufacturing

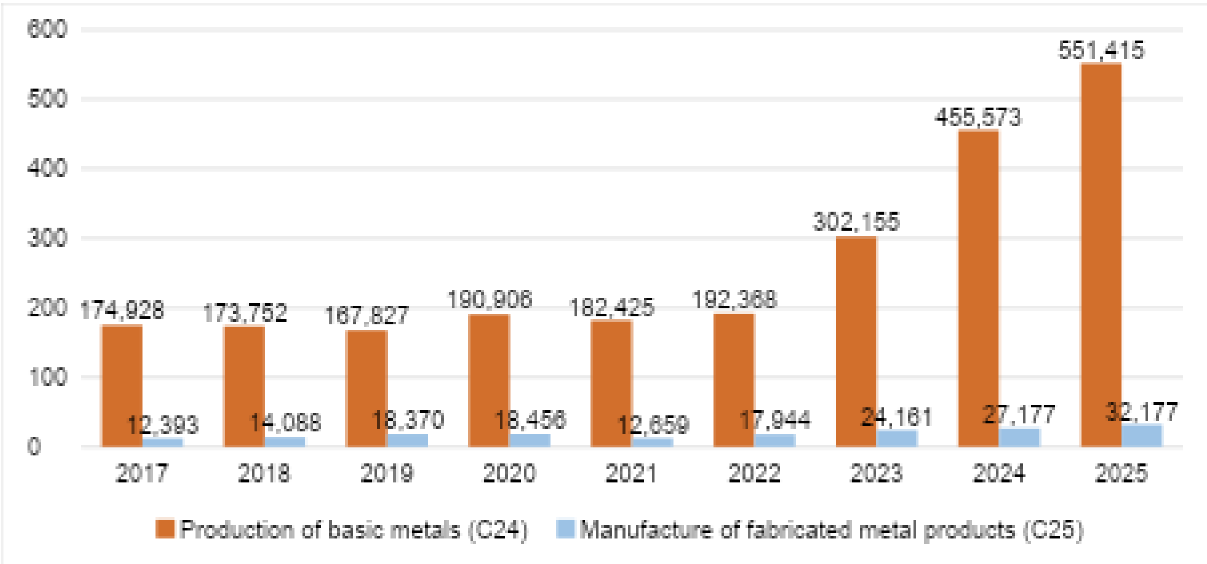
[73] Armenia extending ban on export of ferrous and non-ferrous metal scrap and waste until August 2, 2026 - https://finport.am/full_news.php?id=54534&lang=3

[74] In depth interview with ASCE representative

This stage encompasses the transformation of raw inputs into usable metal products. In Armenia, primary metal production remains limited. There is no crude steel production from iron ore, as the country has no blast furnaces or integrated ironmaking facilities, and primary copper smelting is absent.

In 2025, the production of basic metals in Armenia amounted to AMD 551 billion, significantly exceeding the level recorded in 2022 (AMD 192 billion), while the manufacture of fabricated metal products from AMD 14.9 billion (2022) to AMD 32.2 billion (2025).

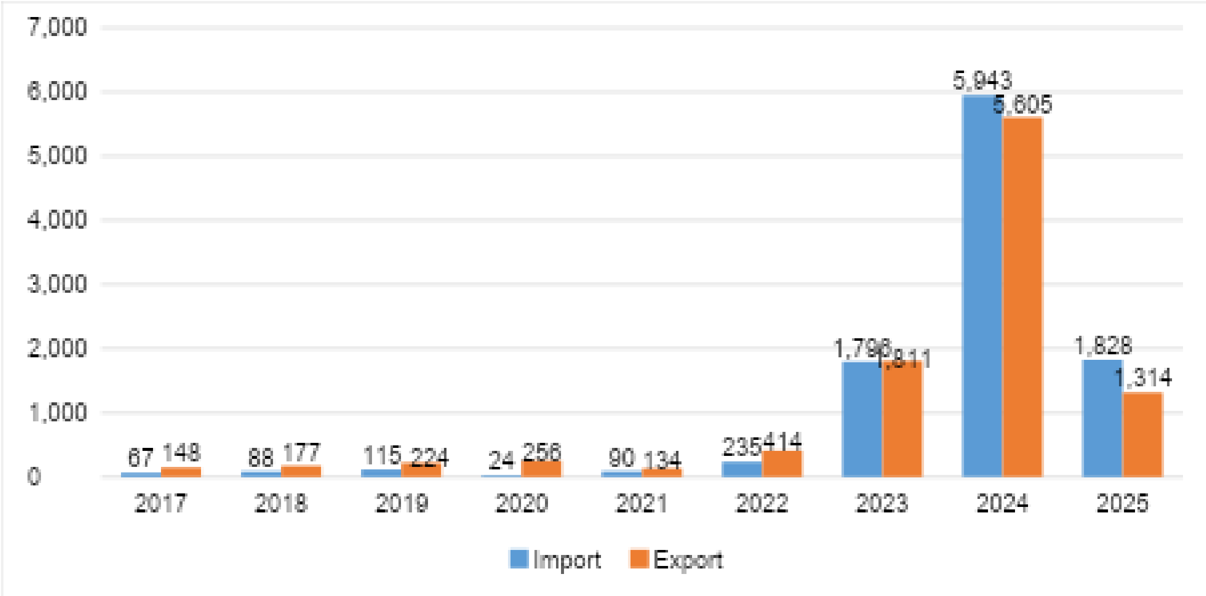
Figure 24. Manufacture of basic metals (NACE C 24) and Fabricated metal products, except machinery and equipment (NACE C 25) in Armenia, 2017-2025 (billion AMD)



Source: Armstat

The increase appears to be partly associated with higher volumes of imported gold, primarily of Russian origin, which officially undergoes remanufacturing in Armenia prior to re-export. Consequently, the rise in recorded output under basic metals production may reflect, to a notable extent, processing and re-export activities, rather than an expansion in domestic extraction of metal ores.

Figure 25. Import and Export of Gold (HS 7108) in Armenia, Million USD.



Source: Armstat

The sharp rise in imports and exports of unwrought and semi-manufactured gold since 2023, with a peak in 2024, strongly suggests that Russian-origin gold re-exports have become a major driver of Armenia's trade flows.

In recent years, secondary metal production has emerged strongly, centered on scrap-based steelmaking using electric arc furnace (EAF) technology. Armenia now has a small but growing steel industry focused on melting ferrous scrap to produce construction materials, including reinforcing bars (rebar), steel wire, pipes, and profiles. The expansion of scrap-based steelmaking has been driven by improved availability of domestic scrap feedstock and investment in new production facilities. Since the initial ban in 2020, steel production has increased significantly, with rolled steel reaching about 120,000 tons in 2022.[75] Armenian Steel Casting Enterprise (ASCE) operates an electric furnace system and downstream processing line that management characterizes as technologically advanced by regional standards, allowing flexible control of chemical composition and production of multiple steel grades. The company produces four types of steel products (including rebar variants and grinding balls) and is preparing to launch **wire rod** production, which has not previously been produced domestically.[76] While ASCE's maximum processing capacity is estimated at approximately **150,000 tons per year**, management emphasized that stable feedstock supply and market competitiveness remain the primary constraints rather than immediate technology gaps.[77]

One of the key recent investments in this segment is Product diversification can strengthen resilience, yet competitiveness is highly sensitive to Armenia's small market scale. For example, ASCE noted that future domestic wire rod production may face price pressure from lower-cost imports (including from Iran), while aluminium radiator production in Armenia struggles to compete with

[75] Armenia extends scrap export ban to boost local steel industry - https://www.yieh.com/en/News/armenia-extends-scrap-export-ban-to-boost-local-steel-industry//148288
[76] In depth interview with ASCE representative
[77] In depth interview with Ministry of Economy representative

Chinese imports due to economies of scale. These examples illustrate that moving into new metal product lines requires careful selection of segments where transport costs, quality differentiation, and policy conditions can offset scale disadvantages. LLC, established in 2022 with diaspora and international backing. The company developed a greenfield scrap-fed steel mill initially planned for Yeraskh but later relocated to Ararat village in the Ararat region. The plant was officially opened in early 2025 and is designed to operate induction furnaces and rolling lines with an annual production capacity of approximately 112,800 tonnes of rebar.[78] According to information released by the Ministry of Economy, the expansion of scrap-based steel production during 2022–2023 resulted in the creation of an estimated 550–750 new jobs and attracted around USD 100 million in investments. By mid-2023, production growth continued, with output of steel pipes and hollow sections increasing by approximately 56% year-on-year to 52,200 tonnes in the first half of 2023.[79] As a result of this expansion, domestic steel producers are now able to fully supply Armenia's demand for basic construction steel products, particularly rebar, and have begun exporting limited volumes of finished steel products to neighbouring markets.

Over the medium to long term, industry representatives anticipate that scrap shortages may require increasing reliance on alternative feedstock—such as imported steel ingots or direct reduced iron (DRI)—to stabilize production volumes.[80]

In **Armenia's non-ferrous metallurgy**, production capacity remains limited but includes several technically advanced downstream facilities. The Rusal-owned Armenal plant in Yerevan operates as an aluminium foil rolling mill, using imported primary aluminium to produce industrial and packaging foil for export—an advanced processing activity rather than a circular aluminium loop.[81] In the copper and molybdenum value chain, Armenia's mines predominantly export concentrates. It is widely referenced in sector discussions that some portion of molybdenum concentrate undergoes further transformation inside the country, including conversion into molybdenum oxide or ferro-molybdenum. The company Metexim operates facilities that produce secondary aluminium ingots and secondary lead ingots from recycled scrap, including aluminium waste and used lead-acid batteries. [82] The company used to collect scrap part of which would later be tranfered to ASCE, but now ASCE collects scrap it needs by itself, part of which he occasionally buys from Metexim.[83]

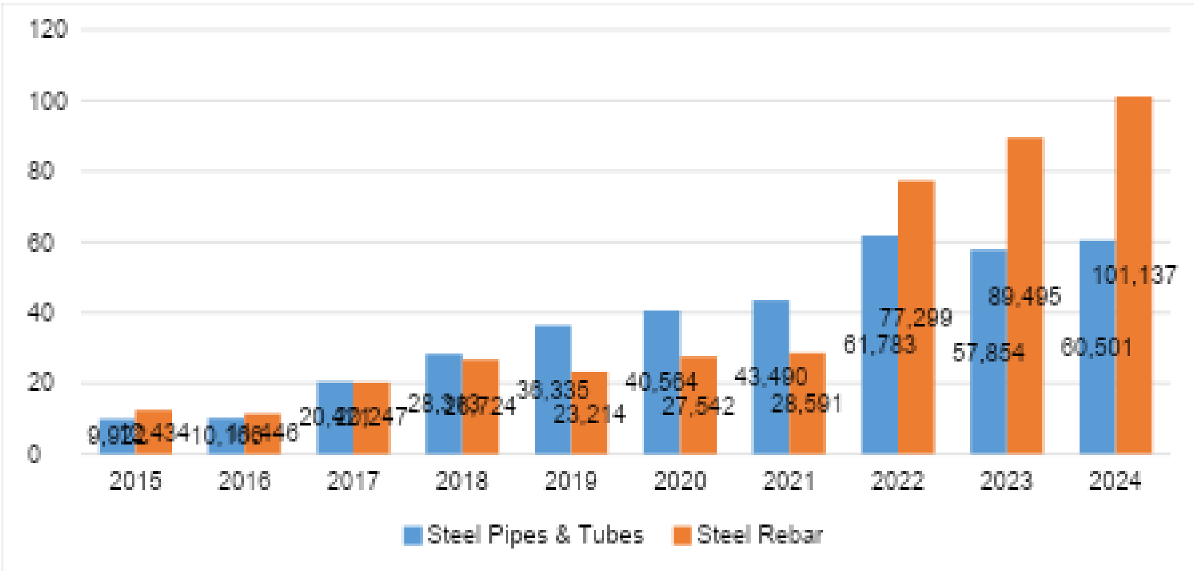
3.2.3 Distribution, Trade and Logistics

The distribution stage of Armenia's metals value chain covers the movement of metal products and raw materials from producers to end users, both domestically and internationally. It includes domestic circulation of metal products, export of mining outputs and manufactured metals, and the logistics systems that connect Armenia's landlocked economy to external markets.

[78] GTB Steel rebar plant opens in Ararat community of Armenia, $31 million invested - https://arka.am/en/news/business/gtb-steel-rebar-plant-opens-in-ararat-community-of-armenia-31-million-invested/
[79] Armenia extends ban on scrap exports for another 6 months - https://gmk.center/en/news/armenia-extends-ban-on-scrap-exports-for-another-6-months/
[80] In depth interview with ASCE representative
[81] Armenal - https://rusal.ru/en/about/geography/armenal/
[82] Metexim - https://metexim.am
[83] In depth interview with ASCE representative

Distribution – Trade and Logistics: On the domestic side, locally made metal products (rebars, pipes, wires) are sold to construction firms, hardware suppliers, and manufacturers. With Armenia achieving self-sufficiency in basic steel products by 2023, imports of those products have reduced (In August 2025, the government imposed a licensing procedure and a hefty duty of 29,000 AMD/ton on imported steel rebar from "third countries" to protect local production.[84]). Despite the introduction of protective measures and the expansion of domestic steelmaking capacity, imports of finished steel products have continued to rise. Data show that purchases of steel rebar and pipes have increased in recent years, indicating that growing domestic demand (due to construction growth) has outpaced local production and necessitated additional imports to fill the supply gap.

Figure 26. Imports of Steel Rebar (HS 7214) and Steel Pipes (HS 7306) to Armenia, million USD



Source: UN Comtrade, Armstat

Export of manufactured metal products: With domestic demand increasingly met by local producers, Armenian steelmakers have begun exporting limited volumes of finished steel products. Armenian-produced rebar and steel products have started entering neighbouring regional markets, including Georgia and other nearby countries, marking a shift from Armenia's historical role as an exporter of raw metal inputs only. Armenia's gold exports consist predominantly of semi-processed gold doré bars that are traded internationally for final refining. Historically, Switzerland served as the principal destination for these exports, reflecting its role as a leading global refining hub. Trade statistics show that Swiss refiners absorbed almost the entirety of Armenia's gold shipments in earlier years, accounting for approximately 99.7% in 2017, 95.8% in 2018, and 96.0% in 2019,

[84] Armenian government establishes procedure for licensing import of finished metal products to protect local production - https://arka.am/en/news/economy/armenian-government-establishes-procedure-for-licensing-import-of-finished-metal-products-to-protect/

underscoring Armenia's near-exclusive dependence on Swiss refining capacity during that period. Since 2021, however, gold exports to Switzerland have effectively ceased[85] [86].

Scrap and secondary material logistics: Due to the export ban, ferrous scrap trade has become largely internalized. Scrap metal is collected domestically and transported by road to steel plants, which are generally located near major transport corridors or borders to facilitate both scrap inflow and product distribution.

Non-ferrous scrap, such as copper and brass, that is not consumed by domestic industry may still be exported legally in limited quantities. Trade records also show small volumes of precious-metal scrap exports.

Logistics constraints and enabling factors: Armenia's landlocked geography shapes the logistics of its metals value chain. Export routes depend heavily on neighbouring countries' infrastructure, particularly Georgia for access to seaports and, to a lesser extent, Iran for overland routes. This reliance increases transport costs for mining exports and reduces competitiveness relative to coastal producers.
At the same time, Armenia's compact territory results in relatively short internal transport distances for scrap collection and domestic distribution of metal products. The location of new metal-processing facilities near border or major transport nodes (GTB Steel) reflects attempts to optimize logistics for both inputs and outputs.

3.2.4 Consumption – Domestic End Use

The main domestic consumers of metal products in Armenia are the construction sector, manufacturing enterprises, and households, primarily through the use of durable goods. Domestic end use represents the final demand stage of the metals value chain and determines the scale and composition of demand for steel and non-ferrous metal products.

Construction sector: Construction is the largest consumer of steel products in Armenia. Ongoing urban development, residential construction, and infrastructure projects generate sustained demand for reinforcing bars, beams, sheet metal, pipes, and other basic steel products.

Following the expansion of scrap-based steelmaking, construction companies increasingly source rebar and other basic steel products from domestic producers rather than imports.

Manufacturing and industrial use: Beyond construction, a number of manufacturing and metalworking enterprises consume steel and non-ferrous metals as intermediate inputs. These include producers of machinery components, electrical wires and cables, pipe fittings, and small industrial parts.

[85] Gold export - https://brokers.am/en/blog/gold-export
[86] UNComtrade - https://comtradeplus.un.org/TradeFlow?Frequency=A&Flows=X&CommodityCodes=TOTAL&Partners=0&Reporters=all&period=2024&AggregateBy=none&BreakdownMode=plus

Most of these enterprises continue to rely on imported inputs such as copper wire rod, aluminium semi-finished products, or specialized steel grades that are not produced domestically. However, part of the basic steel input used by domestic manufacturers—particularly standard billets and rebar—is now supplied by Armenia’s scrap-based steel mills.

Household and commercial consumption: Households and commercial users consume metals indirectly through finished goods such as vehicles, appliances, electronics, and building materials. While most of these products are imported, their use contributes to the accumulation of metal stock within the Armenian economy.

Over time, this in-use stock of metals becomes a potential source of secondary raw materials when products reach end of life.

Consumption trends and material stock: Metal consumption in Armenia increased during 2022–2024 in line with economic growth, higher construction activity, and increased ownership of vehicles and electronic equipment. This trend implies a growing accumulation of metals in buildings, infrastructure, and consumer goods, which will shape future scrap availability.

3.3 Circular Economy Stakeholders in Armenia's Metals Sector

Effective analysis of the value chain must map out the key stakeholders involved in or affected by circular economy (CE) practices, and their relative power and interest. In Armenia's metals sector, stakeholders range from government ministries to individual scrap collectors. Below is an overview of the main groups, along with an indication of their power (influence over the value chain and policy) and interest in circular economy (motivation to promote or engage in circular practices). This can be visualized in a Power–Interest grid categorizing stakeholders into those with high/low influence vs. high/low interest:

3.3.1 Government and Policy Makers

This includes the Ministry of Economy, Ministry of Territorial Administration and Infrastructure (which oversees mining), and the Ministry of Environment. The Government of Armenia has become a pivotal player by setting policies like the scrap export ban and import-substitution measures.

Power: High – it can enact laws/regulations that reshape the chain (as seen with the scrap ban).

Interest in CE: Medium-High – the economic ministries are interested in industrial development and resource efficiency (e.g. the Economy Minister explicitly championed using scrap internally to create jobs and value),[87] while the Environment Ministry is interested in waste reduction and pollution (aligning with CE goals). Overall, the government's interest is growing, seen in its adoption of strategies to align with international best practices in sustainable mining and waste management (e.g. Armenia's involvement in the Extractive Industries Transparency Initiative and discussions of circular economy in national programs).[88] Political will is strong in areas that clearly benefit the economy (like scrap recycling), but perhaps lower regarding enforcing environmental circularity (like mining waste reuse) – suggesting some variability within government stakeholders.

3.3.2 Mining Companies

The large mining firms (e.g. **Zangezur CMC**, **Teghut CJSC**, **Lydian/Amulsar** project, **GeoProMining**) are key upstream stakeholders.

Power: High – they are major employers and contributors to GDP, with significant influence on local economies and some political leverage.

Interest in CE: Low to Medium – traditionally, mining companies have focused on extraction and export, with less incentive to pursue circular practices beyond compliance. Their primary interest is profit from ore; practices like waste reuse or community recycling initiatives have been minimal,

[87] Armenian government establishes procedure for licensing import of finished metal products to protect local production - https://arka.am/en/news/economy/armenian-government-establishes-procedure-for-licensing-import-of-finished-metal-products-to-protect/

[88] Armenia at the Crossroads: Strategic Resources and Sustainable Development - https://www.netzerocircle.org/articles/armenia-at-the-crossroads-strategic-resources-and-sustainable-development

partly due to lack of regulatory pressure. However, some are beginning to explore circular initiatives under global pressure (for instance, reprocessing old tailings if it becomes viable, or improving water recycling on-site).[89] Still, compared to other stakeholders, mining firms in Armenia have not been frontrunners in circular economy – their interest lies more in maintaining operations and less in pioneering recycling (unless it aligns with their business, such as possibly recovering additional metals from waste if profitable). They often perceive strict circular measures (like mandatory tailings reuse or take-back obligations) as a cost, not a benefit, unless guided by policy or market incentives.

3.3.3 Metal Producers (Steel and Non-ferrous Plants)

Armenia does not possess large reserves of non-ferrous metals, which makes recycling and secondary raw materials a strategic necessity rather than an environmental preference. Available copper volumes, for example, are estimated at only around 2,500 tons. Consequently, the long-term viability of the metals sector depends primarily on scrap recovery, reuse, and domestic processing rather than on primary extraction. The backbone of this circular ecosystem is formed by a small but growing group of scrap-based producers and recyclers, including **ASCE Group, GTB Steel LLC**, and recycling companies such as **Metexim**, alongside facilities such as **Qarakert, Dzulakentron, T-Metal**, and **Ed-Met**.[90] Additional specialized operations process used car batteries in Artashat and manufacture aluminum sheets for solar panels. Importantly, Armenia already produces rebar entirely from scrap inputs, demonstrating that a closed-loop steel value chain is technically feasible and commercially viable.

Power: These firms hold moderate and gradually increasing influence. While smaller and newer than large mining companies, they possess technical know-how, established processing capacity, and an organized industry presence. Their dialogue with government has already shaped policy outcomes, such as measures to retain scrap domestically, indicating a growing role in sectoral decision-making.

Interest in Circular Economy: Their interest is high. Their business models are inherently circular, relying on continuous scrap supply, efficient recycling streams, and stable regulation. They actively support improvements in collection systems, incentives for households and firms to return scrap, and policies that prevent raw material leakage through exports. Broader circular measures, such as end-of-life vehicle or e-waste collection programs, would directly expand their feedstock and strengthen their operations.

3.3.4 Industrial Consumers and Manufacturing SMEs

These are companies that use metal inputs – construction firms, equipment manufacturers, automotive repair businesses, etc.

[89] Same.

[90] In depth interview with Ministry of Economy representative

Power: Medium – the construction industry, for instance, has significant economic weight and can lobby for stable supply and prices. Manufacturing SMEs are smaller and individually low-power, but collectively they represent demand for metal.

Interest in CE: Medium – their primary interest is reliable and affordable materials. To the extent that circular practices (like using recycled rebar or locally remanufactured parts) reduce costs or improve supply security, they are interested. Indeed, Armenian construction firms benefited from domestic steel production because it reduced reliance on volatile imports. However, these consumers are generally pragmatic: they will use recycled materials if quality and price are comparable, rather than out of environmental concern. Some manufacturing SMEs (e.g. those engaged in repairs or refurbishing) inherently practice circularity – for example, auto repair shops extend vehicle life by rebuilding parts, and some small businesses refurbish used electronics for resale.[91] Their interest in formal circular economy initiatives (like certification or investing in cleaner production) is growing slowly, often encouraged by donor programs (RECP – Resource Efficient and Cleaner Production – pilots have included some Armenian SMEs).

3.3.5 Waste Management and Scrap Collectors

This includes both formal waste management entities (mostly municipal for general waste) and the network of informal collectors who pick up scrap metal, as well as smaller scrapyards.

Power: Low – individual scrap collectors or small junkyards do not have decision-making power and often operate at the mercy of market prices and regulations set by others.

Interest in CE: High – scrap collection is their livelihood, so they favour any initiative that encourages recycling (deposit systems, buy-back programs, etc.). When the scrap export ban was imposed, some scrap traders initially opposed it (as it disrupted their existing export channels), but many adjusted to selling to local mills. Now, with local demand, their interest aligns with more recycling (since it means more business). This stakeholder group would support, for instance, community metal collection drives or better recycling infrastructure, though they lack influence to implement such programs on their own.

3.3.6 Civil Society, Environmental NGOs, and International Development Partners

Civil society organizations, environmental NGOs, and international development partners represent an important group of external stakeholders shaping the broader governance and policy environment of Armenia's metals value chain. [92] This group includes local advocacy organizations such as **EcoLur**, the **Armenian Environmental Front**, and community initiatives in mining-affected regions, alongside international institutions such as **United Nations Industrial Development Organization (UNIDO)**, **United Nations Development Programme (UNDP)**, the **European Union**

[91] A Report on Waste Governance In Armenia - https://ace.aua.am/wp-content/uploads/2020/08/WGA-Report-Eng.pdf
[92] Principal ecological threats of the mining industry in Armenia and its political and legal background -https://www.succowstiftung.de/fileadmin/Ablage/Projekte/ForschungWeiterbildung/AnnaVardanyanpaperMD.pdf

through the EU4Environment programme, and the **European Bank for Reconstruction and Development (EBRD)**.

Local NGOs primarily focus on the environmental and social impacts of mining and metals production. They have historically highlighted issues such as tailings risks, land degradation, and community health impacts, and have advocated for stronger environmental accountability and stricter regulatory oversight. While their influence on day-to-day industrial practices remains limited, public campaigns and legal advocacy have at times shaped national debates and delayed or modified major projects. At the same time, these groups actively promote circular economy principles, supporting waste reduction, site rehabilitation, recycling culture, and alignment with European environmental standards.

International organizations and donors play a complementary but more institutional role. Rather than direct advocacy, they influence the sector through funding, technical assistance, pilot projects, and policy advice. Through programmes on resource efficiency, cleaner production, and circular economy transition, they provide expertise, introduce international best practices, and frequently convene government, industry, and civil society in joint initiatives. Their engagement has helped mainstream circular economy concepts within national strategies and supported practical measures such as recycling pilots, industrial assessments, and capacity building.

Power: Taken together, this stakeholder group holds low-to-medium direct power. Civil society organizations generally rely on advocacy and public pressure, while international partners exert influence indirectly through financing, technical support, and policy guidance rather than regulation. However, donor-backed programmes and government cooperation give international actors a moderate level of systemic influence over reform directions.

Interest in Circular Economy: Interest is consistently high to very high. Both NGOs and development partners view circular economy measures as essential for reducing pollution, improving resource efficiency, and aligning Armenia with international sustainability standards. They are therefore strong proponents of recycling expansion, improved waste management, and adoption of global best practices.

In summary, stakeholder dynamics in Armenia's metals circular economy feature a government–industry partnership (moderately high power) that is now oriented toward recycling, a set of economic actors (steelmakers, recyclers) who are champions of circularity with growing clout, and a collection of supporting or affected groups (NGOs, collectors, international donors) that have high interest and can influence the narrative or specific projects. A simplified Power–Interest mapping would place Government and large Mining companies in high-power (with government also fairly high-interest recently, mining low-interest), Recycling/Steel companies in mid-power high-interest, NGOs in low-power high-interest, and perhaps disengaged actors (if any) in low-low (though nearly all stakeholders have some interest given the economic importance of metals). An effective circular economy strategy will need to leverage the high-interest groups as change agents, secure buy-in from high-power groups (government, mining), and give voice to those who have interest but low power (NGOs, local communities, informal sector). One tool used in stakeholder mapping is the power–interest grid diagram, which visually plots stakeholders – such a grid for Armenia would show, for example, the Ministry of Economy and steel companies in the “Key Players” quadrant (high power, high interest), mining firms in “Manage Closely” (high power, lower interest), NGOs in “Keep Informed” (low power, high interest), etc., guiding how to engage each in advancing circularity.

3.4 Circular Economy Practices in Armenia's Metals Value Chain

Armenia is in the early phases of integrating circular economy (CE) practices into its metals value chain. There are a few notable existing practices and initiatives that advance circularity (i.e. keeping materials in use longer, reducing waste, and recovering value), alongside many linear practices that persist. This section describes current circular economy practices within the Armenian metals chain.

3.4.1 Scrap Metal Recycling and Local Steel Production

The most significant CE practice is the one discussed earlier – domestic recycling of ferrous scrap into new steel products. Instead of scrap iron/steel being treated as waste or exported cheaply, it is now collected nationwide and melted in Armenian steel mills, effectively closing the loop for steel within the country. This practice has multiple circular benefits: it diverts metal from landfill/export, reduces the need for importing new steel (saving resources and energy), and cuts environmental impact. Recycling steel scrap consumes far less energy and raw materials than producing steel from iron ore – for perspective, *recycling 1 ton of steel saves about 1.1 tons of iron ore, 0.6 tons of coking coal, and 0.05 tons of limestone*,[93] and avoids around 1.5 tons of CO_2 emissions that would be produced in primary steelmaking.[94] Armenia's pivot to scrap recycling thus not only yields economic gains but also environmental benefits. In practice, this involves an ecosystem of scrap yards (like Metexim's collection sites in Yerevan, Vanadzor, Gyumri, etc.), feeder transport, and electric arc or induction furnaces that turn out steel products with limited material losses. In essence, the metals sector has created an internal circular loop for steel, which did not exist a few years ago.

3.4.2 Non-Ferrous Metal Recycling

There are emerging circular activities in non-ferrous metals as well. Lead-acid battery recycling is one example: used car batteries, which contain lead and acid, are collected by scrap companies. The lead can be smelted into lead ingots, which are either reused in-country or exported as secondary raw material. Metexim's operations include processing "used lead batteries" and producing lead ingots. This prevents hazardous lead from entering the environment and provides a local source of lead for industries (or for export revenue). Similarly, aluminium scrap (such as old aluminium window frames, machine parts, or packaging) is collected and remelted. Armenia's recyclers produce secondary aluminium alloy ingots that can be sold to make new aluminium products. While the scale is not very large, it is a concrete CE practice – aluminium recycling saves 95% of the energy compared to primary aluminium production. We also see copper scrap being recycled to a degree: for instance, copper wires and pipes from demolition are stripped and sold; local scrap processors grade and bundle copper scrap (types like Birch/Cliff, Milberry, etc. as listed by scrap dealers) which can either be exported or potentially fed into small foundries to cast bronze/brass parts. Brass scrap and stainless steel scrap are also collected, suggesting that Armenia's metal recyclers deal with a broad range of materials, not just iron. These practices, though primarily driven by profit from valuable scrap, align

[93] Iron And Steel Scrap - https://pubs.usgs.gov/periodicals/mcs2022/mcs2022-iron-steel-scrap.pdf
[94] Understanding Recycled Steel Prices: A Comprehensive Guide - https://www.okonrecycling.com/industrial-scrap-metal-recycling/steel-and-aluminum/recycled-steel-price/

perfectly with circular economy principles – they extend the life of metals indefinitely through repeated recycling.

3.4.3 Repair, Reuse, and Refurbishment Culture

Another aspect of circular economy is keeping products and materials in use for longer. In Armenia, there is a strong culture of repair and maintenance which, while born out of economic necessity, contributes to circularity. For example, in the automotive sector, it is *"very common to repair parts subject to replacement"*, such as brake discs, shock absorbers and other components, rather than discarding them. This extends the life of metal parts and reduces scrap generation. Similarly, household appliances and electronics are often repaired by a network of technicians or resold second-hand. The excerpt from a waste governance report notes a "well-developed infrastructure and market for repaired electric equipment" – items like refrigerators, washing machines, and ovens are fixed and sold on online platforms (e.g. a site specializing in refurbished fridges). By repairing and reusing, Armenia reduces the demand for new metal-containing products and delays items from becoming waste.

3.4.4 Resource-Efficient Processes in Mining

Within the mining sector, some practices reflect elements of circular resource use. Water recycling at mine sites is one example: mines such as Zangezur Copper-Molybdenum Combine reuse process water in closed or semi-closed circuits to reduce freshwater intake. This practice is driven by both regulatory requirements and operational efficiency considerations.

Historically, metallurgical operations also included elements of by-product recovery. For example, when operational, the Alaverdi copper smelter captured sulfur dioxide emissions from smelting and converted them into sulfuric acid, effectively transforming an emission into a usable product.

3.4.5 Policy and Pilot Initiatives

On the institutional side, there have been some pilot projects and policies geared towards circularity. For example, UNDP and the EU have supported pilot projects on waste management and circular economy in Armenia. A notable initiative is the EU4Environment program's RECP (Resource Efficient and Cleaner Production) audits for SMEs, which included some companies in light industry and perhaps metalworking – helping them identify ways to reduce waste and reuse materials. Additionally, recently an **"Impact Hub Yerevan – Circul'UP!"** project was launched in 2023 to promote circular startups.[95] While not specific to metals, it indicates growing awareness. The government too references circular economy in strategic documents; the National Comprehensive Green Transition agenda (2025) includes circular economy focus areas (e.g. waste management reforms).[96]

[95] Is Circularity coming to Armenia? - https://regionalpost.org/en/articles/is-circularity-coming-to-armenia.html
[96] Towards a Green Economy with EU4Environment in Armenia - https://www.eu4environment.org/app/uploads/2022/08/Armenia-profile-2022.pdf

3.5 Circularity Gaps and Pain Points in Armenia's Metals Value Chain

Despite the circular economy practices described above, Armenia's current circular activities in the metals sector remain limited in scope and coverage. Circular economy activities are largely concentrated around high-value scrap recycling and informal reuse practices, while more systematic circular systems are largely absent.

Processing Capacity vs. Collection Bottlenecks: A key structural imbalance persists between installed processing capacity and the volume of scrap reliably captured through formal channels. While major operators such as ASCE maintain nationwide collection centers and purchase scrap both directly and via smaller aggregators, the overall system remains fragmented and partly informal, limiting predictability of feedstock supply. Unverified estimates suggest that a large stock of unprocessed metal may exist in dispersed forms, but the central issue is not industrial capability; it is weak collection coverage, inconsistent traceability, and the gradual depletion of legacy scrap streams.[97] As domestic scrap availability tightens, maintaining circular steel production will increasingly depend on improved collection performance and, potentially, planned supplementation through alternative inputs such as imported ingots or DRI.[98]

Trade policy shaping circularity outcomes: Measures such as licensing requirements and duties on imported steel rebar should not be viewed solely as protectionist trade instruments, but as de facto industrial policy tools that influence the viability of domestic scrap-based steelmakers. By limiting low-cost imports, these measures help secure stable demand for locally recycled steel and reinforce the economics of retaining and processing scrap within the country. At the same time, poorly calibrated tariffs risk raising construction costs or creating supply shortages if domestic capacity is insufficient. Trade instruments therefore need to be carefully aligned with circular economy objectives, balancing support for local recycling and value addition with price stability and reliable market supply.[99]

Absence of Formal E-Waste Recycling: Armenia: lacks formal recycling facilities for electronic waste and complex multi-metal products. There are no domestic facilities capable of recovering metals from electronic circuit boards or other complex metal-containing items. As a result, such materials are either exported in small quantities, handled informally, or disposed of, leading to the loss of valuable metals and potential environmental risks.

Lack of Mining Waste and Tailings Reuse: Mining waste reuse represents another major gap. Large volumes of tailings, waste rock, and metallurgical residues are generated annually, yet there are no established practices for repurposing these materials into construction inputs or other secondary uses. While international examples of tailings reuse exist, no comparable applications have been implemented in Armenia to date. Consequently, mining residues remain stored in tailings facilities rather than contributing to circular material flows.

[97] In depth interview with Ministry of Economy representative
[98] In depth interview with ASCE representative
[99] In depth interview with Ministry of Economy representative

Limited Consumer-Level Participation and Source Separation: Consumer participation in circular practices remains low. There is minimal source separation of metal-containing waste at the household level, and formal collection systems for end-of-life metal products are underdeveloped. While informal scavenging captures some high-value scrap, this approach is fragmented and insufficient to support systematic recovery or industrial-scale recycling.

Fragmented and Project-Based Circular Economy Development: Circular economy practices in Armenia's metals sector have largely emerged through market-driven incentives or isolated project-based interventions rather than through a coordinated national framework. Existing practices depend on the economic value of scrap or on individual initiatives, rather than on integrated systems linking production, consumption, and waste management.

While Armenia's experience with scrap-based steel production demonstrates the potential to transform linear flows into circular ones, this success has not yet extended to other segments of the metals value chain. Circular economy practices therefore remain uneven, fragmented, and limited to a narrow set of materials and activities.

3.6 Opportunities for Circular Interventions and International Benchmarks

Despite the gaps identified, there are substantial opportunities and actionable measures that Armenia can pursue to bring its metals value chain closer to international circular economy standards. Many of these measures are informed by effective interventions elsewhere, and they offer not only environmental benefits but also economic gains (jobs, investment) for Armenia. Below, we outline key recommended measures across different pillars, including examples and quantified potential impacts where possible, and provide international benchmarks to illustrate success cases.

3.6.1 Technological and Industrial Measures

Establish an E-waste Collection and Recycling Program: Armenia can develop a nationwide system for collecting electronic waste (discarded phones, computers, appliances) and partner with technology providers to set up an e-waste processing facility.

Benchmark: High-tech smelters in Belgium and Sweden recover precious and base metals from electronic waste at scale, demonstrating the technical feasibility of advanced e-waste recycling.

Impact: If Armenia were to collect even a portion of its annual electronic waste, this could enable recovery of valuable metals such as gold and copper while reducing environmental risks associated with hazardous substances. Proper e-waste management would also substitute some imported raw materials with secondary inputs.

Promote "Urban Mining" of End-of-Life Vehicles (ELVs): Armenia could develop facilities or encourage investment in automotive shredding and metal separation technologies to enable more comprehensive recycling of end-of-life vehicles. At present, ELV processing is largely limited to partial reuse and manual dismantling.
International benchmark: European ELV frameworks achieve recovery rates of around 95%, supported by automated shredders and post-shredder separation technologies in countries such as Germany and Japan.

Potential impact: More complete recycling of end-of-life vehicles would increase recovery of steel, aluminium, and copper, supply secondary materials to domestic industry, and support job creation in dismantling and recycling activities.

Invest in Tailings Reprocessing and Valorization Projects: Pilot projects could be launched to assess the feasibility of converting mining tailings into usable construction materials, such as manufactured sand or aggregates, in collaboration with research institutions and international partners. [100][101]

[100] Sand produced by Vale is a solution to sand sustainability and mine tailings reduction, according to universities - https://saladeimprensa.vale.com/w/sand-produced-by-vale-is-a-solution-to-sand-sustainability-and-mine-tailings-reduction-according-to-universities/-/categories
[101] OreSand: A circular economy solution to reduce mineral wastes and improve global sand sustainability - https://smi.uq.edu.au/gcms/research/ore-sand-circular-economy-solution-reduce-mineral-wastes-and-improve-global-sand-sustainability

International benchmark: Examples include initiatives in Brazil and Australia where iron ore tailings have been processed into construction-grade materials, reducing both waste volumes and demand for natural aggregates.

Potential Impact: Even partial conversion of tailings into construction inputs could reduce environmental risks, lower pressure on natural sand resources, and create new revenue streams for mining companies while reducing long-term waste liabilities.

Adopt Energy-Efficient and Low-Carbon Technologies in Metallurgy: Armenian steelmakers could further improve energy efficiency through upgrades to modern electric arc or induction furnaces and operational measures such as scrap pre-heating.[102]

- **Enable industrial energy storage and "green steel" positioning:** ASCE reports that it operates 15 MW of installed solar capacity, covering approximately 20–25% of its electricity needs, and highlighted the need for industrial-scale battery storage to absorb excess generation and avoid grid overload. Given Armenia's electricity mix—reported by industry as roughly 40% nuclear and 40% gas-based thermal—scrap-based electric furnace production can achieve a comparatively low-carbon profile relative to coal-based blast furnace routes. Supporting storage infrastructure and credible ESG-aligned certification could help position Armenian scrap-based steel within an emerging "green steel" narrative, although volume constraints and consistent quality requirements remain limiting factors.[103]

International Benchmark: Across Europe, steel producers increasingly rely on low-carbon electricity for scrap-based steelmaking and pursue furnace efficiency improvements to reduce emissions.
Potential Impact: Improved energy efficiency would reduce production costs and emissions, strengthening the competitiveness of Armenia's scrap-based steel sector as markets increasingly value low-carbon materials.

3.6.2 Regulatory and Institutional Measures

Implement Extended Producer Responsibility (EPR) Laws: Armenia could introduce EPR requirements for metal-containing products such as batteries, electronics, and vehicles, assigning responsibility for end-of-life management to importers and manufacturers.

International Benchmark: EU EPR systems for electronics, vehicles, and batteries have resulted in high collection and recycling rates, particularly for lead-acid batteries.[104]

[102] The Circularity in Steel Series, Part 3: Benefits of Electric Arc Furnace (EAF) Steelmaking - https://nucor.com/newsroom/the-circularity-in-steel-series-part-3-benefits-of-electric-arc-furnace-eaf
[103] In depth interview with ASCE representative
[104] Understanding Recycled Steel Prices: A Comprehensive Guide - https://www.okonrecycling.com/industrial-scrap-metal-recycling/steel-and-aluminum/recycled-steel-price

Potential Impact: EPR frameworks would improve formal collection of end-of-life products, provide a stable supply of secondary materials, and reduce environmental and public health risks associated with improper disposal.

Strengthen Mining Waste Regulations and Enforcement: Mining legislation could be updated to require waste management and closure plans that assess reuse and reprocessing options and ensure financial provision for reclamation.

International Benchmark: Canada requires detailed mine closure plans and have funds reserved;[105] South Australia has a policy encouraging re-mining of legacy tailings.[106]

Potential Impact: Stronger regulatory requirements would reduce environmental risks and incentivize more resource-efficient mining practices.

Introduce Green Public Procurement and Standards: Public procurement policies could encourage the use of recycled-content materials in construction and infrastructure projects and establish quality standards for secondary materials.

Inetnational Benchmark: OECD and UNEP reviews show that green public procurement is widely used to stimulate markets for recycled materials in leading circular economy countries.[107]

Potential Impact: Even modest procurement requirements could create stable demand for recycled materials, supporting domestic recycling industries and reducing reliance on virgin resources.

3.6.3 Market and Financial Measures

Incentivize Circular Business Models and SMEs: The most impactful state support mechanism identified by industry has been access to affordable financing—particularly subsidized credit programmes under industrial modernization frameworks—rather than direct operational intervention; such instruments can be targeted to support product diversification and deeper processing (e.g., billets, selected aluminium profiles) where domestic producers can compete. Targeted financial incentives such as grants, concessional loans, or tax measures could support SMEs engaged in repair, refurbishment, upcycling, and use of recycled materials.

International Benchmark: OECD and UNEP analyses highlight the effectiveness of financial incentives and innovation grants in supporting circular SMEs in countries such as Sweden and Finland.[108] [109]

[105] Mine closure, reclamation and monitoring - https://www.rcaanc-cirnac.gc.ca/eng/1646321588912/1646321643743
[106] Mine closure and progressive rehabilitation - https://www.energymining.sa.gov.au/industry/minerals-and-mining/mining/mine-closure-and-progressive-rehabilitation
[107] Water Funds to Institutionalize Nature-based Solutions in Ecuador - Guiding Principle 4: Avoiding Environmental Impacts and Investing in Nature - https://wedocs.unep.org/items/1836252f-545e-4d5e-b041-7530d2247950
[108] SMEs and entrepreneurship - https://www.oecd.org/en/topics/smes-and-entrepreneurship.html
[109] Second meeting of the Conference of Parties to the Bamako Convention Abidjan (Cote d'Ivoire), 29–31 January 2018 - Draft report - https://wedocs.unep.org/items/c6601c8c-567f-4b4b-97d6-ddae64835862

Potential Impact: Supporting circular SMEs would promote job creation, reduce waste, and diversify domestic value chains for secondary materials.

Develop Partnerships with International Firms: Armenia could seek partnerships with established international recyclers to introduce advanced recycling technologies and attract foreign investment.
International benchmark: International recyclers have expanded operations across borders to establish regional recycling hubs, particularly for batteries and catalytic converters.

Potential impact: Such partnerships could position Armenia as a regional recycling hub, build domestic capacity, and improve handling of complex waste streams.

3.7 International Benchmark Cases

Case 1 – EU Nation Leading in Circular Metals

One deep case study is Sweden, a country with a long history of circular practices in metals. We've mentioned Boliden Rönnskär in Sweden which is one of the world's largest e-scrap recyclers. *Lessons for Armenia:* Sweden's approach shows the value of investing in technology and stringent environmental control to make recycling viable and clean. Rönnskär not only recycles 120k tonnes of electronics annually, but it also *uses the energy from plastic in e-waste to cogenerate electricity and district heat*, demonstrating creative energy recovery. Sweden also has strong EPR laws; for example, virtually 100% of scrapped cars are recovered through a producer-responsibility system. Additionally, Swedish industries practice industrial symbiosis (e.g. steel mill dust is recycled to extract zinc). For Armenia, emulating elements of the Swedish model – such as requiring high environmental standards for recyclers (to avoid pollution) and encouraging use of by-products – will be important. Sweden's success is also due to policy consistency and public awareness; Armenia can improve awareness so that the public cooperates (returning electronics, segregating scrap, etc.).[110]

Case 2 – SME/Industry-led Initiative

A notable example is the OreSand start-up (spin-off from University of Queensland, Australia) which was highlighted earlier. It's a small venture that identified a circular solution for mining: turning mine tailings into a marketable construction sand. They refer to it as using the whole ore "nose-to-tail" – akin to making sausages from the leftover of the mining "meat".[111] This SME has gained recognition as a global innovator.[112] *Lesson:* Even a relatively small, innovative company can have outsized impact by addressing a specific waste stream. Armenia could encourage local innovators or universities to focus on the country's biggest waste (mining tailings) similarly. Perhaps an Armenian university research group, with modest funding, could prototype using copper tailings to make ceramic tiles or bricks. Another SME example: In the EU, there are small enterprises like "Betolar" in Finland that transforms industrial mineral waste (like steel slag, fly ash) into construction cement alternatives.[113] They emphasize turning waste to value – an approach highly relevant to Armenia's slag from old copper smelting or cement dust etc.

By studying these cases, we see common threads: *innovation, supportive policy, and cross-sector collaboration*. For Armenia, adopting these measures can yield quantifiable results. For instance, if all recommendations are pursued over the next 5–10 years, Armenia could achieve: an increase in overall metals recycling rate to >80% (from current ~50-60% mainly due to scrap steel), a significant

[110] Extracting zinc through steel mill dust recycling at Rönnskär - https://www.boliden.com/sustainability/case-studies/steel-mill-dust-recycling/
[111] OreSand: A circular economy solution to reduce mineral wastes and improve global sand sustainability - https://smi.uq.edu.au/gcms/research/ore-sand-circular-economy-solution-reduce-mineral-wastes-and-improve-global-sand-sustainability
[112] UQ sand mining startup named among top global innovators by World Economic Forum - https://rtcm-trailblazer.au/uq-sand-mining-startup-named-among-top-global-innovators-by-world-economic-forum
[113] Circular Economy Is Not a Trend – It's a Competitive Advantage https://www.betolar.com/blog/circular-economy-is-not-a-trend-its-a-competitive-advantage

reduction in mining waste per unit output (through reuse and stricter controls), and lower import dependency for metal products. Greenhouse gas emissions would drop (one study suggests that maximizing global scrap use in steel to 50% can cut 650 Mt CO_2 by 2050; Armenia's share of that may be small, but proportionally significant for our footprint).[114] Economically, hundreds of new jobs could be created in recycling, and value added in-country could increase by tens of millions of dollars (for example, instead of exporting all copper concentrate, if even a portion of metals like molybdenum, gold, etc. are recovered or transformed locally, the export value per unit rises).

In conclusion, Armenia stands at a point where it can leapfrog towards a more circular metals sector by learning from global leaders and leveraging its recent momentum. The scrap metal success story provides a template: with government will, industry partnership, and the right incentives, linear flows can be turned into circles. Scaling that up to other materials and deeper into the mining sector will move Armenia closer to international best practice. The recommended interventions – from EPR laws to tailings recycling pilots – are actionable and, as seen elsewhere, effective. By implementing them, Armenia can reduce environmental pressures (less waste, less pollution), strengthen resource security, and generate economic opportunities, thus aligning its metals value chain with the principles of sustainability and long-term resilience.

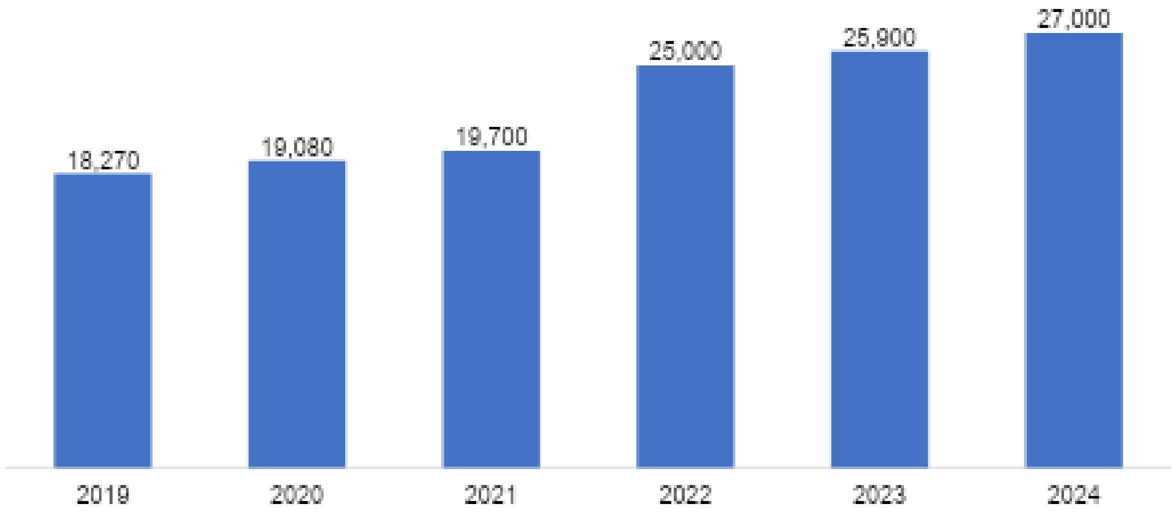
[114] Unlocking potential in the global scrap steel market - https://www.oecd.org/en/publications/unlocking-potential-in-the-global-scrap-steel-market_d7557242-en.html

4. FISHING SECTOR IN ARMENIA: CIRCULAR ECONOMY VALUE CHAIN ANALYSIS

4.1 Sector Overview

Armenia's fish catch increased steadily over the past six years, rising from 18,270 tons in 2019 to 27,000 tons in 2024, which represents a total growth of approximately 48%. The period from 2019 to 2021 saw moderate and gradual expansion, with annual volumes increasing from 18,270 to 19,700 tons. A more pronounced shift occurred beginning in 2022, when output rose sharply to 25,000 tons, marking a nearly 27% year-on-year increase, the highest growth rate in the observed period. This surge likely reflects an external demand shock for Armenian fish in Russia, driven by Western sanctions. Growth continued at a moderate pace through 2023 and 2024, reaching 25,900 tons and 27,000 tons, respectively.

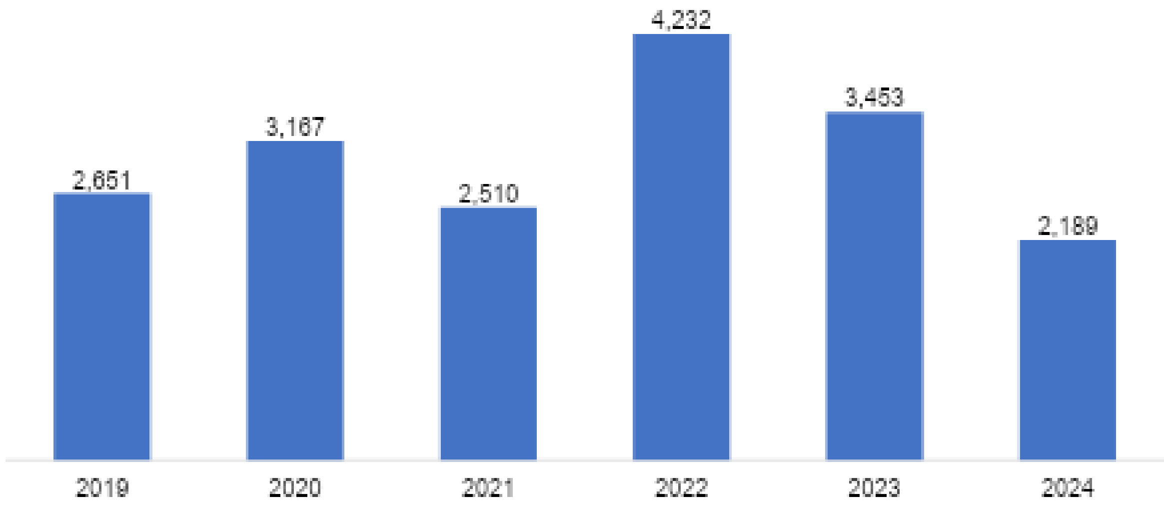
Figure 27. Volume of Fish Catch in Armenia, 2019–2024



Source: Armstat

Fish processing output has shown notable fluctuations over the 2019–2024 period. Processing volumes increased from 2,651 tons in 2019 to 3,167 tons in 2020, suggesting. However, in 2021, processing output declined to 2,510 tons, likely influenced by external factors. A significant rebound occurred in 2022, when processing volumes surged to 4,232 tons, marking the highest level in the six-year period. Following this peak, processing output moderated to 3,453 tons in 2023, but declined more sharply to 2,189 tons in 2024.

Figure 28. Processing of Fish in Armenia, 2019-2024



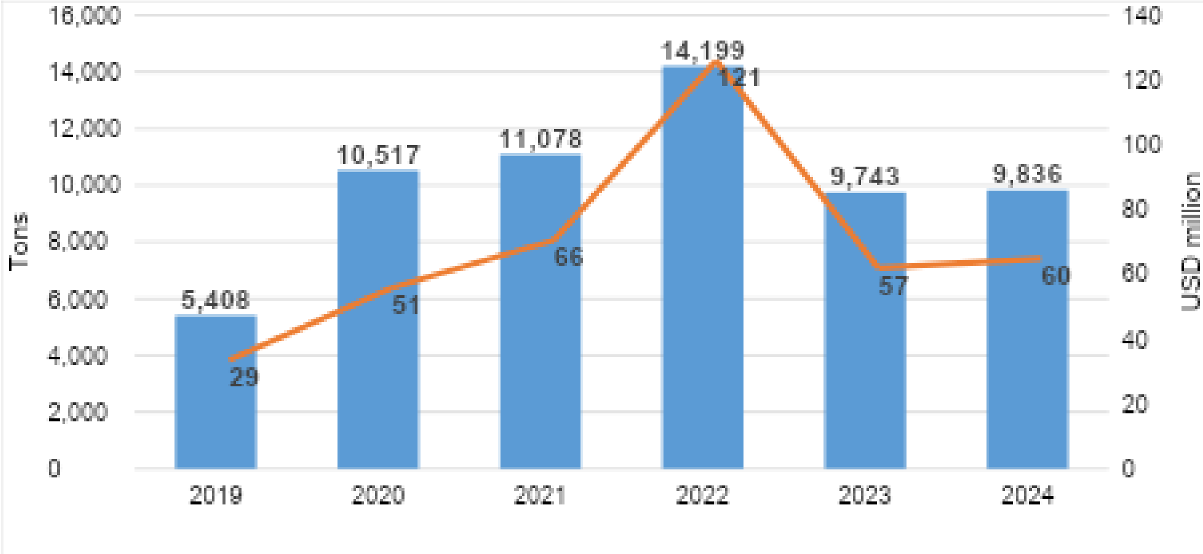
Source: Armstat

Armenia's exports of fish and fish products demonstrated strong growth momentum between 2019 and 2022. Export volumes more than doubled from 5,408 tons in 2019 to 10,517 tons in 2020, and continued to grow modestly to 11,078 tons in 2021. The upward trend peaked in 2022, when exports reached 14,199 tons, marking a 2.6-fold increase compared to 2019. This surge was driven by rising demand from Russia, Armenia's primary export market for fish, which stimulated higher production and drove a significant expansion in export volumes.

Export performance strengthened not only in volume terms but also in value terms. Export earnings increased from USD 29 million in 2019 to USD 121 million in 2022, marking a more than four-fold rise, which is mainly driven by external demand shock. Notably, in 2022 the value of fish exports grew significantly faster than export volumes. While export volumes increased by around 28% relative to 2021, export earnings nearly doubled, rising from USD 66 million to USD 121 million.

However, export volumes declined in 2023 to 9,743 tons, and remained at a similar level in 2024, reaching 9,836 tons. Export values followed a similar pattern. While still well above pre-2020 levels, the decline from the 2022 peak likely reflects a combination of factors, including the resumption of fish exports to Russia from European countries via third-party intermediaries.

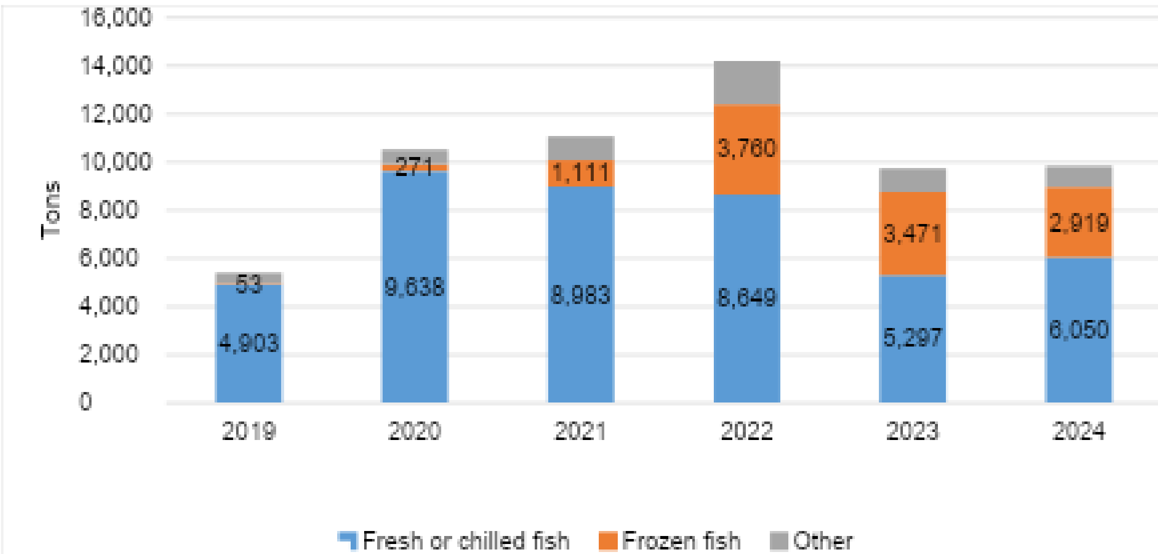
Figure 29. The Volume and Value of Export of Fresh, Frozen and Processed Fish from Armenia, 2019-2024



Source: UN Comtrade

Armenia's fish export structure has undergone a noticeable shift over 2019–2024. In 2019, exports were dominated by fresh or chilled fish (4,903 tons or 91%) with frozen fish accounting for a negligible share (53 tons or 1%). Fresh/chilled fish exports peaked in 2020 at 9,638 tons but gradually declined thereafter, reaching 6,050 tons (62%) in 2024. In contrast, frozen fish exports expanded rapidly, rising from just 53 tons in 2019 to a peak of 3,760 tons in 2022 (26%) and remaining high through 2023 (3,471 tons) before settling at 2,919 tons (or 30%) in 2024. Exports of other fish products also grew significantly between 2019 and 2022, increasing from 452 tons to 1,790 tons, before moderating to 867 tons in 2024.

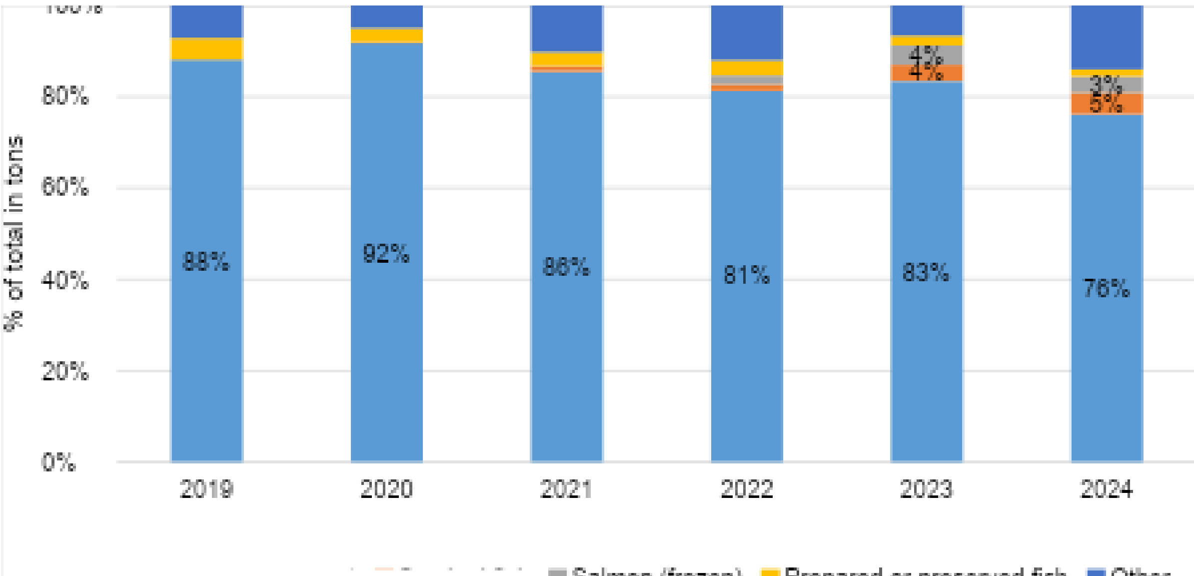
Figure 30. Export of Fresh, Frozen and Processed Fish from Armenia, 2019-2024



Source: UN Comtrade

Trout consistently accounted for the majority of Armenia's fish export throughout 2019–2024. Although still dominant, trout's share declined from 88% in 2019 to 76% in 2024. In that period, exports of smoked fish and frozen salmon expanded, reducing trout's share slightly.

Figure 31. Armenia's Main Fish Export Products, 2019-2024



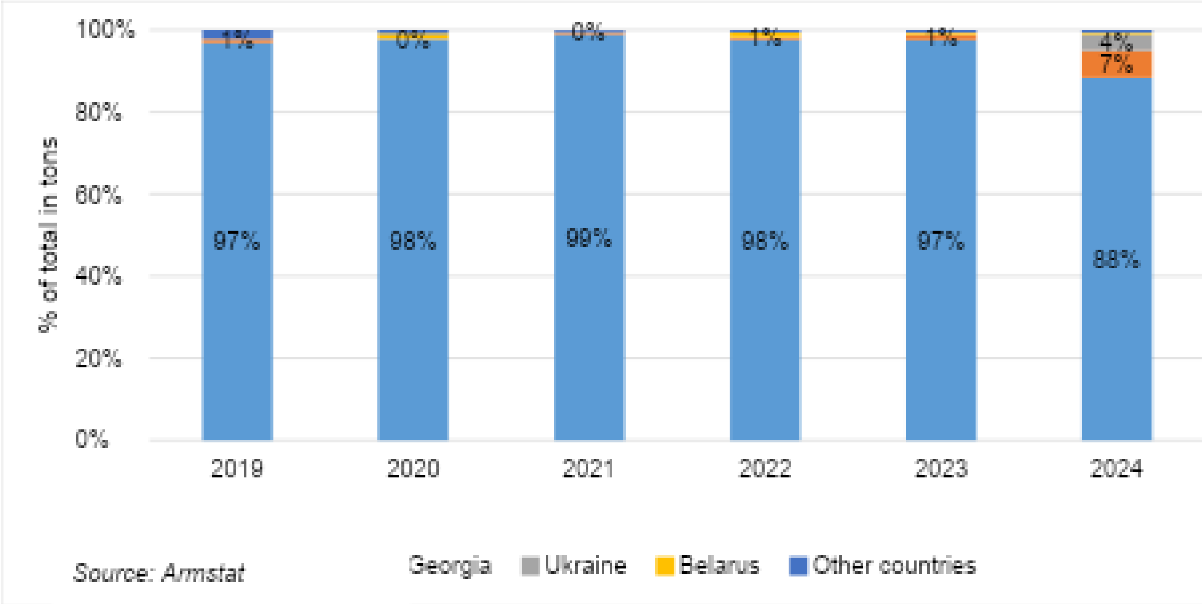
Source: Armstat, UN Comtrade

Russia remains the dominant export destination for Armenian fish, consistently absorbing more than 90% of total exports throughout the period, with the exception of 2024 when its share declined slightly to 88%. Particularly between 2019 and 2023, 97% to 99% of Armenia's fish exports were directed to Russia. In 2024, exports to Georgia and Ukraine surged, reducing Russia's share slightly.

In 2024, Georgia was Armenia's second-largest export market for fish. That year Armenia exported 654 tons of fish to Georgia, accounting for 7% of total fish exports. In 2024, Armenia's exports of fish to Georgia consisted primarily of frozen fish (75%), followed by dried and salted fish (25%). It is noteworthy that in 2024 Armenia's exports to Georgia rose sharply, increasing nearly five-fold compared to the previous year and more than thirteen-fold relative to 2019.

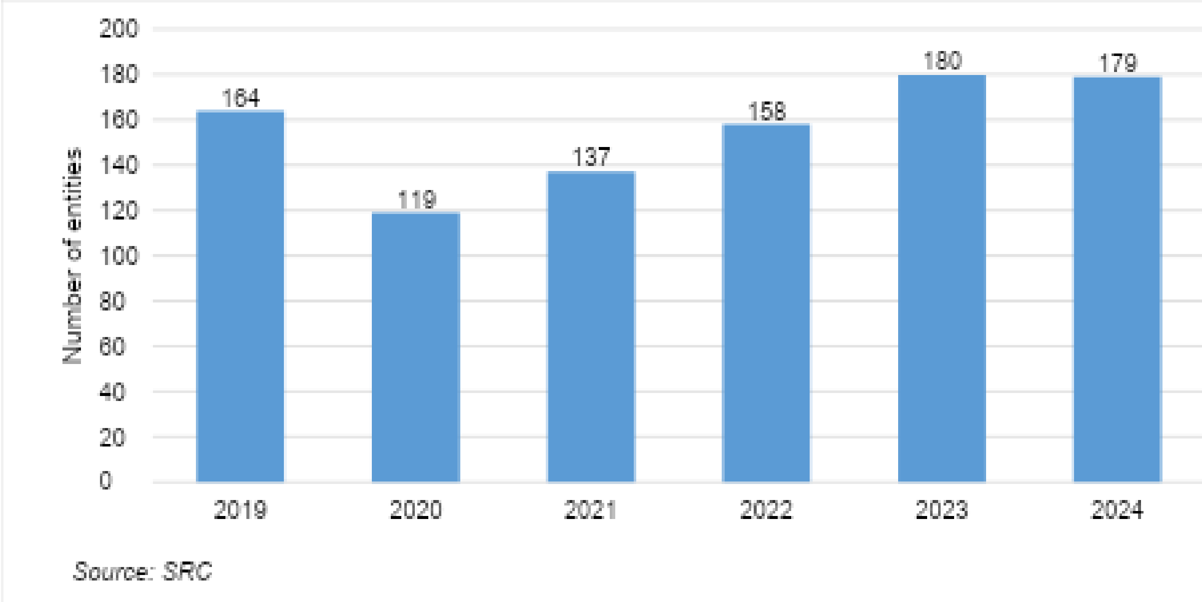
Another export destination that emerged for Armenian fish in 2024 was Ukraine. Armenia had not exported fish to Ukraine prior to 2024, however, in that year, nearly 394 tons were exported, accounting for around 4% of total fish exports. Notably, Armenia's exports to Ukraine consisted entirely of frozen fish.

Figure 32. Geographical Distribution of Exports of Fresh, Frozen and Processed Fish from Armenia in 2019-2024



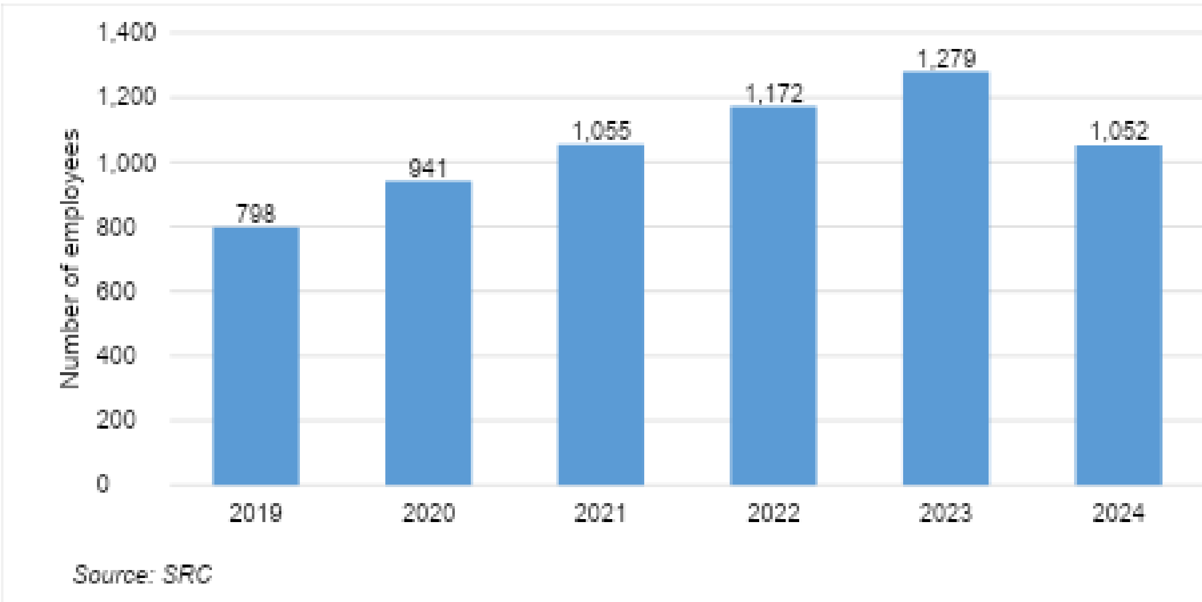
At the end of 2024, 179 entities were operating in the aquaculture and fish-processing sectors in Armenia, reflecting a notable expansion compared to earlier years. The sector experienced a decline in the number of enterprises in 2020, falling to 119 from 164 in 2019, likely reflecting disruptions associated with COVID-19 and economic uncertainty. However, the aquaculture and fish-processing sectors began to recover in 2021, with active entities rising to 137, and continued expanding in 2022, reaching 158. Growth accelerated further in 2023, when the number of active enterprises at the end of the year increased to 180, supported by rising fish production and strong export demand.

Figure 33. Year-End Count of Active Aquaculture and Fish-Processing Entities in Armenia, 2019–2024



In 2024, the aquaculture and fish-processing sectors in Armenia employed 1,052 salaried and contractual employees, 32% more than in 2019. This growth reflects the sector's gradual expansion over the past five years, driven by rising fish production, increasing export demand, and the entry of new enterprises. Employment gains were particularly strong between 2020 and 2023, when the sector added more than 450 workers, reaching a peak of 1,279 employees in 2023. Although employment declined slightly in 2024, the overall workforce remains significantly larger than before the recent growth cycle.

Figure 34. Average Annual Employment in Aquaculture and Fish-Processing in Armenia, 2019–2024

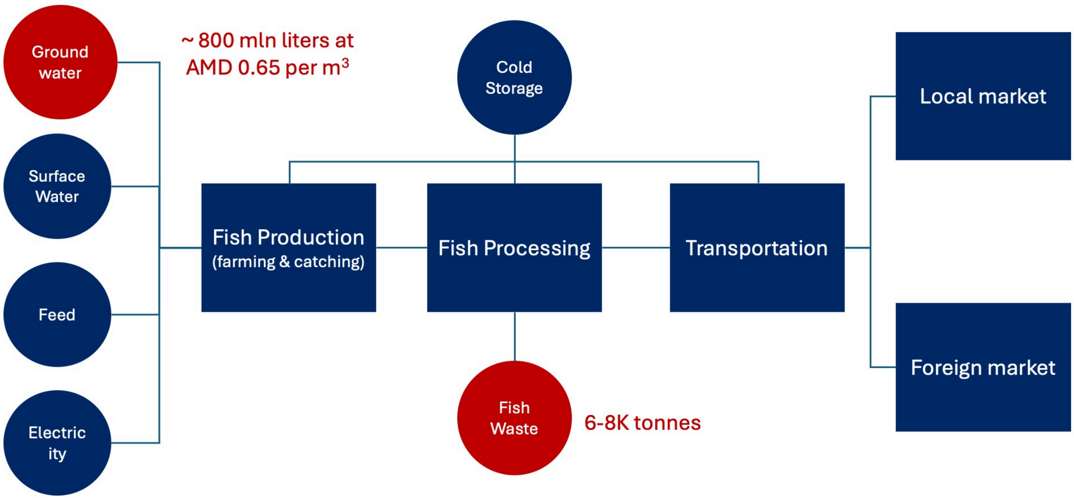


Employment is concentrated in a small number of enterprises. For example, in 2024, only four entities employed 50 or more workers. The majority of firms were very small: more than 80% of all entities had 5 or fewer employees, and nearly half operated with just one or two workers, suggesting widespread small-scale or household-level production. Our observations also indicate widespread informal employment in the sector, implying that the true number of employees is significantly higher.

4.2 Current linear value chain description

Armenia's fish value chain follows a largely linear model (Diagram 1), moving from resource extraction to consumption with limited resource recovery. The sector can be described across five interconnected stages: input supply, production, processing, distribution, and consumption/end-of-life. Each stage has distinct material flows and environmental impacts, particularly around groundwater use and unmanaged nutrient and fish-waste streams.

Figure 35. Linear Fish Value Chain in Armenia



At the same time, the Ararat Valley hosts dozens of **carp pond farms** whose operations are **partially aligned with circular economy practices,** a model that dates back to the Soviet period. In response to widespread soil salinization in the region, farmers periodically convert agricultural land plots into carp ponds to help reduce soil salinity. After several years of aquaculture use, the same plots are returned to crop production, most commonly melons and watermelons, creating a rotational system that combines aquaculture and crop production. Typically, land plots are used as carp ponds for 3–7 years, followed by approximately 2 years of crop production before the cycle is repeated.

4.2.1 Input Supply

The value chain begins with substantial inflows of natural resources and imported materials. **Feed** is the single largest input by volume and cost. Producing 1 tonne of marketable rainbow trout requires roughly 1.25 tonnes of feed[115]. Thus, supporting a national output in 2024 required an estimated 30,000 tonnes of feed. Armenia has limited domestic fish feed production. According to our in-depth interview with the director of the Yeghvard Compound Feed Factory, the company sells approximately 5–6 thousand tonnes of feed annually. However, several key feed components, such as hemoglobin meal, are imported from Europe, despite the fact that they could be produced domestically from livestock slaughter by-products. At present, **animal blood from slaughterhouses is**

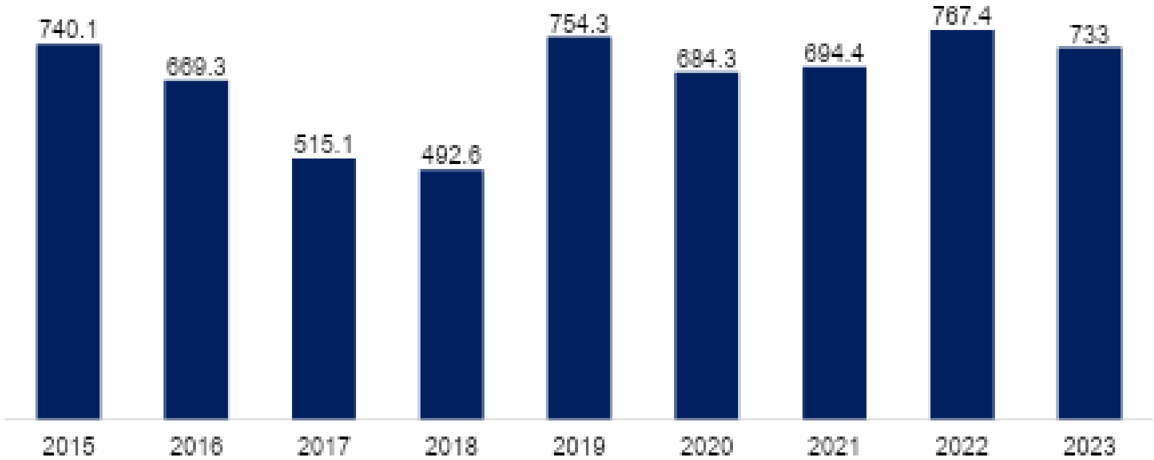
[115] Seafish. "Rainbow Trout: Feed." Accessed: December 12th, 2025. https://is.gd/Bt2x9Y

largely wasted, representing a missed opportunity for local feed production and value addition. The main reason is the fragmented nature of the slaughtering sector, characterized by small-scale slaughterhouses dispersed across the country and the lack of technologies for the immediate stabilization of blood. A large share of feed is imported, with farms relying on high-protein pellets, mainly from Russian and EU producers, required for trout and sturgeon aquaculture.

In carp pond aquaculture, **the use of artificial feed is generally minimal.** Fish largely depend on natural food sources, including residual plant biomass and aquatic vegetation that develops due to the shallow pond depth (approximately 1.5 meters). Consequently, carp production in pond systems is predominantly based on natural feed resources.

According to **the State Water Cadastre of the Ministry of Environment**[116], there are currently 226 water use permits issued for fish farming, with a total authorized water use volume exceeding **965 million cubic meters.** The majority of this volume is **groundwater** (641 million cubic meters), followed by **surface water** (180 million cubic meters) and water from **drainage/irrigation systems** (144 million cubic meters). Overall, according to the Armstat, the country every year uses about 700-800 million cubic meter freshwater for fish farming purposes.

Figure 36. Freshwater abstraction by fish farms, 2015-2023



While fish farming is well developed in the country, **the adoption of circular practices in water use remains limited.** In particular, only **9 out of 226 water use permits assumes re-use of water**, such as irrigation or public utility purposes, with a combined authorized water use volume of **21.6 million cubic meters**. It is worth noting that in the Masis region, a system of water pumps and irrigation channels was introduced in 2018 with funding from USAID. This infrastructure enabled the reuse of water from fish farms for irrigation purposes, allowing the cultivation of approximately 100 hectares

[116] State Water Cadastre, MoEnv, https://url-shortener.me/AEUQ, accessed on 31 January, 2026

of previously abandoned land[117]. This circular practice currently under the focus of some international donors, including Asian Development Bank, which recently launched a project to assess the potential of use of fish farms water for irrigation purposes in the Ararat Valley.

Our further analysis indicates that **many fish farms rely on basic water aeration technologies,** sometimes combined with small-scale solar PV installations, to improve water-use efficiency and fish farming productivity. However, the adoption of advanced recirculating aquaculture systems (RAS) remains limited. One of the most advanced RAS installations has been introduced at the state-owned Sevani Ishkhan company, which operates a fingerling farm near Lake Sevan as well as cage aquaculture facilities in the lake. According to the company's director, Sevani Ishkhan currently operates a Danish-manufactured RAS alongside a custom-designed and locally produced RAS developed in-house. These systems have reduced water use to approximately 12 m^3 per second, compared to an estimated 130–150 m^3 per second without such technologies. However, he noted that the capital expenditure for RAS is very high, making it economically viable primarily for high-value species such as sturgeon and for fingerling production. At the same time, interviewees operating in the Ararat Valley noted that the effectiveness of RAS is more limited in hot regions. During water recirculation, water temperatures tend to increase, requiring additional investment in chilling systems to maintain temperatures within the ranges suitable for fish production.

In contrast to fish farms that rely heavily on groundwater, **carp pond farms in the Ararat Valley are more water-efficient.** According to interviews, approximately 15 cubic meters of water from the drainage system are required to establish one hectare of carp ponds, with an additional 20% used annually to compensate for evaporation losses. Under this system, farms produce around 300–500 kg of fish per hectare per year, indicating a more water-efficient production practice. Given the current water usage rate, the cost of water consumption is estimated at around AMD 30,000, which is negligible relative to the total cost of goods sold of carp farms. At the same time, this measure is expected to almost double watermelon harvests over the subsequent two years.

Additional inputs include **electricity** for pumping, aeration, heating, and cold-storage facilities, **equipment** such as pumps, nets, tanks, pipes, freezers, and oxygenation systems, mostly imported, etc. It is worth noting that, according to producers' estimates, electricity costs for water aeration in fish farms do not exceed 5% of the cost of goods sold, and in many fish farms have installed solar PV systems to reduce electricity-related operating costs.

4.2.2 Production (Fish Farming and Catching)

Fish production in Armenia is dominated by land-based, flow-through aquaculture systems located mainly in the Ararat Valley. Farms use continuously flowing artesian water through concrete raceways or earthen ponds to raise rainbow trout, sturgeon, and smaller volumes of carp species. Growth

[117] ME&A, New Irrigation System for Community in Armenia's Ararat Valley Officially Opens, https://url-shortener.me/AEXE, accessed on 31 January, 2026

cycles range from 12–18 months for trout to multiple years for sturgeon, especially for females raised for caviar[118].

Material flows at this stage are significant. As already mentioned, feed use exceeds 30,000 tonnes. Uneaten feed and excreted nutrients represent a major loss of material value. Aquaculture accounts for more than 50% of annual groundwater extraction in the Ararat basin[119]. As water flows through the ponds, it becomes laden with fish waste: excreta, uneaten feed (about 20–30% of feed may go uneaten or be excreted as solid waste)[120]. Under the current linear system, this nutrient-rich effluent is discharged directly into drainage canals and eventually the Araks River without treatment or reuse. This represents both a lost resource (nutrients that could be valorized) and an environmental pressure (eutrophication). Armenia's capture fishery is small and centered on Lake Sevan. Overfishing and ecological stress have reduced catches. Nonetheless, these products enter local markets and supplement aquaculture supply.

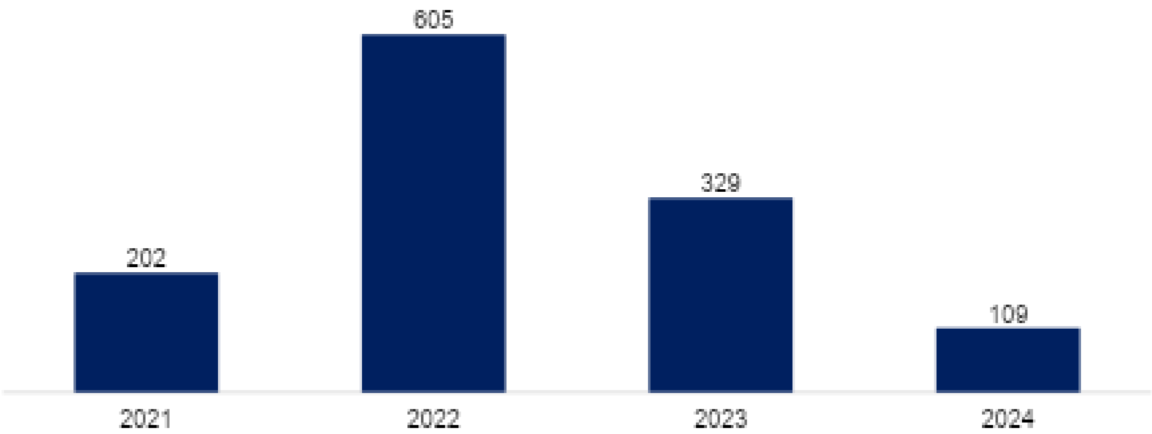
4.2.3 Post-Production Processing

After harvest, fish are delivered to processing units where they are cleaned, filleted, frozen, smoked, or packaged according to market requirements. Our estimates indicate that Armenia generates several thousand tones of fish processing by-products each year, including heads, bones, skin, blood, trimmings, and residues from caviar processing. Managing these **waste streams represents a notable environmental challenge.** At present, Armenia does not have industrial facilities for producing fishmeal, fish oil, or gelatin, which means that most processing residues are disposed of either as solid waste or discharged through wastewater systems. This situation constitutes one of **the most pronounced circular-economy gaps in the fish value chain.** At the same time, this underutilization highlights significant potential for circular-economy solutions, including fishmeal production, composting, and bioenergy generation.

In addition, **most fish farms do not operate their own processing facilities**. Instead, they either sell live fish to retailers or specialized processors, or outsource slaughtering and cleaning to third-party service providers. Despite generating substantial volumes of waste, amounting to several thousand tonnes annually, and having a clear economic rationale to invest in recycling technologies, processors in practice largely depend on informal or unsanctioned disposal at landfills, **thereby missing opportunities to recover value from these by-products.** Official data further illustrate this gap. According to the Ministry of Environment, fish processors reported disposing of only 109 tones of fish waste, a figure that appears disproportionately low relative to current sectoral production levels.

[118] FAO. "Cultured Aquatic Species Information Programme: Oncorhynchus mykiss." 2024. Accessed: December 12th, 2025. https://is.gd/f7JGH4
[119] (First Citation) Lori Youmshajekian. "As Armenian Fish Farming Expands, a Pristine Aquifer Is Drying Up". August 10, 2023. https://is.gd/4ztemw
[120] (First Citation) EU4Environment. Draft Agenda: Round Table on Armenia's Fisheries Sector. 2022. https://is.gd/9TY5VX

Figure 37. Formal disposal of waste by fish farms, 2015-2023



Our value chain analysis also identified a small number of specialized waste management firms handling fish waste. According to the director of Ecologia LLC, one such provider, the company currently serves 4–5 clients, processing a total of approximately 5–6 tonnes of fish waste at a tariff of AMD 60 per kilogram. Fish waste is delivered by clients to the company's facility in Ejmiatsin, where it is aggregated and ultimately disposed of at the Shahumyan landfill. Typically, fish processors prefer to collaborate with waste management companies in order to reduce their administrative burden and interactions with state authorities.

4.2.4 Distribution

The distribution stage connects fish producers and processors to final markets through domestic logistics and export channels.

In **local market** fish products are distributed to supermarkets, wholesalers, restaurants, and retail outlets across Armenia. It is also worth noting that in Armenia, consumers often purchase live fish in supermarkets and request on-site slaughtering. As a result, **the fish waste generated at retail outlets is frequently not handled properly.**

Armenia **exports** fish, especially processed trout and sturgeon, to regional and international markets. Russia is the primary destination for Armenian trout, sturgeon, and caviar. Products are typically shipped by refrigerated trucks through Georgia, reaching markets within 2–3 days. Cold-chain integrity is essential; historically, smaller operators transported live fish in oxygenated tanks, a costly and fragile method that is gradually being replaced by chilled transport. High-value caviar is sometimes exported via air freight due to its low volume and stringent freshness requirements.

In distribution, the key concerns are preserving product quality (to avoid losses from spoilage) and the flow of packaging materials. Anecdotally, post-harvest fish losses in Armenia are not well documented, but likely a few percent of output may be lost due to handling damage, delays, or temperature breaks. The lack of a fully developed cold chain historically could lead to some spoilage, but as the industry is export-driven (with strict timelines), waste in this stage is relatively low compared to global averages. Packaging waste (plastic film, foam boxes) is generated and usually ends up in municipal waste streams (landfills). There is no specific recycling program for fish packaging materials yet.

At the consumption stage, organic waste like fish bones or leftovers arise. Typically, these end up in garbage bins and then landfills, as composting of food waste is not yet common. Thus, nutrients that could return to soil are lost. There is also the matter of end-of-life for materials used in the value chain, particularly fishing gear and farm equipment. In capture fisheries (Lake Sevan), used nets and lines often become ghost gear if lost in the lake, or are collected during enforcement sweeps (hundreds of illegal nets are seized annually from Sevan to combat poaching)[121]. Currently, there is no system to recycle or properly process this old gear – confiscated nets are typically destroyed or discarded. In aquaculture, equipment like PVC pipes, tanks, and nylon seine nets have a finite lifespan; when they break or wear out, farmers usually dump them in local landfills. This represents another linear path (resource to waste) with missed circular opportunities (these plastics could be recycled into new products).

4.2.5 Policy and Institutional Framework

The Armenian government has introduced strategies and regulations in recent years to support the sector's growth while addressing sustainability issues. Fish farming falls under the purview of the **Ministry of Economy (Department of Livestock and Aquaculture)** for industry development, and under the **Ministry of Environment** for resource use and ecological regulation. A **10-year Agriculture Strategy (2020–2030)** emphasizes sustainable and innovative practices in all agro sub-sectors, including aquaculture[122] (for example, providing leasing subsidies for the acquisition of aeration systems and processing equipment[123]). Specific policies and laws affecting the fish sector include the Law on Food Safety, veterinary and animal feed laws (important for meeting export standards), and the Water Code. Notably, **Armenia's obligations under the EU-Armenia Comprehensive and Enhanced Partnership Agreement (CEPA)** have driven improvements in food safety and waste management. After roughly 8 years of reforms and negotiations, in **March 2025 Armenia was officially approved to export aquaculture fish and caviar to the EU**[124]. This was a milestone achievement, requiring establishment of EU-equivalent sanitary controls and farm monitoring. It signals that Armenian producers now meet higher standards in areas like hygiene, disease control, and traceability, a positive foundation for circular practices as well.

Environmental concerns have prompted new regulations. **Overuse of groundwater** in the Ararat Valley, where fish farms have drawn freely from a once-pristine aquifer, led to a crisis of dropping

[121] (First Citation) Tert.am. "346 illegally installed crab traps and 90 fishing nets were removed from Lake Sevan, and 76 crabs were released into the lake." November 01, 2025. https://is.gd/MvafCD
[122] Ministry of Economy of RA. "10-year Agriculture Strategy (2020–2030)". [in Armenian] 2019. https://is.gd/OB8ru3
[123] Ministry of Economy, Leasing Support Program for Agri-Food Sector Equipment in the Republic of Armenia, accessed 19 February, 2026, https://tinyurl.com/27k8pwwf
[124] (First Citation) Arka.am. "Armenia plans to export fish and fish products to the EU for the first time". March 13, 2025. https://is.gd/GPNL5w

water tables[125]. In response, the government amended the Water Code in 2022 to **mandate closed-loop or recirculating water systems in fish farms**[126]. The Ministry of Environment issued an order in January 2023 giving farms *one year* to install **recirculating aquaculture systems (RAS)** or other water-saving technology[127]. The new regulation was challenged in court, resulting in its enforcement being suspended for a prolonged period. In light of the legal challenges and opposition from the industry, representatives of the Ministry indicated that an alternative approach was chosen to limit groundwater use in the Ararat Valley. In September 2025, Parliament adopted amendments to the Water Code under which fish farmers, instead of being required to introduce recirculating aquaculture systems (RAS), were obliged to reduce their water use by approximately 40%. **This measure is expected to compel fish farmers either to reduce production or to adopt new water-efficient measures.** However, the **environmental tax rate for groundwater use in the fish farming industry—AMD 0.65 per cubic meter,** and does not provide sufficient incentives for businesses to actively adopt water-efficient measures at the individual farm level.

Armenia, also has a comprehensive legislation on fish waste management - **a Ministerial Order (No. 262-d) on Fish Waste Management was approved from July 27, 2022**[128], aims to ensure that fish processing waste (offal, sludge, etc.) is handled in ways that protect ecology and human health, moving up the waste hierarchy toward reuse and recycling., including identification and regular reporting. It represents one of Armenia's first explicit circular economy regulations in this sector. Enforcement of these new rules is backed by donor-funded initiatives (EU4Environment, UNDP, etc.) and reflects a growing recognition by policymakers that "business-as-usual" fish farming, with unchecked water extraction and waste discharge, is unsustainable. However, according to representatives of the Ministry, misreporting is widespread. To address this, the authorities have initiated the digitalization of reporting processes and their integration with the State Revenue Committee's tax administration system in order to strengthen compliance and law enforcement. At the same time, under current legislation, fish waste is classified as non-hazardous waste, and the Tax Code sets an environmental tax of AMD 780 per cubic meter of fish waste[129]. This level of taxation does not provide sufficient economic incentives for the adoption of waste recycling technologies.

In summary, Armenia's policy context is evolving to balance the economic promise of aquaculture with the need for resource efficiency, aligning with international best practices. The stage is set for a transition from a linear to a more circular value chain, though significant gaps remain in practice, as explored above.

[125] (Subsequent Citation) Lori Youmshajekian. 2023
[126] (Subsequent Citation) EU4Environment. 2022
[127] (Subsequent Citation) Lori Youmshajekian. 2023
[128] (Subsequent Citation) EU4Environment. 2022
[129] ARLIS. "Tax Code of the Republic of Armenia". October 4 , 2016. https://www.arlis.am/hy/acts/109017

4.3 Mapping of Circular Economy Stakeholders and Initiatives

4.3.1 Stakeholders of circular economy practices

Transitioning Armenia's fish and aquaculture sector to a circular economy model involves a range of stakeholders, such as government, industry, civil society, and international partners, each with different interests and influence. Below we **identify key stakeholders** in the value chain and their roles, and discuss existing circular economy initiatives they are involved in. We also position them on a **power vs. interest grid** to understand who can drive or block circular innovations:

- **Ministry of Economy (Department of Animal Farming/Aquaculture):** This ministry oversees fisheries development and provides support programs. It has **high power** (policy-making, funding) and a growing **interest** in circular practices to boost competitiveness and meet export requirements. For example, the Ministry has supported negotiations for EU market access (requiring improved waste handling and traceability)[130]. Its interest is primarily economic (e.g. ensuring fish farmers remain profitable) so it supports circular measures insofar as they improve efficiency or open new markets (such as organic certification, value-added processing). The Ministry of Economy also collaborates with donors on pilot projects (like introducing new technologies). Overall: **Power = High, Interest = Moderate** (economic focus with selective interest in sustainability).
- **Ministry of Environment:** This body regulates water use, waste management, and biodiversity, all directly affected by the fish industry. It wields **high regulatory power**, and its **interest in circular economy is very high** because circular practices (water recycling, waste utilization) align with its mandate to protect natural resources. The Ministry of Environment has been a key driver of new rules: e.g. issuing the RAS installation order and the fish waste management order. It also leads enforcement against illegal fishing in Lake Sevan (confiscating illegal nets and traps to protect fish stocks)[131]. The Ministry's department of water resources and environmental impact assessment are actively pushing fish farms to reuse water and properly treat effluents. They partner with projects like EU4Environment to promote Resource Efficient and Cleaner Production (RECP) in aquaculture. **Power = High, Interest = High** (champion of CE to reduce environmental harm).
- **Food Safety Inspection Body:** This state inspectorate ensures fish products meet hygiene and safety standards, which is crucial for both local public health and export eligibility. It has **medium to high power** (it can certify or shut down processing facilities) and a **moderate interest in circular practices**. Its primary focus is food safety (e.g. controlling fish diseases, preventing contamination). It has been training fish processors on EU TRACES system and standards, indirectly encouraging better resource use. **Power = Medium-High, Interest = Moderate**.
- **Environmental Protection and Mining Inspection Body:** This state inspection authority is responsible for monitoring environmental compliance in the fish industry, including water abstraction, wastewater discharge, waste management, and compliance with environmental permits. Its role is particularly relevant for groundwater use, effluent control, and the handling and disposal of fish waste. The Inspection Body has high formal power, as it can impose fines, suspend operations, or revoke permits in cases of non-compliance. However, its interest in circular economy practices

[130] (Subsequent Citation) Arka.am. 2025
[131] (Subsequent Citation) Tert.am. 2025

remains moderate, as enforcement is primarily focused on regulatory compliance rather than on promoting resource efficiency or waste valorization. Recent efforts to digitalize reporting and strengthen inter-agency data integration may improve oversight and indirectly support circular practices. Power = High, Interest = Moderate.

- **Fish Farming Companies (Producers):** These include around 200 fish farm enterprises, ranging from small family ponds to large commercial operations (some integrated with processing). As the producers, they are **central stakeholders**, any circular intervention on the farm (water reuse, feed change, waste separation) depends on their adoption. However, their **interest in circular economy varies**: larger, export-oriented farms are increasingly interested in sustainability if it ensures long-term water supply or opens premium markets, whereas smaller farms may be more focused on short-term costs and thus less inclined unless there are direct benefits or mandates. In general, fish farmers' interest is *"mixed/conditional"* – many are concerned about the water crisis (so they see the need for recirculation), but they also fear high costs (RAS equipment investments). A case in point is **Svet Fish farm** in Ararat Valley, whose owner implemented a home-made recirculating system due to limited water access, and advocates it as a model[132]. Yet, he notes neighbors with ample water have "no incentive" to invest. Fish farmers do have **moderate power collectively**, especially through their association (see below) – they can lobby government (e.g. for subsidies or tariff changes) and their compliance (or non-compliance) can make or break regulatory initiatives. So far, compliance with new CE-related rules has been slow (few farms installed RAS by the initial deadline). In summary, **Power = Medium (high for large farms), Interest = Low-to-Medium (cost/benefit driven)**.
- **Association of Fish Farmers of Armenia (AFFA):** This non-governmental industry body represents producers and processes their collective interests. The AFFA serves as a voice for the industry in policy dialogue. It has **moderate power** – for example, it coordinated negotiations for EU export approval by facilitating farm audits and information flow[133]. The Association's president has publicly discussed export and quality issues. Regarding circular economy, AFFA's stance is pragmatic: they support measures that help the sector's growth and reputation. AFFA likely favors receiving government support for RAS or waste processing rather than outright opposing such moves. Still, if circular measures threaten to impose heavy costs, AFFA might lobby for leniency or financial aid (as seen historically in their push to remove import duties on eggs and possibly seeking subsidies for RAS upgrades). **Power = Medium, Interest = Moderate** (they recognize sustainability is tied to long-term viability but must balance member concerns).
- **Local Communities and Water Users:** Residents in fish-farming regions (especially rural communities in Ararat Valley and around Lake Sevan) are indirect stakeholders. Farmers in Ararat Valley who rely on the aquifer for irrigation have a stake in fish farms not depleting water. Many have witnessed wells running dry as fish farms expanded. These communities have **high interest in circular practices** like water conservation – it literally impacts their livelihoods and environment. For instance, villages have seen traditional agriculture suffer from falling groundwater due in part to fish farm extraction. Also, communities around Lake Sevan care about sustainable fisheries and preventing lake pollution (Sevan has faced algal blooms, and illegal fishing gear threatens fish populations). However, their **power is relatively low**; they depend on government action to control industrial water use or enforce regulations. Community voices are heard via NGOs or local councils,

[132] (Subsequent Citation) Lori Youmshajekian. 2023
[133] (Subsequent Citation) Arka.am. 2025

but individually they cannot force fish farms to change. In some cases, conflict has led to government action (e.g. community outcry over wells prompted the crackdown on illegal fish wells in 2014–2016). **Power = Low, Interest = High** (they stand to benefit from CE via environmental restoration).

- **Environmental NGOs and Academia:** Environmental organizations (e.g.,"Ecolur") and research institutes (e.g. Institute of Geological Sciences; ICARE – International Center for Agribusiness Research and Education) are stakeholders advocating for sustainable practices. They have **low direct power** but can influence through advocacy, data, and pilot projects. ICARE conducted research on the costs of RAS implementation in Armenia (finding capital costs USD 16K–130k per farm depending on size), which is being used to advise policy on possible subsidies[134]. Some NGOs focus on Lake Sevan's ecosystem, pushing for stricter controls on fishing and possibly promoting eco-tourism in place of consumptive use. Environmental NGOs have a **very high interest** in circular economy interventions, be it recycling fish waste to prevent water pollution, or retrieving ghost nets to protect wildlife. They often collaborate with international partners to propose solutions. But their leverage lies in raising awareness and knowledge-sharing rather than decision-making. **Power = Low, Interest = Very High**.
- **International Development Partners:** Several international organizations and donors are actively engaged in Armenia's circular economy transition for aquaculture. The EU is the most active international partner. For example, EU4Environment (OECD, UNEP, UNIDO, UNECE consortium) focuses on resource efficiency, industrial pollution control, waste management, environmental permitting, and green transformation of sectors including aquaculture. FAO has supported sustainable fisheries and aquaculture development in Armenia through analysis of the sector's potential and institutional frameworks. The ADB is engaged in sustainable water management area. International donor organizations have **moderate power** – they cannot enforce policy but heavily influence it through conditional assistance and by sharing global best practices. Their **interest is very high** in showcasing successful circular economy models (as part of climate and environmental objectives). They also facilitate knowledge transfer: e.g. bringing Norwegian or Dutch experts to advise Armenian farms, or funding feasibility studies for a fish waste biogas plant. Often, they act as neutral conveners among government, industry, and NGOs. **Power = Medium, Interest = High**.
- **Downstream Market Actors:** This includes supermarkets, fish vendors, and exporters. Their interest in circularity is emerging – for example, if EU buyers demand sustainably produced fish, exporters will in turn pressure farmers to improve practices. Currently, Russian market demand does not strongly emphasize sustainability (it's more about price and quality), so exporters focus less on "green" branding. However, with potential EU market entry, Armenian exporters/processors are starting to consider eco-certifications and waste reduction as marketing advantages. These actors have **medium power** (they decide what products to source and can set standards for suppliers). If a major buyer (say a European distributor) required that fish come from a farm with water recycling and proper waste disposal, that would ripple upstream. Domestically, large supermarket chains could influence packaging recycling or push for consistent quality (reducing spoilage). So far this is nascent. **Power = Medium, Interest = Low-to-Moderate** (growing if market incentives align).

[134] Tadevosyan, Lusine, Natella Mirzoyan, Narek Avetisyan, Shahen Mirakyan, and Vardan Urutyan. "Introducing Recirculating Aquaculture Systems in Armenia: Is the Change Worth It?" April 2018. ICARE. https://is.gd/x9Z6yk

Power–Interest Mapping: In summary, the **high-power, high-interest** stakeholders – those most likely to drive circular transition – are the **regulators (Ministry of Environment)** and supportive **international partners**, possibly joined by some **leading farmers** who see long-term benefits. They form the champions of change. **High-power but mixed-interest** stakeholders (e.g. Ministry of Economy, big fish companies) will be crucial – they need to be convinced that circular measures align with economic gains. **Low-power but high-interest** groups (NGOs, communities, researchers) provide moral and knowledge impetus; they can pilot solutions and keep up pressure but require backing from those with authority.

4.3.2 Existing Circular Initiatives

Despite being early in its transition, Armenia's fishing and aquaculture sector has begun to implement or experiment with several **circular economy practices** across different stages of the value chain. Below we describe the **current circular practices** (as of 2025) within this value chain in Armenia, including those related to gear reuse, cold chain optimization, waste valorization, and more:

- **Water Recirculation and Reuse:** Water management is the clearest area where circular practices are emerging. Historically, most farms operated once-through systems, abstracting groundwater and discharging it after a single use. In response to aquifer depletion and new regulations, the government now requires fish farms using groundwater to adopt closed or semi-closed circulation systems, with targets of re-using a large share of outlet water. A few pioneering farms have already installed recirculating or water-saving systems that filter and re-use water, and donor projects (e.g. USAID/ASPIRED) have demonstrated re-use of fish farm effluent for irrigation in nearby communities. In addition, carp pond farming is widespread in the Ararat Valley and is inherently more circular than traditional groundwater-based fish farms.
- **Cold Chain Optimization:** Export-oriented producers rely on refrigerated transport and cold storage to meet Russian and other market standards, and modern processing plants use chilling and freezing to maintain product quality and reduce losses. This is in line with global best practice, where improved cold chains are a key measure to cut food waste in fish value chains. Domestically, more retailers use refrigeration for fish display than a decade ago,. While hard data on waste reduction isn't readily available, anecdotal evidence suggests that **product loss due to spoilage has dropped**, meaning a higher percentage of harvested fish is actually consumed. This is a circular outcome in the sense of reducing food waste. Additionally, some companies are exploring use of **solar-powered cold rooms** on farms to reduce grid energy use (one farm in Armavir province installed solar panels to run its freezers, lowering both cost and carbon footprint – an example of integrating renewable energy, which aligns with circular economy's energy efficiency ethos).
- **Reuse and Repurposing of Fishing Gear:** Though formal recycling is lacking, there is a culture of **maximizing the use of gear** in the sector. For instance, fish farmers typically reuse costly items like nets, pipes, and filtration media for as long as possible. When a net cage or screen is damaged, farmers often **repair** it (using nylon twine to patch holes) rather than throw it away immediately – a basic circular behavior (prolonging product life). On Lake Sevan's capture fishery side, a positive development is that local environmental departments have started **reusing confiscated nets for**

constructive purposes: in one case, old nets were given to a local crafts group that used the netting material to make fences for tree saplings (protecting young trees along the lakeshore). While small-scale, it's an innovative repurpose of what would be waste. Moreover, as noted earlier, discussions are in progress to establish a collection point for end-of-life nets from aquaculture farms. Currently, farms often stockpile old netting on-site; a pilot project in 2024 aimed to collect a few tons of such netting and send it to an EU recycling facility through a waste management NGO. The results are pending, but if successful, it could kickstart a formal **gear recycling initiative** in Armenia – turning polypropylene and nylon from nets into plastic pellets for new products (like textile fibers or construction materials).

- **Fish Waste Valorization (Emerging Practices):** At present, full waste "upcycling" is not yet industrialized in Armenia, but there are emerging practices hinting at future circular loops.
- **Energy Recovery Initiatives:** While Armenia does not yet have aquaculture-based energy recovery systems, the concept is consistent with international RECP and circular economy recommendations. Under the EU4Environment programme, RECP experts emphasize that many industrial waste streams represent lost value and could be recovered for energy or nutrient use. Organic residues—including fish processing waste—could in principle be used in anaerobic digestion to produce biogas and fertilizer, although no feasibility study or pilot project has yet been implemented in Armenia. Similarly, international best practice suggests that low-temperature effluent water from aquaculture can be reused for heating applications (e.g., greenhouses), but such systems have not been documented in Armenia to date.
- **Circular Business Model Exploration:** International experience shows strong potential for insect-based protein—such as black soldier fly (BSF) larvae—to convert organic residues, including fish processing waste, into high-value feed ingredients. While BSF farming is not yet established in Armenia, stakeholders and development partners have expressed interest in exploring this model as part of a broader circular bioeconomy approach, given Armenia's dependence on imported fish feed and the lack of organized fish-waste valorization. If developed, BSF-based systems could simultaneously reduce waste and produce local feed inputs, as demonstrated in comparable international pilots.

4.4 Circularity Gaps and Pain Points

Despite some progress, Armenia's fishing and aquaculture value chain still faces significant gaps in achieving circularity. These gaps exist across multiple domains – technological, regulatory, financial, and market – and they result in lost economic opportunities and environmental harm. Here we identify the major circularity gaps and associated pain points, and where possible compare Armenia's situation to international best practices to highlight the deficiencies:

Technological Gaps

- **Limited Waste Treatment and Valorization Technology:** Limited waste treatment and valorization technologies remain a structural weakness in Armenia's aquaculture value chain. **At the fish farm level,** residues such as sludge, mortalities, and nutrient-rich effluents are rarely collected or treated through modern solutions (e.g., composting or anaerobic digestion). Small farm size, geographic dispersion, limited access to capital, and lack of collective infrastructure constrain investment in such technologies. **At the processing stage,** waste streams (offal, heads, bones, viscera, blood) are largely underutilized. Unlike countries with established rendering and fishmeal industries, Armenia has no dedicated fishmeal plants or integrated by-product processing facilities. The main limiting factors include insufficient scale, high capital and energy costs, weak vertical integration, and underdeveloped regulatory and market frameworks*. Pain point:* valuable proteins and nutrients are lost, increasing dependence on imported feed inputs while creating environmental risks from poorly managed residues. Addressing this gap would require coordinated investment and policy support to overcome scale and structural constraints.
- **Lack of Full RAS Implementation:** Most farms still do *not* have fully closed-loop systems. The **technologies for efficient RAS (e.g. advanced filters, UV sterilizers, oxygenation systems)** are expensive and not widely available in Armenia. Many farmers aren't trained to operate them. Compared to best practice (e.g. in the Netherlands or Denmark, where land-based fish farms achieve >90% water reuse with sophisticated RAS), Armenian farms are at a basic level of water reuse. *Pain point:* Until RAS tech is fully adopted, **groundwater over-extraction continues**, threatening the aquifer and competing with agriculture. Water loss is also a hidden economic cost – while water isn't priced highly now, wells running dry mean some farms will literally not be able to operate in the future. The technological gap here also means fish effluent is not captured for nutrient recovery – it flushes out, causing **eutrophication** (nutrient pollution) in receiving waters. Lake Sevan has experienced algal blooms partly due to nutrient inflow, to which fish hatcheries and agriculture both contribute; better waste treatment tech would mitigate this.
- **Energy-Inefficient Systems:** Many Armenian fish farms rely on aging pumps and aeration systems, contributing to high electricity use and operating costs. Renewable energy integration appears limited, and no large-scale use of solar, heat pumps, or energy-recovery systems has been documented. In contrast, international best practice (particularly in Scandinavia) shows extensive use of heat pumps to recover heat from water, optimized pumping systems, and increasing adoption of solar energy for RAS operations. *Pain point:* The absence of such technologies in Armenia raises both production costs and the carbon footprint of farmed fish. Energy-efficient and circular solutions, such

as solar-assisted pumping or thermal energy recovery, remain largely untapped opportunities for the sector.

- **Insufficient Cold Storage and Processing Tech in Some Segments:** While Armenia's larger aquaculture processors have modern chilling, freezing, and processing equipment, many small-scale actors, such as artisanal fishers or small smokehouses, often operate with limited or outdated refrigeration and processing technology. This uneven cold-chain capacity can lead to quality deterioration and potential post-harvest losses, particularly in warm seasons, although these losses are not formally quantified. In more advanced value chains, temperature control is maintained at every stage to minimize waste; in Armenia, this level of cold-chain consistency is not yet universal, contributing to variable product quality and economic losses for smaller operators.
- **Gear Recycling Technology/Infrastructure Absent:** Armenia currently lacks facilities to collect or recycle polymer fishing nets and aquaculture gear. As a result, old nets are typically stored on-site or disposed of, with no mechanism to recover value from spent materials. In contrast, several countries, such as Norway through the Nofir system, and EU member states with port-based collection schemes, operate dedicated programmes that recycle nets into nylon granulate and yarn. *Pain point:* The absence of similar infrastructure in Armenia has environmental consequences, including the risk of wildlife entanglement from lost nets and long-term microplastic pollution, as well as economic losses because farmers cannot recover any value from used gear.

Regulatory and Institutional Gaps

- **Enforcement and Compliance Issues:** Armenia may have introduced progressive regulations (e.g. mandatory RAS, waste-management), but **enforcement is lagging**. For example, the legislation requires identification and regular reporting of fish waste, while in the reality only a few farms comply with the regulations. *Pain point:* the country has limited enforcement capacity and the absence of clear operational guidelines or supporting infrastructure.
- **Lack of Extended Producer Responsibility (EPR) or Take-Back Schemes:** There are no regulations making producers responsible for their waste or end-of-life gear. Internationally, there's a trend toward **EPR for fishing gear** (the EU, for instance, has directives on port reception facilities for waste gear and is considering EPR). In Armenia, once a net or packaging leaves a factory, the producer has no responsibility. Possibly, EPR costs could be placed on fish farms rather than on processors, given the current consumption structure, where fish is mainly sold live in retail stores. However, this could lead to inflation of fish products, particularly in the absence of subsidies. *Pain point:* This means **no incentives for companies to design products for recyclability or to arrange for collection**. For example, feed companies provide feed in large plastic sacks – these often end up burned or dumped on farms. If an EPR scheme existed (or even a deposit-return for sacks), those could be returned and recycled. The absence of such frameworks contributes to plastic pollution and waste of materials.
- **Environmental taxes and Rights:** The regulatory regime for water use historically allowed cheap, virtually unlimited use of groundwater for fish farms. Although regulations have tightened recently, including stronger permit requirements and enforcement measures, the tax rate of groundwater remains extremely low and does not reflect its scarcity or environmental value. This provides little economic incentive for farms to invest in water-saving or recirculation technologies.

Historically, illegal wells were common, and although many have been closed in recent years, the risk of continued aquifer overdraft persists. In the absence of more robust pricing or enforcement, the cost of extraction can remain lower than the cost of adopting water-efficient technologies, undermining incentives for circularity and sustainable water use. A similar issue exists with fish waste disposal.

- **Fragmented Governance and Lack of Cooperatives:** The fish farmers association exists, but true cooperative schemes (e.g. sharing of infrastructure for waste management or joint investments in feed production) are lacking. The Georgian value-chain analysis shows a similar weakness: *"lack of cooperatives and interprofessional agreement"* as a weakness in aquaculture[135]. In Armenia, this translates to each farm acting alone, which is inefficient for circular solutions. For example, a single small farm cannot economically build a fertilizer plant from its sludge – but a cooperative of farms might pool waste to justify one. *Pain point:* Without collective action mechanisms, **economies of scale are missed** for circular investments, and small players are left out. This institutional gap slows adoption of innovations that would benefit from a cluster approach.
- **Standards and Certification Gaps:** There is currently no national standard or certification for sustainable/circular aquaculture. Unlike countries that use eco-labels or organic standards to incentivize better environmental performance, Armenian fish farms operate without a label that rewards circular practices. *Pain point:* The lack of market differentiation means no price premium for sustainable fish, which could otherwise motivate farmers to invest in circular improvements. It also means consumers (domestic or foreign) can't easily identify if a fish was produced with circular methods, missing an opportunity to leverage consumer choice to drive change.

Financial and Market Gaps

- **High Upfront Costs, Low Access to Finance:** Many circular solutions (RAS, waste processing units, renewable energy installations, etc.) require **significant capital investment**. Armenian fish farmers, especially small and medium ones, often lack access to affordable financing for such upgrades. Commercial banks may be hesitant to lend for unfamiliar technologies, or interest rates may be high. There have been some government loan subsidy programs for agriculture, but none specifically tailored to circular upgrades in aquaculture. *Pain point:* This financial gap is arguably the **biggest practical barrier** – even willing farmers struggle to afford expensive RAS or waste equipment. Without financial support (grants, low-interest loans, or co-investments), many will delay compliance or cut corners, perpetuating linear practices. The environmental consequence is continued resource waste; the economic consequence is that only a few well-capitalized firms modernize, potentially squeezing out smaller players (a social equity issue).
- **Market fails to reward circularity (yet):** Armenia's export markets (particularly Russia, the primary destination for farmed trout and sturgeon) do not currently offer price premiums for sustainably or circularly produced aquaculture products. These markets are largely volume- and price-driven, in contrast to Northern Europe, where eco-labels and organic standards can command a premium. Because Armenia lacks domestic certification schemes and sells mainly into markets with low demand for sustainability attributes, producers who invest in water recirculation, waste management, or other circular practices cannot recover these additional costs through higher prices.

[135] European Commission. "Freshwater aquaculture value chain analysis in Georgia". June 2022

Pain point: This reflects a classic market failure: environmental externalities are not priced, so producers using linear, higher-impact methods face lower costs and may have a competitive advantage unless regulation levels the playing field.

- **Reliance on Imported Inputs:** A circular economy also implies more local self-sufficiency and closed loops. Armenia's heavy reliance on imported feed is a gap in this sense – it's both a vulnerability (exposed to exchange rates, international fishmeal supply issues) and a missed circular opportunity (since local agricultural by-products could potentially be used in feed). Right now, up to 80% of high-protein feed is imported, meaning nutrients are brought from elsewhere and after use, wastes are disposed locally, with no mechanism to return nutrients to the origin. *Pain point:* If supply chains falter (as seen during COVID or geopolitical tensions), fish farmers face feed shortages or price spikes, threatening their operations. International practice is moving towards more local or novel feed resources (like insect meal, algae, or integrating agriculture-fisheries). Armenia's gap is the absence of a local feed industry that could, for example, use some fish processing waste or other local ingredients to make feed – a circular loop that remains open.
- **Knowledge and Human Capacity Gaps:** A softer gap, but important: many farmers and workers are not yet fully aware of circular practices or trained in them. Without knowledge, even if equipment is available, optimal use is not guaranteed. *Pain point:* This can lead to **misuse or underperformance of new systems** (e.g. a farm installs RAS but runs it incorrectly, achieving poor results and then abandoning it). It can also mean slower innovation diffusion – farmers may be skeptical of unfamiliar practices until they see local proof and gain know-how.

Environmental and Social Consequences of Gaps

It's worth explicitly linking how these gaps impact the environment and economy:

- The **water management gap** has led to severe **aquifer depletion**. Environmentally, this threatens wetlands and other users (the aquifer also supports irrigation and drinking water in some villages). Economically, if water continues to dwindle, the entire fish farming industry is at risk of collapse in some areas. This "tragedy of the commons" scenario is a direct consequence of not closing the water loop.
- **The potential concentration of antibiotics along the value chain.** Antibiotics may enter the system through imported fish feed or veterinary treatments used in aquaculture, and their residues can accumulate in fish biomass as well as in processing by-products and waste streams. In the absence of systematic monitoring, these residues may pose risks to environmental health, food safety, and the viability of circular-economy solutions such as fishmeal, compost, or bioenergy production. Addressing this risk would require strengthened monitoring and control mechanisms, both for imported fish feed and for residues generated during fish processing and waste recycling, in line with international food safety and environmental standards.
- The **waste gap** (no treatment/utilization) results in **pollution**: nutrient effluents contribute to algae blooms (like in Lake Sevan, where fish waste and other sewage cause declining water quality), and dumping of solid waste can attract pests and cause odor/public health issues. These environmental issues can, in turn, hurt tourism (Sevan's water quality is important for recreation) and impose cleanup costs on society.

- The **gear and plastic waste gap** contribute to **plastic pollution**. Lost or discarded nets in Sevan entangle birds and fish; microplastics from degrading equipment may enter food chains. Socially, scenic areas get blighted by trash if not managed (not good for communities or tourism). Removing these after the fact is expensive (e.g. divers periodically have to retrieve ghost nets – an avoidable cost if recycling/prevention were in place).
- The **financial and market gaps** mean that smaller farmers are **struggling to adapt**, which could widen inequality in the sector. Big players may manage to invest and thrive, while small family farms could be left behind, possibly going out of business if they cannot meet new standards or afford new tech. That has social implications (loss of rural jobs) and could concentrate the industry (less resilience). It also slows overall progress: if a significant subset of farmers doesn't implement circular practices, the aggregate environmental benefit is reduced.
- The **lack of local feed loop** means Armenia is indirectly contributing to pressure on wild fisheries elsewhere (since fishmeal is often made from wild-caught fish). There's a global concern about that – as the WEF article noted, *"one third of global wild fish catch is used for feed or wasted, so using by-products for feed is a big opportunity"*[136]. Armenia not utilizing by-products means it is not helping to alleviate that wider issue – in fact it's part of it by importing feed made from wild fish, while throwing away local fish waste that could replace some fishmeal. In circular terms, it's a glaring inefficiency and environmental disconnect.

Summary of Pain Points: Technologically, **waste of resources** (water, nutrients, energy) and **pollution** are the symptoms. Regulatory-wise, **lack of compliance and incentives** hinder progress. Financially, **investment barriers** slow technology adoption. Market-wise, **no reward for good behaviour** perpetuates the status quo. And underlying all is the challenge of aligning all actors to act in concert rather than at cross purposes. These gaps and pain points underscore that while the vision and initial steps toward circularity exist in Armenia, substantial interventions are needed to overcome the current limitations.

[136] WEF. "To feed the world, we need to waste less fish. Here's how". September 29, 2022 https://is.gd/kyQPKY

4.5 Case Examples and International Benchmarks

4.5.1 Opportunities for Armenia to enhance circularity

Despite the challenges detailed above, there are numerous **opportunities for Armenia to enhance circularity** in its fishing and aquaculture value chain. By learning from global best practices and leveraging local initiatives, Armenia can implement measures that close loops, reduce waste, and create value from by-products. Below we detail specific opportunities across technology, policy, and business models:

Technology and Infrastructure Opportunities

- **Scaling Recirculating Aquaculture Systems (RAS):** International experience shows that RAS can reduce water use by more than 90 percent compared with flow-through systems, while also concentrating effluent and lowering nutrient discharge. Given that fish farms in the Ararat Valley collectively extract around a billion cubic meters of groundwater each year—far exceeding natural recharge rates—broad adoption of partial or full recirculation could substantially reduce pressure on the aquifer. Although Armenia has begun requiring closed-circulation systems, the transition remains incomplete. With targeted government support and donor co-financing, Armenia could accelerate retrofitting of medium and large farms over the next several years. Global research indicates that RAS can improve fish growth rates and survival by providing tightly controlled water quality, which may lead to higher productivity compared to open-flow systems. Countries such as Norway have promoted RAS development through research and innovation funding, offering useful lessons for Armenia. Establishing technical training programs and financial support mechanisms could help build the capacity needed to operate these systems effectively. In the long term, adopting advanced water-saving technologies could not only reduce groundwater extraction and pollution but also position Armenia to market its aquaculture products as produced with state-of-the-art, resource-efficient methods.
- **Fish Waste Processing Facility (Fish By-Product Hub):** Armenia currently lacks any organised system for valorising fish processing waste, even though international experience shows that such by-products can be turned into high-value products. In Norway, for example, around 80 percent of the total harvest and up to 99 percent of salmon farming by-products are utilised in some form, including fishmeal, fish oil, collagen and other ingredients[137]. Armenia's opportunity would be to start with a modest facility focusing on 1–2 products. For example, a fishmeal and oil plant could process the ~5,000–6,000 tonnes/year of offal into ~1,000–1,200 tonnes of fishmeal and a smaller amount of fish oil. At recent international prices, this could correspond to several million US dollars' worth of products annually, turning what is currently an environmental burden into an economic resource. Another possibility is the production of organic fertiliser from dried sludge and bones, providing local farmers with an alternative nutrient source and reducing reliance on imported synthetic fertilisers. Public-private partnership might be needed to build this plant – perhaps an existing agri-processing company diversifying into fish waste with government incentive. Ensuring steady supply is key: thus,

[137] Business Norway. "How the Life Sciences Sector Uses Marine Residuals to Create Sustainable Products.". March 9, 2023. https://is.gd/xeavkb

regulation must require all processors to send waste to the facility (or sell it). A logistics network for cold collection of fish waste from farms/processors to the plant will be needed – this can create a few new jobs (waste collection services). Iceland's experience, where specialized companies and plants now utilize most parts of the fish, offers a useful model that Armenia could adapt on a smaller scale[138]. Donor funding (EU, FAO) could assist in feasibility and initial investment. Ultimately, such a hub would bring Armenia from nearly zero to high by-product utilization, closing loops and adding revenue.

- **Renewable Energy and Bioenergy Integration:** Armenia's aquaculture sector has significant potential to integrate renewable energy solutions that reduce operating costs and environmental impacts. Globally, fish waste can be digested anaerobically, and studies show methane yields typically in the range of 80–120 m³ of biogas per tonne of wet waste. A centralized digester that co-processes fish waste with manure or slaughterhouse residues could therefore generate substantial amounts of renewable energy, replacing fossil fuels and capturing methane that would otherwise escape during decomposition. Although no such facility currently exists in Armenia, international experience—such as in Norway and Denmark—demonstrates the feasibility of these systems. Additional opportunities include installing solar photovoltaic systems to power pumps and aerators and applying heat exchangers to recover residual heat from the warm artesian water used on many farms. These measures could reduce long-term energy costs and help align Armenian aquaculture with emerging sustainability requirements in export markets. Government incentives, such as green-energy grants or pilot power-purchase agreements for biogas-generated electricity, would support adoption. In combination, these interventions could lower the carbon footprint of aquaculture while improving energy resilience for producers.
- **Advanced Cold Chain and Product Preservation:** Building on improvements, Armenia can further optimize the cold chain using technology. One opportunity is to use digital tools (IoT sensors) in transport and storage to monitor temperature and humidity in real-time, ensuring no breaks (some advanced logistics companies do this to guarantee quality - Armenia's exporters could adopt the same, especially for sensitive items like caviar). Additionally, food processing innovations like individual quick freezing (IQF) for fish portions or modified atmosphere packaging (MAP) can extend shelf-life and reduce spoilage. Quantifiable impact: If better preservation cuts post-harvest losses by even 2%, that's an extra ~500 tonnes of fish per year reaching market instead of waste (worth perhaps USD 1+ million). It also could allow reaching farther markets (like EU) without quality loss. Success factors: Partnering with companies (maybe an EU trade program) to transfer these technologies. For instance, a Dutch-Armenian project could demonstrate MAP packaging for Armenian trout, which could open sales to high-end EU retailers with guaranteed freshness, fetching higher prices. Combining quality with sustainability (e.g. labeling packaging that it's recyclable or reusable) can enhance brand value.

Policy and Market-based Opportunities

- **Economic Incentives for Circular Practices:** Armenia could accelerate the adoption of circular technologies in aquaculture by introducing targeted economic incentives. These may include tax deductions or credits for capital investments in pollution control, waste valorization, or recirculating

[138] Arctic today. "The New Fish Wave: The Iceland Ocean Cluster Turns 10". May 23, 2021 https://is.gd/K6rcsj

aquaculture systems (RAS), as well as VAT or customs-duty exemptions for importing environmentally efficient equipment—similar to incentives previously used for renewable energy technologies. International practice offers relevant models: for example, Vietnam has provided low-interest loans to shrimp farmers investing in water-treatment infrastructure. Additional incentive mechanisms could include tiered water-pricing schemes that reward reduced groundwater use or guaranteed purchase schemes for renewable energy or organic fertilizer produced from fish waste. Such policies would lower financial barriers, reduce risk for early adopters, and help ensure markets for circular outputs. Success will depend on careful policy design, clear communication, and close engagement with producers to ensure the incentives are understood and utilized.

- **Adopting Certification and Eco-Labeling:** Armenia can work towards obtaining internationally recognized certifications for its fish products, such as Aquaculture Stewardship Council (ASC) certification or even organic certification for certain farms (if they meet criteria like no antibiotics, etc.). Achieving these standards often inherently requires circular practices (ASC standards include criteria on waste management, effluents, resource use). By positioning "Armenian Trout" or "Sevan Trout" as a sustainably farmed, eco-friendly product, they could carve a niche in European or premium markets. For example, ASC-certified salmon often sells at a premium in EU supermarkets. If an Armenian farm becomes ASC certified (perhaps the first in the Caucasus), it could gain access to these higher-margin markets. Even a 5-10% price premium on exported fish could translate to millions in added revenue annually, which then justifies the cost of certification and better practices. Additionally, an "Armenian Eco-Fish" label could be created domestically to raise consumer awareness. While domestic consumers are price-sensitive, a segment (especially restaurants and health-conscious buyers) might pay a bit more for fish tagged as environmentally friendly. Over time, as seen in many countries, consumer pressure complements regulatory pressure to improve industry standards.
- **Circular Business Models and Entrepreneurship:** Encouraging new businesses that thrive on circular economy principles is a key opportunity. For instance, insect farming (black soldier fly) on organic waste as mentioned - government or donors could fund a pilot facility that uses fish waste to produce insect protein for feed. If successful, this could reduce feed import needs and spawn a new agri-tech sector. Another business model: shared resource platforms - for example, a company that rents out RAS mobile units or sludge processing equipment to multiple small farms (like a service model). If one farm alone can't afford tech, perhaps a service provider can install a unit and charge farms per use or volume treated. This is analogous to how some companies offer mobile milk chillers to dairy farms in some countries. Success factor: Support from innovation grants and incubators - Armenia's tech/startup scene could be tapped to look at circular bioeconomy solutions. Perhaps an annual "Blue Economy Innovation Challenge" could be launched, soliciting ideas to solve fisheries waste and efficiency problems, with winners getting seed funding. Such entrepreneurship can fill gaps that top-down approaches miss, and create jobs.
- **International Partnerships and Learning:** Armenia can actively seek partnerships with countries that are advanced in circular aquaculture. For example, twinning arrangements with Norway or the Netherlands: exchange programs where Armenian farm managers visit Norwegian salmon farms to see 100% waste utilization in action, and Norwegian experts help adapt those practices to Armenian species. Twinning arrangements or exchange programs—where Armenian farm managers visit Norwegian salmon operations to observe best-practice systems for high-level

(>80%) by-product utilization and water-efficient farming—could accelerate learning. International experts have previously visited Armenia and expressed satisfaction with the quality of Armenian fish products (arka.am), suggesting a foundation for deeper cooperation focused on sustainability. Regionally, Armenia could collaborate with Georgia and Moldova, whose aquaculture sectors share similar structures and challenges. A joint capacity-building project or a regional training center on circular aquaculture practices could attract support from EU instruments such as ENI CBC or Interreg NEXT. Such partnerships would help Armenia adopt proven technologies faster and potentially attract foreign investment—for example, a Norwegian firm participating in the development of a by-product processing facility.

- **Strengthening Enforcement and Support Systems:** Armenia has adopted several regulations on water use, waste management, and RAS installation, but enforcement remains limited. A key opportunity is to strengthen compliance mechanisms by pairing enforcement with support. After a clear grace period, the government could introduce systematic audits of fish farms for compliance with RAS and waste management requirements. Farms found non-compliant could face penalties but also receive technical assistance to help them meet the standards—an approach used in EU environmental compliance systems. Establishing a dedicated unit or interagency task force within the Ministry of Environment to oversee aquaculture sustainability could further improve transparency and coordination.

4.6 International Benchmarks

In this section, we present two case studies that serve as benchmarks for circular economy practices in fishing and aquaculture – one from a global leader in the field, and one from a peer country with a similar context to Armenia. These examples will highlight concrete measures implemented, results achieved, and insights that Armenia can draw upon.

Case Study 1: Norway – A Global Leader in Circular Aquaculture

Norway is the world's leading producer of Atlantic salmon and has a long-established, technologically advanced aquaculture industry. Faced with environmental challenges and high production volumes, Norway has pioneered circular economy approaches to minimize waste and maximize resource efficiency in fisheries and aquaculture.

Norwegian companies and regulators have introduced a wide range of circular initiatives and practices spanning the entire aquaculture value chain:

- **High Utilization of Fish By-Products:** Norway has achieved one of the world's highest rates of resource utilization in fisheries and aquaculture. More than 80 percent of the total fish harvest is used in some form, with salmon farming approaching near-total utilization of by-products. Fish heads, viscera, skins, and trimmings are no longer treated as waste but as valuable raw materials, processed into fishmeal and fish oil for aquaculture and pet feed, or into food and specialty products. For example, cod heads are dried and exported as food to African markets, while salmon processing residues are rendered into high-protein meal and oil. This high utilization is underpinned by strict regulation: disposal of fish processing waste is tightly controlled, and companies must document waste handling and recovery. As a result, landfill disposal of fish by-products is minimal, pollution risks are reduced, and additional revenue streams are created.
- **Innovative Waste-to-Product Technologies**: Norwegian firms have pioneered technologies that convert aquaculture waste into high-value products. Companies such as **Bioretur** install systems at land-based salmon facilities to capture fish sludge (feces and uneaten feed), which is dried and processed into organic fertilizer. Large producers, including **Grieg Seafood**, report producing tens to hundreds of tonnes of dried sludge annually in certain regions, all of which is valorized rather than discarded. Beyond fertilizers, Norwegian enterprises extract collagen from fish skins for cosmetic and biomedical uses, and chitin from shrimp shells for nutraceutical applications—demonstrating how low-value residues can be upgraded into high-value bio-products.
- **Gear and Material Circularity**: Norway is also a global leader in recycling fishing gear and aquaculture materials. The company **Nofir** operates an international system for collecting discarded fishing nets, ropes, and cages; since 2011 it has recovered more than 40,000 tonnes of gear worldwide. These materials are recycled—often by partners such as **Aquafil**—into nylon yarn used in textiles and carpets (e.g., Econyl). Norwegian ports are required to accept used gear free of charge to prevent dumping, and policy incentives support collection and recycling. Some salmon farms now use ropes and cages made from recycled plastics, and in 2020 the first full-scale salmon pens made entirely from recycled nylon were launched, marking a significant step toward closed material loops.

- **Energy and Resource Efficiency**: Resource efficiency is further enhanced through advanced water and energy management. Many Norwegian salmon hatcheries operate recirculating aquaculture systems (RAS), typically reusing more than 95 percent of water and significantly reducing effluent discharge. Fish sludge and other organic residues are increasingly viewed as energy resources; studies highlight the substantial theoretical potential of aquaculture waste for biogas production, with digestate reused as fertilizer. In parallel, research and pilot projects are exploring biodegradable or low-impact materials for nets and feed sacks to reduce plastic pollution risks.
- **Regulatory Framework and Industry Collaboration**: Norway's progress is supported by a strong regulatory framework combined with close industry collaboration. Environmental standards impose limits on discharges and require waste management planning, while industry-research platforms such as the **Norwegian Seafood Innovation Cluster** facilitate joint pilots, knowledge sharing, and rapid diffusion of circular solutions. This cooperative model has accelerated adoption of waste-drying, recycling, and resource-recovery technologies.

Case Study 2: Georgia – Moving Toward Circular Practices in a Peer Context

Georgia, like Armenia, is a post-Soviet country with an emerging aquaculture sector and a mix of freshwater fish farming (trout, carp, sturgeon) and Black Sea capture fisheries. Its aquaculture production—amounting to only a few thousand tonnes annually—is smaller than Armenia's but comparable in species composition and structural challenges, including reliance on imported feed, water management constraints, and underdeveloped cold-chain logistics. Georgia is a relevant peer country because it faces similar resource-management issues and has been actively modernizing its fisheries and aquaculture value chain with support from the EU, USAID, and other development partners.

Georgian aquaculture has traditionally relied on semi-intensive systems, notably large carp ponds inherited from the Soviet period and newer tank-based trout farms. A 2022 EU-supported value-chain analysis estimated that only around 20 percent of Georgia's theoretical aquaculture water potential is currently utilized, suggesting room for expansion but also highlighting the need for careful water governance. The analysis identified key constraints, including dependence on imported feed, limited training in modern production and post-harvest techniques, and inefficient distribution practices—such as transporting live fish in small, uninsulated vehicles—which increase fuel use, stress fish, and raise mortality. These challenges closely mirror those observed in Armenia.

Below are presented the circularity-related practices and emerging opportunities in Georgia:

- ***Integration of Agriculture and Aquaculture (Polyculture):*** A notable positive practice in Georgia is the continued use of polyculture in carp ponds. Farms commonly stock multiple species—such as herbivorous carp, predatory species, and filter-feeding silver carp—to exploit different ecological niches and feed sources. Local agricultural by-products (e.g., bran, corn, grasses) are often used as feed inputs. This system exemplifies a traditional circular approach, where farm by-products support fish growth and fish waste fertilizes ponds, sustaining plankton productivity.

Such low-input, nature-based solutions offer lessons for Armenia, including the potential use of nutrient-absorbing species or plants in effluent channels.

- ***Water Management Awareness:*** While most Georgian farms still operate flow-through systems, awareness of water efficiency is growing. Some trout farms, particularly in water-constrained regions of western Georgia, have experimented with partial water reuse. At the governance level, Georgia is advancing reforms toward basin-based water management and greater stakeholder inclusion, including fish farmers. This participatory approach—through water-user associations or local planning bodies—offers a relevant model for Armenia's Ararat Valley.
- ***Cold-Chain Improvements:*** EU-supported analyses explicitly recommend replacing live fish transport with chilled transport using refrigerated trucks. In response, donor-supported programs have facilitated the acquisition of refrigerated vehicles for cooperatives and supported the establishment of new trout processing facilities capable of filleting and packing fish for export. These changes reduce transport losses, improve product quality, and lower fuel use, representing a clear efficiency and waste-reduction gain.
- ***Waste Management and Marine Initiatives:*** In Black Sea fisheries, Georgia has piloted small-scale "Fishing for Litter" activities in selected ports, encouraging fishers to bring collected marine debris to shore for proper disposal. Although limited in scale, these pilots promote environmental awareness and reduce marine pollution. Some recovered gear is being stored with the intention of future recycling, potentially through regional recycling schemes.
- ***Moving Up the Value Chain:*** Georgia's efforts to access higher-value export markets—particularly the EU—have required improvements in sanitary and environmental standards. In this context, at least one sturgeon processing company reportedly installed a wastewater treatment unit to meet EU discharge requirements, illustrating how market-access ambitions can drive investments in cleaner production.

International experience highlights that circular economy practices in aquaculture can deliver both environmental and economic gains. Norway's experience demonstrates how a shift in mindset—from treating waste as a disposal problem to viewing it as a valuable resource—can underpin high by-product utilization, reduced pollution risks, diversified revenues, and greater sector resilience. This transformation has been driven not by a single policy tool, but by the combined effect of strict regulation, sustained investment in infrastructure and technology, and close collaboration among government, industry, and research institutions. While Armenia operates at a much smaller scale, Norway's example shows that early investment in utilization infrastructure, clear enforcement of environmental rules, and coordinated action across the value chain can generate long-term returns that outweigh initial costs.

Georgia's experience, though more modest, offers complementary and highly relevant lessons for Armenia. Pilot-level interventions—such as shifting from live fish transport to chilled distribution, improving cold-chain logistics, maintaining polyculture pond systems, and composting fish pond residues with livestock manure—have shown that even low-tech, incremental improvements can reduce losses, lower costs, and close nutrient loops. These examples underline that circularity does not always require large capital investments; basic operational changes can yield immediate benefits. Georgia also illustrates the importance of policy direction: alignment with EU standards has acted as a strong incentive for firms to invest in cleaner and more efficient practices. Armenia can similarly leverage its EU export ambitions to raise domestic standards. Finally, both cases point to the value of regional cooperation. Joint initiatives with Georgia—such as shared programs for fishing-gear recycling, feed innovation, or benchmarking water use and farm performance—could help achieve economies of scale, accelerate learning, and support Armenia’s transition toward a more circular and resilient aquaculture sector.

5 FRUIT AND VEGETABLE PROCESSING SECTOR IN ARMENIA: CIRCULAR ECONOMY VALUE CHAIN ANALYSIS

5.1 Sector Overview and Context

5.1.1 Global Background

The fruit and vegetable processing sector is a significant component of the global agri-food system, linking primary agricultural production with domestic and international food markets. In the context of this study, fruit and vegetable processing is defined as the industrial transformation of horticultural produce into processed food and beverage products, including juices, preserved and processed goods, dried fruits and vegetables, as well as products of grape processing (wine and grape spirits), intended for year-round consumption and export.

At the global level, fruit and vegetable processing is embedded in a multi-stage value chain encompassing primary agricultural production, collection and aggregation, industrial processing, distribution to domestic and export markets, and final consumption. In this broader context, fruits and vegetables are consistently identified as product groups associated with relatively high levels of loss and waste within global food systems. Globally, losses arising from fruits and vegetables account for approximately 16% of total food waste and contribute around 6% of global greenhouse gas emissions, with similar patterns observed in both developed and developing countries[139][140].

Empirical evidence indicates that the non-edible portion of fruits and vegetables generated after industrial processing—such as peels, skins, seeds, pomace, and other organic residues—typically accounts for approximately 10–50% of the total weight of fresh produce, depending on product type and processing technology. In absolute terms, fruit-processing industries alone are estimated to generate more than 0.5 billion tonnes of waste annually worldwide[141]. These waste streams represent not only disposal and environmental management challenges, but also significant losses of potentially valuable biomass and nutrients.

The scale of processing-related residues is particularly evident in specific product streams. For example, the global citrus juice industry alone produces over 110 million tonnes of peel and pulp waste annually[142]. In the absence of effective recovery and valorisation pathways, these materials are

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[139] Food and Agriculture Organization of the United Nations (FAO). 2017. The State of Food Security and Nutrition in the World 2017: Building Resilience for Peace and Food Security. Rome: FAO. https://www.fao.org/3/I7695e/I7695e.pdf

[140] Jiménez-Moreno, N., I. Esparza, F. Bimbela, L.M. Gandía, and C. Ancín-Azpilicueta. 2020. Valorization of selected fruit and vegetable wastes as bioactive compounds: Opportunities and challenges. Critical Reviews in Environmental Science and Technology, Vol. 50, pp. 2061–2108. https://doi.org/10.1080/10643389.2019.1694819

[141] Bancal, V., Ray, R. C. (2022). *Overview of Food Loss and Waste in Fruits and Vegetables: From Issue to Resources.* In: Fruits and Vegetable Wastes (Chapter 1, pp. 1–XX). Springer, Singapore. https://www.researchgate.net/publication/370628243_Overview_of_Food_Loss_and_Waste_in_Fruits_and_Vegetables_From_Issue_to_Resources

[142] Food Technology and Biotechnology (FTB). *A Review on Innovative Biotechnological Approaches for the Upcycling of Citrus Fruit Waste to Obtain Value-Added Bioproducts*. https://www.ftb.com.hr/archives/1951

commonly landfilled, used as low-value animal feed, or otherwise discarded, despite their potential to be converted into higher-value products such as pectin, biopolymers, fertilizers, and bioenergy.

Alongside organic residues, the linear fruit and vegetable processing value chain also generates other waste streams, including packaging materials used at the processing, storage, and distribution stages. These include primarily plastic packaging, as well as glass containers and other packaging materials. However, within the scope of this study, the analysis is limited to waste directly associated with fruit and vegetable processing, with a primary focus on organic residues generated during processing.

These global patterns highlight the importance of focusing analytical attention on the processing stage, where large and relatively homogeneous streams of organic waste are generated and where circular economy interventions can deliver the greatest environmental and economic returns. In this context, the subsequent sections assess Armenia's fruit and vegetable processing sector and its circular economy potential, with a particular emphasis on organic waste arising from processing activities.

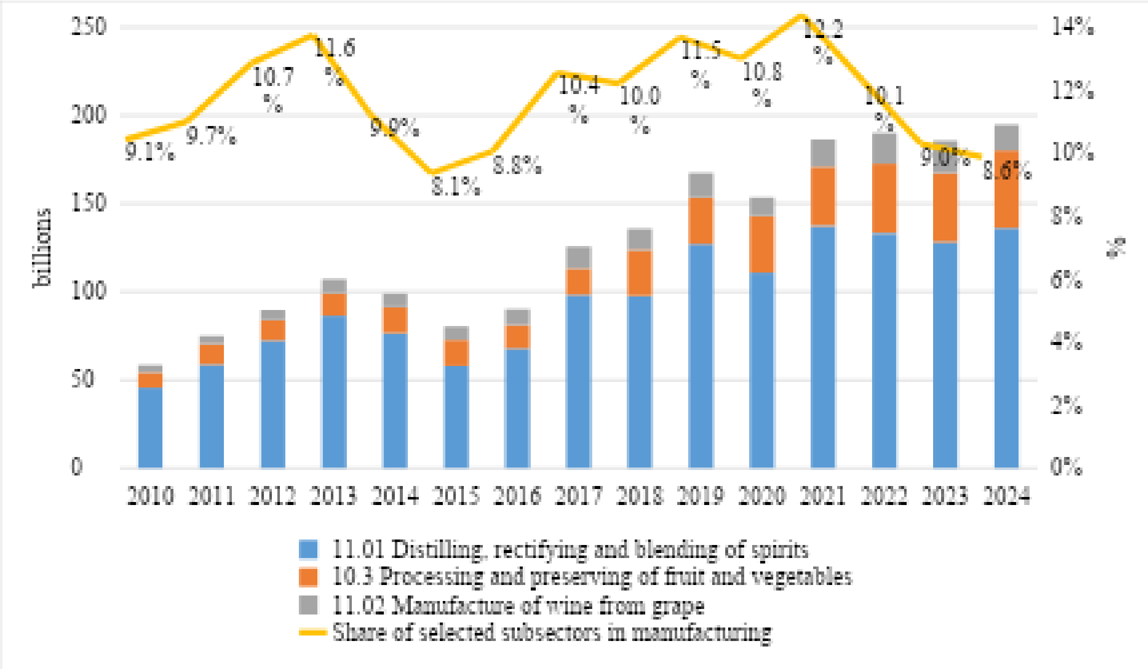
5.1.2 Armenia's Fruit and Vegetable Processing Sector: Structure and Economic Significance

Fruit and vegetable processing has long been an important and historically significant sector in Armenia's economy, dating back to the Soviet era. Over time, the sector has evolved into a structured manufacturing segment linking primary agricultural production with domestic and external markets. Through its processing activities, it contributes to rural income generation, agro-industrial employment, and the commercialisation of agricultural output.

For the purposes of this analysis, the sector is defined in accordance with NACE Rev.2 classification, covering Group 10.3 (Processing and preserving of fruit and vegetables), as well as grape-based processing activities under NACE Rev.2 11.02 (Manufacture of wine from grape) and 11.01 (Distilling, rectifying and blending of spirits). Trade flows are analysed using the corresponding HS codes, including Chapter 20 (Preparations of vegetables, fruit, nuts or other parts of plants; HS 2001–2009), HS 2204 (Wine of fresh grapes), and HS 2208.20 (Spirits obtained by distilling grape wine or grape marc).

Industrial production dynamics in Armenia's fruit, vegetable, and grape processing sector during 2010–2024 indicate sustained medium-term expansion, while remaining sensitive to external macroeconomic and trade-related factors. From 2010 to 2024, total nominal output increased from AMD 58.4 billion to AMD 194.8 billion, representing growth of about 3.3 times. At the same time, the sector's development trajectory was not linear and reflected the impact of external shocks and fluctuations in export demand.

Figure 38. Volume of Industrial Production in the Fruit, Vegetable, and Grape Processing Sector (NACE 10.3, 11.01–11.02), Armenia (2010–2024, current prices), with Share of Total Manufacturing



Source: Statistical Committee of the Republic of Armenia (Armstat)

During 2010–2013, the sector experienced rapid growth (+83%), coinciding with the post-crisis recovery of regional markets and the expansion of export supplies. In 2014–2015, a significant contraction followed (-7.6% and -18.9%), synchronised with the currency crisis in the Russian Federation, ruble depreciation, and a decline in external demand. This underscores the sector's strong dependence on export dynamics, particularly the Russian market.

The period 2016–2019 was characterised by accelerated recovery growth, including a sharp increase in 2017 (+39.3%), amid improving demand conditions and expanding export channels. In 2020, output declined (-8.3%) due to the COVID-19 pandemic and related logistical disruptions; however, in 2021 the sector rebounded rapidly (+21.4%), reaching a new historical peak.

In 2022–2024, growth stabilised with moderate fluctuations, reflecting adjustments in trade flows, changing logistics routes, and adaptation to a transformed regional environment.

The structural impact of subsectors on overall growth varied considerably. Over 2010–2024:

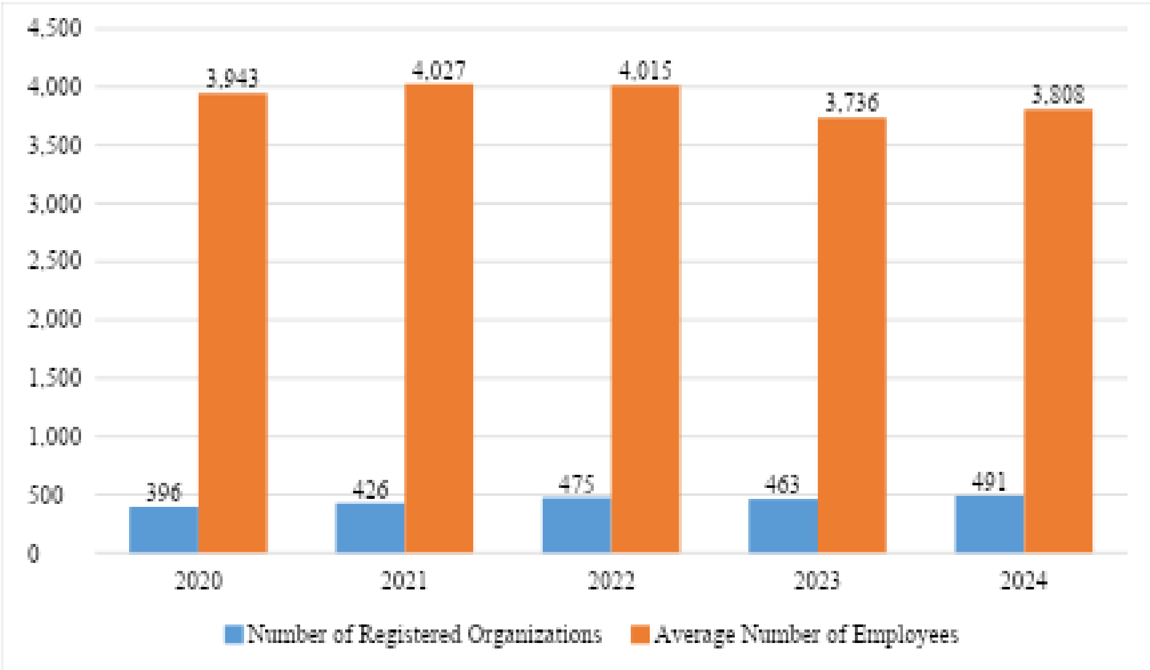
- production of distilled grape spirits (NACE 11.01) increased about 2 times (from AMD 45.7 billion to AMD 136.2 billion);
- processing and preserving of fruit and vegetables (NACE 10.3) expanded more than fivefold – from AMD 8.6 billion to AMD 44.0 billion, demonstrating the highest relative growth rate;

- wine production (NACE 11.02) grew from AMD 4.5 billion to AMD 14.6 billion, showing an increase of about 3 times.

Throughout the entire period, the combined share of these subsectors in total manufacturing output remained within the 8–12% range, reaching a peak of 12.2% in 2021 and standing at 8.6% in 2024. Even during downturns, the sector remained within this corridor, confirming its stable structural role within Armenia's manufacturing base rather than a peripheral agro-processing niche.

Alongside the growth in production volumes, the organisational base of the sector has also expanded. According to administrative statistics (NACE 10.3 — *processing and preserving of fruit and vegetables*), the number of registered organisations increased from 396 in 2020 to 491 in 2024, representing growth of 24%. At the same time, average employment in this segment remained relatively stable, fluctuating within the range of approximately 3,700–4,000 employees.

Figure 39. Number of Registered Organizations and Average Employment in Fruit and Vegetable Processing (NACE 10.3), Armenia, 2020–2024



Source: State Revenue Committee of the Republic of Armenia

The divergence between the increasing number of enterprises and stable employment levels suggests that expansion has occurred primarily through the entry of small and medium-sized operators rather than through large-scale industrial consolidation. This confirms the structurally fragmented nature of the fruit and vegetable processing segment.

Additional insight into the sector's structure is provided by data from the Ministry of Economy of the Republic of Armenia[143]. According to official estimates, approximately 69 enterprises operate in fruit and vegetable processing, of which eight are considered relatively large processors: **Artashat Cannery OJSC, Proshyan Brandy Factory LLC, Yeghegnadzor Cannery LLC, Ararat Food Factory LLC,**

[143] Ministry of Economy of the Republic of Armenia. *Agro-processing Industry Overview*. https://www.mineconomy.am/en/page/1327

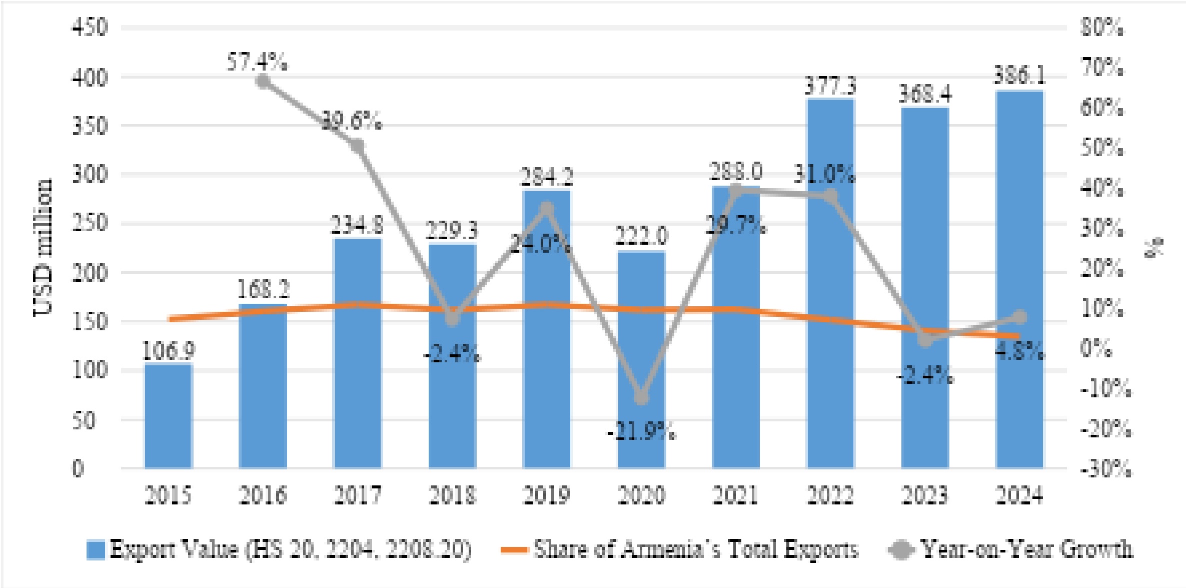
Ararat Canning Factory LLC, Euroterm CJSC, MAP CJSC, and Yerevan Beer CJSC. The total annual processing capacity of this segment is estimated at approximately 250,000 tons of fruits and vegetables.
Within this broader category, a significant number of operators are small-scale producers, including those engaged in dried food products and spices. The combined processing capacity of this subsegment is estimated at approximately 15,000 tons per year, indicating its niche and predominantly small-scale character within the overall processing landscape.

Grape processing represents a structurally distinct and more capital-intensive segment, encompassing wine and grape spirit production. Armenia hosts approximately 50 grape-processing enterprises, of which 12 are relatively large producers: **Yerevan Brandy Factory CJSC, Artashat Vinco CJSC, Ijevan Wine Brandy Factory CJSC, Yerevan Ararat Brandy-Wine-Vodka Factory OJSC, Proshyan Brandy Factory LLC, Ararat Wine Factory LLC, Avshar Wine Factory LLC, Wine Brandy House Shahnazaryan LLC, AKZ LLC, Samkon LLC, Armenia Wine Factory LLC, and Vedi Alco LLC**. The total grape-processing capacity is estimated at approximately 265,000 tons per year.

Comparing these segments reveals structural differences in concentration. While fruit and vegetable processing (NACE 10.3) remains highly fragmented with a large number of small operators, grape processing exhibits a higher concentration of capital and production capacity. This distinction has direct implications for circular economy analysis: larger processing facilities tend to generate more concentrated and technologically homogeneous streams of organic by-products, whereas the fragmented structure of NACE 10.3 results in more dispersed and heterogeneous material flows.

Export performance further reinforces the sector’s structural importance within Armenia’s external trade profile. Between 2015 and 2024, export increased from USD 106.9 million to USD 386.1 million, representing cumulative growth of +261% (more than 3.6 times). This expansion significantly outpaced overall production growth and confirms the sector’s increasing export orientation.

Figure 40. Export Value, Growth and Share in Total Exports Armenia’s Fruit, Vegetable and Grape Processing Products (HS 20, 2204, 2208.20), 2015–2024



Source: UN Comtrade data

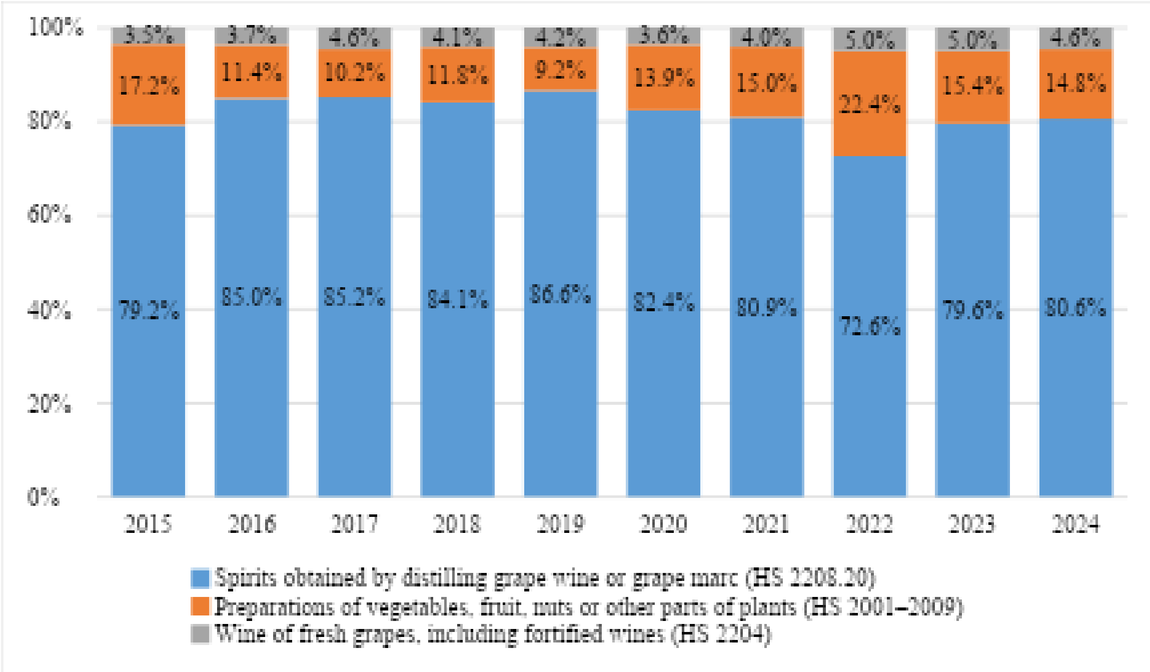
The growth trajectory, however, was cyclical. Rapid expansion in 2016 (+57.4%) and 2017 (+39.6%) marked a phase of export scaling and market penetration. A subsequent slowdown in 2018 (-2.4%) was followed by renewed growth in 2019 (+24.0%), indicating recovery of demand in key markets.

The contraction in 2020 (-21.9%) reflects the impact of COVID-19-related trade disruptions, logistical bottlenecks, and temporary demand contraction, particularly in HoReCa-sensitive segments. The sector demonstrated strong resilience in 2021 (+29.7%) and 2022 (+31.0%), recovering lost volumes and reaching a new export peak of USD 377.3 million in 2022. Although growth moderated in 2023 (-2.4%), exports increased again in 2024 (+4.8%).

Despite robust absolute growth, the sector's share in Armenia's total exports declined from 7.2% in 2015 to 3.0% in 2024. This relative decline reflects the faster expansion of other export sectors in the Armenian economy rather than a weakening of fruit, vegetable, and grape processing exports themselves. In absolute terms, the sector strengthened its export base and foreign currency earnings capacity.

The internal composition of exports reveals a pronounced structural concentration around deep grape processing.

Figure 41. Product Composition of Exports in the Fruit, Vegetable and Grape Processing Sector (HS 20, 2204, 2208.20), Armenia, 2015–2024 (%)



Source: UN Comtrade data

Throughout the reviewed period, grape spirits (HS 2208.20) consistently dominated the export basket, accounting for between 72% and 87% of total export value. In 2024, they represented 80.6% of sector exports; the highest concentration was observed in 2019 (86.6%).
Processed fruit and vegetable products (HS 2001–2009) formed the second-largest export category, with their share fluctuating between 9% and 22%. The structural shift in 2022, when the share reached 22.4%, suggests temporary diversification in export composition, potentially linked to changing demand patterns or market reorientation. By 2024, the share stabilised at 14.8%, confirming its structurally secondary yet economically relevant role.

To better understand the composition of this segment, the internal distribution of exports across HS 2001–2009 product groups was considered. The internal composition of processed fruit and vegetable exports (HS 2001–2009) reveals a structurally concentrated yet moderately evolving product mix over the reviewed period. Throughout most years, exports were dominated by HS 2008 (other prepared fruits and nuts) and HS 2005 (prepared vegetables, non-frozen), which jointly accounted for the largest share of the segment. While HS 2008 prevailed in 2015–2019, its relative weight declined after 2021, coinciding with a stronger impact from HS 2005 and a marked expansion of prepared tomatoes (HS 2002) in 2023–2024. Jams and purées (HS 2007) and fruit juices (HS 2009) maintained stable mid-range shares, whereas the remaining categories played a marginal role in aggregate export value.

Wine exports (HS 2204) remained comparatively modest in scale, accounting for approximately 3–5% of total sector exports. Although the share increased slightly in 2022–2023 (up to 5.0%) and stood at 4.6% in 2024, wine exports remain significantly smaller in aggregate value than grape spirits. However, this does not imply lower value intensity, as unit price analysis suggests otherwise.

Overall, the export structure demonstrates that the bulk of export revenues is generated by grape distillation, while wine and processed fruit and vegetable products contribute more moderately in value terms.

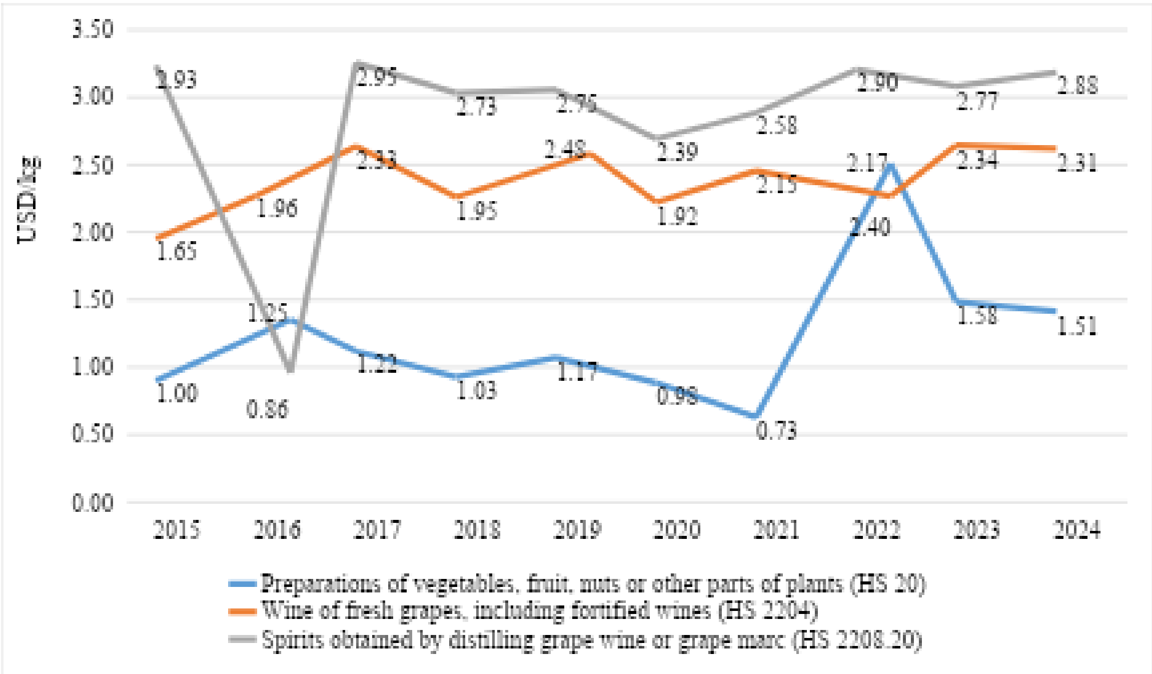
Export unit value analysis provides additional insight into value-added formation across product categories (Figure 6).

Grape spirits (HS 2208.20) exhibit the highest unit value levels, generally ranging between USD 2.39 and USD 2.95 per kilogram across most years. The irregular decline in 2016 (USD 0.86/kg) likely reflects reporting or shipment structure effects rather than structural price compression. In 2024, the unit value reached USD 2.88/kg, confirming the consistently high price density of distilled grape products.

Wine (HS 2204) demonstrates relatively stable and gradually increasing unit values, ranging from USD 1.65 to USD 2.48/kg over the period and reaching USD 2.31/kg in 2024. This suggests steady price positioning and potential movement toward higher-value segments, particularly in niche and premium markets.

Processed fruit and vegetable products (HS 20) show greater volatility. After fluctuating between USD 1.00–1.25/kg in 2015–2019 and declining to USD 0.73/kg in 2021, unit values surged to USD 2.40/kg in 2022 before stabilising at USD 1.51/kg in 2024. This volatility likely reflects shifts in product mix, destination markets, and temporary price effects rather than uniform quality upgrading.

Figure 42. Dynamics of Export Unit Value (USD/kg) for Fruit, Vegetable and Grape Processing Products (HS 20, HS 2204, HS 2208.20), Armenia, 2015–2024



Sourse: UN Comtrade data

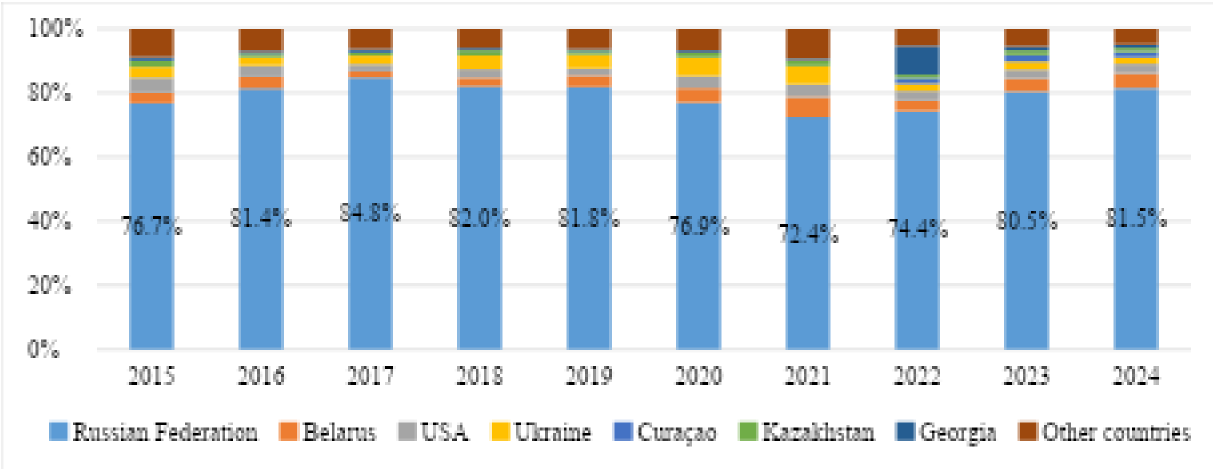
Taken together, the combination of:

- a dominant export share of grape spirits,
- and their consistently high unit value,

indicates that grape distillation constitutes the principal driver of export revenue and value creation within the sector.

An analysis of export destinations reveals a persistently high degree of geographic concentration, with the Russian Federation serving as the dominant external market throughout the entire period.

Figure 43. Export Market Concentration by Destination Country (HS 20, 2204, 2208.20), Armenia, 2015–2024



Source: UN Comtrade data

Between 2015 and 2024, Russia's share in total exports of fruit, vegetable, and grape processing products fluctuated within a range of 72–85%; the highest share was recorded in 2017 (84.8%). In 2024, the Russian market accounted for 81.5% of total sector exports, reaffirming its structural dominance in the sector's external trade profile.

Even during periods of relative diversification (notably 2020–2022), Russia consistently absorbed more than 70% of exports, underscoring the sector's systemic dependence on a single destination market.

A second group of markets includes Belarus, Ukraine, and the United States, although their individual shares remain significantly lower. Belarus accounted for between 1.9% and 6.3% of exports, peaking in 2021. Exports to Ukraine exhibited notable volatility (2.0–5.7%), reflecting regional instability. The United States maintained a relatively stable share in the range of 2–4%, indicating presence in higher-value segments but without substantial scale.

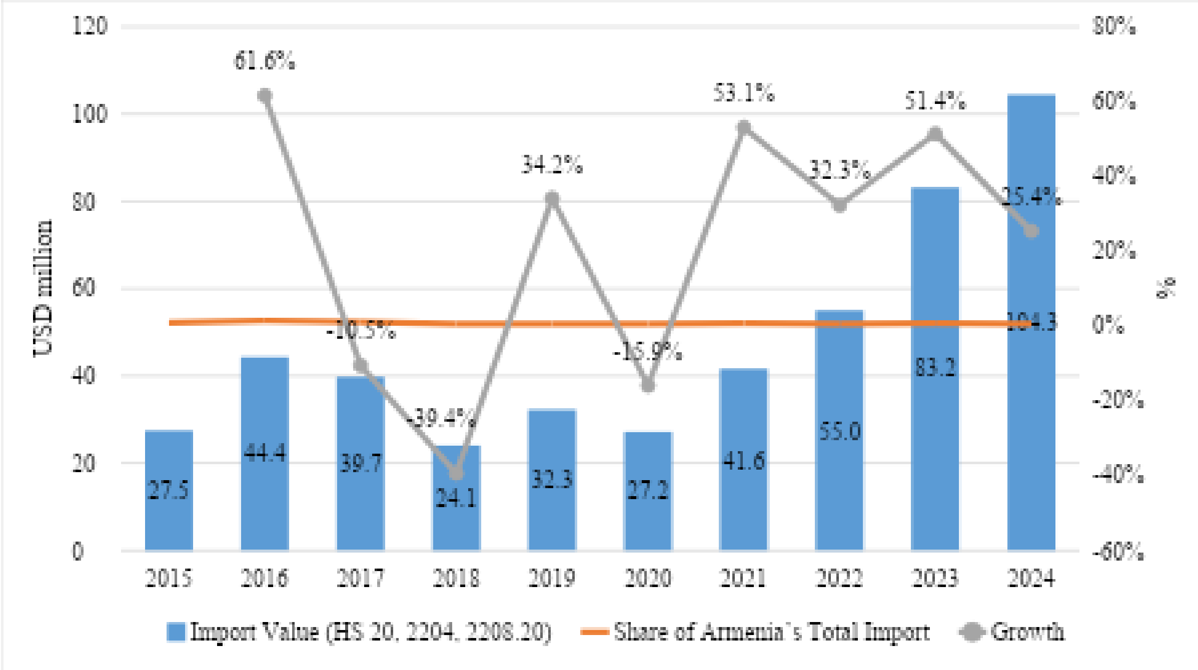
One of the distinctive structural shifts occurred in 2022, when Georgia's share temporarily increased to 8.9%, significantly exceeding its historical average (typically below 1–2%). This likely reflects adjustments in logistics routes and reconfiguration of regional trade flows amid geopolitical and supply-chain disruptions.

UN Comtrade data indicate the emergence of Curaçao as an export destination beginning in 2022 (1.7–2.0%); however, Armstat data do not record Curaçao in a comparable manner. This discrepancy most likely reflects subsequent adjustments in Armenia's official export statistics (e.g., clarification of the final destination country), while corresponding revisions may not have been incorporated into the UN Comtrade mirror database.

Meanwhile, the aggregate share of "other countries" declined from 8.9% in 2015 to 4.8% in 2024, indicating a tendency toward sustained concentration rather than progressive diversification.

While export dynamics highlight the sector's outward orientation, import patterns provide important additional context regarding domestic demand structure, competitive pressures, and product complementarity within the Armenian market.

Figure 44. Import Value, Share in Total Imports and Growth of Armenia's Fruit, Vegetable and Grape Processing Products (HS 20, 2204, 2208.20), 2015–2024



Source: UN Comtrade data

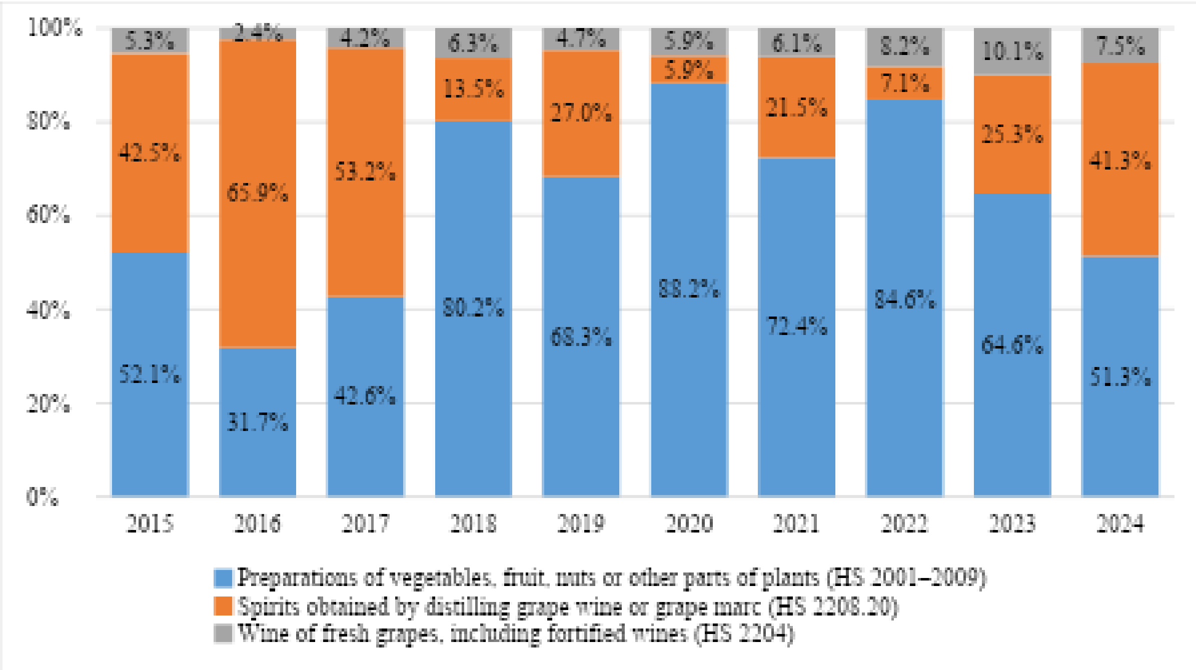
Between 2015 and 2024, import value increased from USD 27.5 million to USD 104.3 million, representing cumulative growth of almost 3.8 times. In 2024, import value amounted to roughly 27% of export value, confirming that Armenia maintains a strong net export position in this product group.

Import growth was highly volatile. A sharp increase was recorded in 2016 (+61.6%), followed by contraction in 2017 (–10.5%) and a pronounced decline in 2018 (–39.4%). Recovery resumed in 2019 (+34.2%), before another downturn in 2020 (–15.9%), reflecting pandemic-related disruptions similar to those affecting exports.

A particularly notable acceleration occurred in 2021–2024, with growth of +53.1% (2021), +32.3% (2022), +51.4% (2023), and +25.4% (2024). The strong increase in 2023–2024 suggests expanding domestic demand for imported products, possible premium segment growth, and increased market openness. Despite this growth, the sector’s share in Armenia’s total imports remained limited, fluctuating between 0.5% and 1.4%, and standing at 0.6% in 2024.

The product structure of imports demonstrates pronounced variability and alternating dominance of product categories, in contrast to exports, where grape spirits consistently prevail.

Figure 45. Product Composition of Imports in the Fruit, Vegetable and Grape Processing Sector (HS 20, 2204, 2208.20), Armenia, 2015–2024 (%)



Source: UN Comtrade data

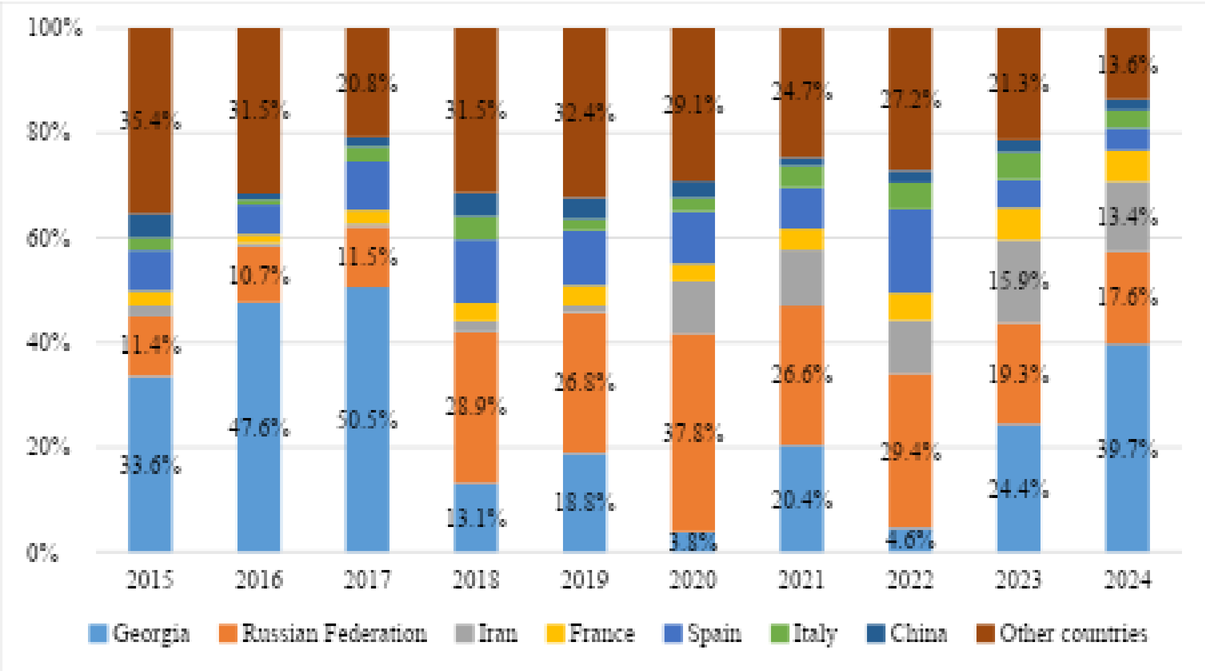
Throughout most of the reviewed period, processed fruit and vegetable products (HS 2001–2009) accounted for the largest share of imports. Their share fluctuated from 31.7% in 2016 to 88.2% in 2020. Between 2018 and 2022, this segment consistently exceeded 68%, reaching 84.6% in 2022. In 2024, its share stood at 51.3%. This pattern suggests that imports are largely oriented toward preserved and processed food products, likely including specialized or branded items that are not fully represented in domestic production.

Imports of grape spirits (HS 2208.20) exhibit high volatility. In certain years, they dominated the import structure—reaching 65.9% in 2016 and 53.2% in 2017. However, their share declined sharply in subsequent years (to 5.9% in 2020 and 7.1% in 2022) before increasing again to 41.3% in 2024. Wine imports (HS 2204), on the other hand, remain comparatively moderate in scale but show a gradual increase in recent years—from 5.3% in 2015 to 10.1% in 2023, before adjusting to 7.5% in 2024. This trend indicates sustained demand for imported wine products, particularly in premium and niche segments that complement domestic offerings.

Overall, the structure of imports indicates that the domestic market is largely supplied by national production—especially in the grape distillation segment—while imports primarily play a complementary role. Rather than substituting mass domestic output, imports contribute to product diversification, broaden price and quality categories, and satisfy specialized or niche consumer demand that is not fully covered by domestic production capacity.

The geographic structure of imports is considerably more diversified compared to exports. Georgia consistently ranks among the largest suppliers, although its share demonstrates substantial fluctuations — from more than 50% in 2016–2017 to 39.7% in 2024. This dynamic may reflect competitive pressures in the wine and spirits segments, as well as shifts in regional trade patterns.

Figure 46. Import Structure by Country of Origin (HS 20, 2204, 2208.20), Armenia, 2015–2024



Source: UN Comtrade data

The Russian Federation also remains an important supplier; however, its share has gradually declined — from levels exceeding 30% in 2018–2020 to 17.6% in 2024. This trend indicates a progressive diversification of import sources.

The role of Iran has increased significantly, with its share reaching 15.9% in 2023 and 13.4% in 2024. European Union countries — primarily France, Spain, and Italy — maintain stable, albeit moderate, positions in the import structure. Their supplies are likely concentrated in premium wine and higher-value processed categories.

Meanwhile the share of partners included in "other countries" declined from 35.4% in 2015 to 13.6% in 2024, suggesting a gradual consolidation of import flows around a more stable group of trading partners.

Overall, Armenia's fruit, vegetable, and grape processing sector constitutes a structurally significant and export-oriented segment of the national manufacturing industry; between 2010 and 2024, total output more than tripled. Export dynamics demonstrate strong expansion, with grape distillation (HS 2208.20) serving as the principal driver. This segment dominates both in terms of export share and unit value, underpinning the sector's value-added generation. At the same time, exports remain highly geographically concentrated, primarily oriented toward the Russian market, which creates structural dependence and exposure to external shocks.

Imports, by contrast, remain relatively modest in scale and more diversified in composition. Their role is predominantly complementary — expanding product variety and satisfying niche demand rather than substituting mass domestic production.

5.1.3 Policy Context

Effective management of organic residues generated during fruit, vegetable, and grape processing requires a clear regulatory framework, defined institutional responsibilities, and appropriate economic instruments. When large and relatively homogeneous streams of organic material arise at the industrial processing stage—such as peels, seeds, pomace, grape marc, and other biodegradable residues—the feasibility of recovery, reuse, or valorisation depends not only on technological solutions, but also on how these streams are classified, what regulatory requirements apply to them, and how state oversight is exercised. In this regard, the role of government is central: it determines whether such materials are treated as waste or as by-products, establishes sanitary and environmental standards for their handling, and shapes the incentives that influence whether they are landfilled, used in low-value applications, or integrated into circular production chains.

In Armenia, the primary legal act governing waste management—including streams generated by agro-processing enterprises—is the "Law of the Republic of Armenia on Waste (2004, as amended)"[144]. The law establishes the general principles of waste management, defines the responsibilities of waste generators, and regulates collection, transportation, storage, treatment, and disposal activities. Organic residues from fruit and vegetable processing, when not reused within the production cycle, fall under this legal framework as industrial waste. The legislation obliges economic operators to ensure environmentally sound handling of waste and to prevent harm to human health and the environment. However, the law does not explicitly provide sector-specific procedures tailored to biodegradable agro-industrial residues, nor does it explicitly differentiate between potentially hazardous industrial waste and biologically degradable by-products with recovery potential.

At the strategic level, Armenia's environmental policy framework emphasizes modernization of the waste management system, reduction of landfill dependency, and strengthening of regulatory and institutional capacity. The "National Environmental Action Programme (NEAP)"[145] outlines priorities related to waste governance, infrastructure development, and improved enforcement mechanisms. In parallel, analytical reports prepared by the World Bank on Armenia's solid waste management sector[146] have identified structural challenges in governance, infrastructure limitations, and the need for systemic reform of the waste management system.

[144] Law of the Republic of Armenia on Waste (Adopted 24 November 2004, with subsequent amendments) https://cis-legislation.com/document.fwx?rgn=99878&utm

[145] National Environmental Action Programme of the Republic of Armenia (NEAP), Ministry of Environment of the Republic of Armenia. https://ace.aua.am/wp-content/uploads/2019/06/2008-2nd-National-Environmental-Action-Program.pdf

[146] World Bank (2016; 2020). Solid Waste Management in Armenia – Technical and Analytical Assessments, Washington, DC. https://documents1.worldbank.org/curated/en/099110124070522534/pdf/P501643-bcc395c0-b81a-4210-8b6c-1f0b8eaa8daf.pdf

Nevertheless, policy attention has historically focused primarily on municipal solid waste management—particularly landfill rehabilitation and regional waste infrastructure—while industrial organic residues from food processing have received comparatively limited targeted policy intervention. As a result, although general waste legislation applies to agro-processing enterprises, a dedicated regulatory or incentive-based framework specifically designed to stimulate the valorisation of fruit and vegetable processing residues remains underdeveloped.

In parallel, sanitary and food safety regulations—administered by the Food Safety Inspectorate Body of the Republic of Armenia—influence the permissible pathways for reusing processing residues, particularly when such materials are intended for secondary applications such as animal feed, soil amendments, or further industrial transformation. The Law of the Republic of Armenia on Food Safety[147] and related implementing regulations establish hygiene, traceability, and quality requirements that must be met before such materials can be reintroduced into economic circulation. In practice, limited publicly available sector-specific standards and streamlined procedures for recognizing certain organic residues as usable by-products may increase regulatory costs and discourage higher-value recovery models.

Overall, Armenia's current regulatory and strategic framework provides general environmental governance applicable to organic waste generated in the fruit and vegetable processing sector, but it does not yet constitute a comprehensive, sector-specific policy architecture aimed at systematic valorisation of agro-industrial bio-residues. Legal mechanisms to prevent environmental harm and ensure sanitary oversight are in place; however, targeted economic incentives, specialized technical guidance, and integrated planning for bio-waste recovery remain limited. Consequently, the practical implementation of circular economy principles in this sector depends largely on enterprise-level initiatives rather than on a coherent public policy framework explicitly designed to unlock the resource potential of organic processing residues.

[147] Law of the Republic of Armenia on Food Safety (Adopted 21 June 2014, with subsequent amendments); Food Safety Inspectorate Body regulations. https://faolex.fao.org/docs/pdf/arm69365E.pdf

5.2 Value Chain Mapping and Material Flow

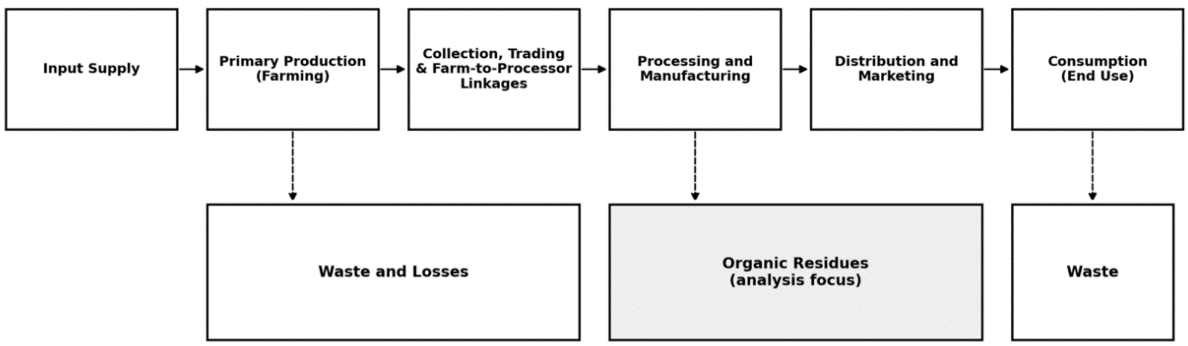
Against this background, it is necessary to analyze the value chain in order to understand how value is created, distributed, and captured across different stages of the sector. This section examines the sector not through aggregate production and trade indicators (already presented in Section 5.1), but through the logic of material flows: how the raw material base is formed, how agricultural products move toward processors, how they are transformed at the industrial stage, and how outputs are subsequently allocated between export markets, domestic consumption, and final use.

The fruit, vegetable, and grape processing value chain in Armenia is shaped by two structural characteristics: the high seasonality of primary production and the strong export orientation of processing activities, which together influence quality requirements, logistics, and flow stability. In its current configuration, the system remains predominantly linear: resources move sequentially from input supply and farming to collection and aggregation, industrial processing, distribution, and consumption, after which a significant share of materials exits economic circulation.

Material losses and waste may arise at multiple stages of the chain. However, within the framework of this analysis, primary attention is given to organic residues generated at the industrial processing stage, as this is where the most concentrated, relatively homogeneous, and technologically manageable biomass streams are formed, offering the greatest practical potential for circular economy interventions.

On this basis, the following figure presents the current configuration of the value chain and its main material flows.

Figure 47. Current Fruit and Vegetable Processing Value Chain



Source: Ameria team analysis based on stakeholder consultations with industry representatives and public institutions, and review of sector statistics

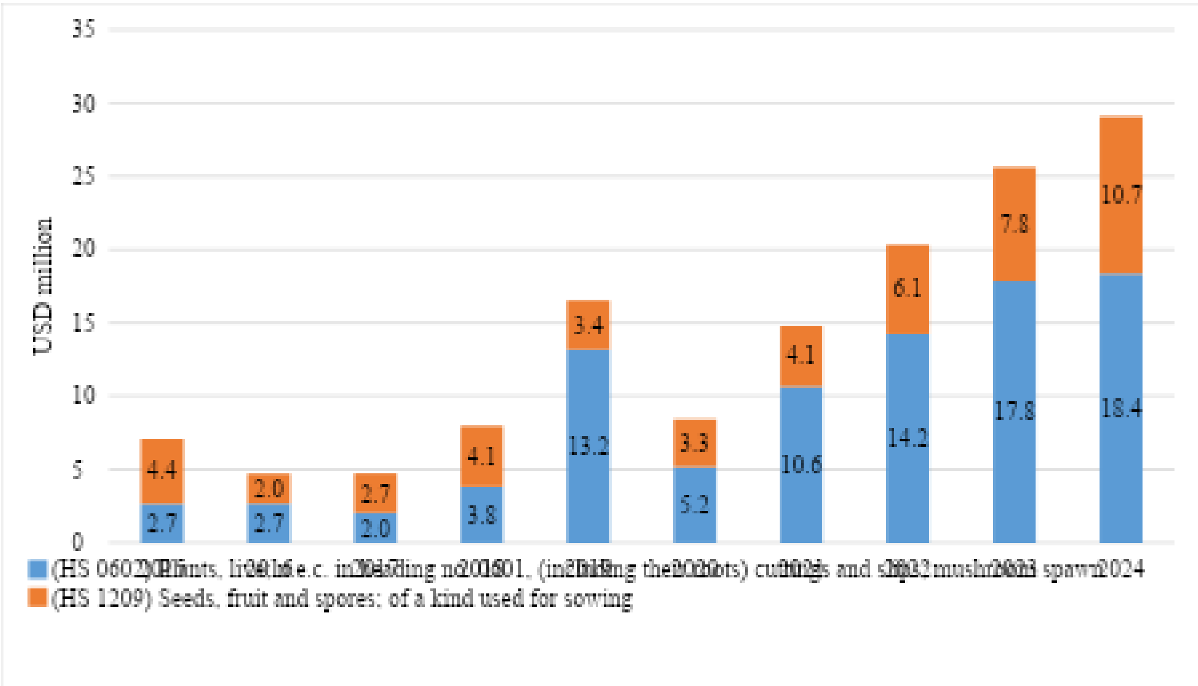
The following subchapters provide a detailed analysis of each stage of the value chain. They examine the key actors, activities, and processes at every stage, as well as the linkages that connect them. In addition, the discussion highlights the flow of goods, services, and value across the chain, identifying the factors that influence efficiency, competitiveness, and potential for upgrading. This structured approach ensures a comprehensive understanding of the sector’s value creation and distribution mechanisms.

5.2.1 Input Supply

The upstream stage of Armenia’s fruit and vegetable processing value chain is shaped by a significant reliance on imported agricultural inputs. From a material-flow perspective, these inputs can be grouped into primary raw inputs — forming the biological foundation of production — and auxiliary inputs, which support yield formation, crop protection, and quality stabilization. This distinction allows a clearer understanding of how the structure of input supply influences primary production and, subsequently, processing volumes.

Imports of seeds for sowing (HS 1209) and live plants and planting material (HS 0602) demonstrate a pronounced upward trend over 2015–2024. Imports of planting material increased from USD 2.7 million in 2015 to USD 18.4 million in 2024, representing more than a sixfold expansion. Seed imports also grew steadily, rising from USD 4.4 million to USD 10.7 million during the same period (approximately +143%). Such strengthening of the biological production base directly determines the scale and varietal composition of agricultural raw materials entering the processing stage.

Figure 48. Import Dynamics of Planting Material and Seeds (HS 0602, HS 1209), Armenia, 2015–2024 (USD million)

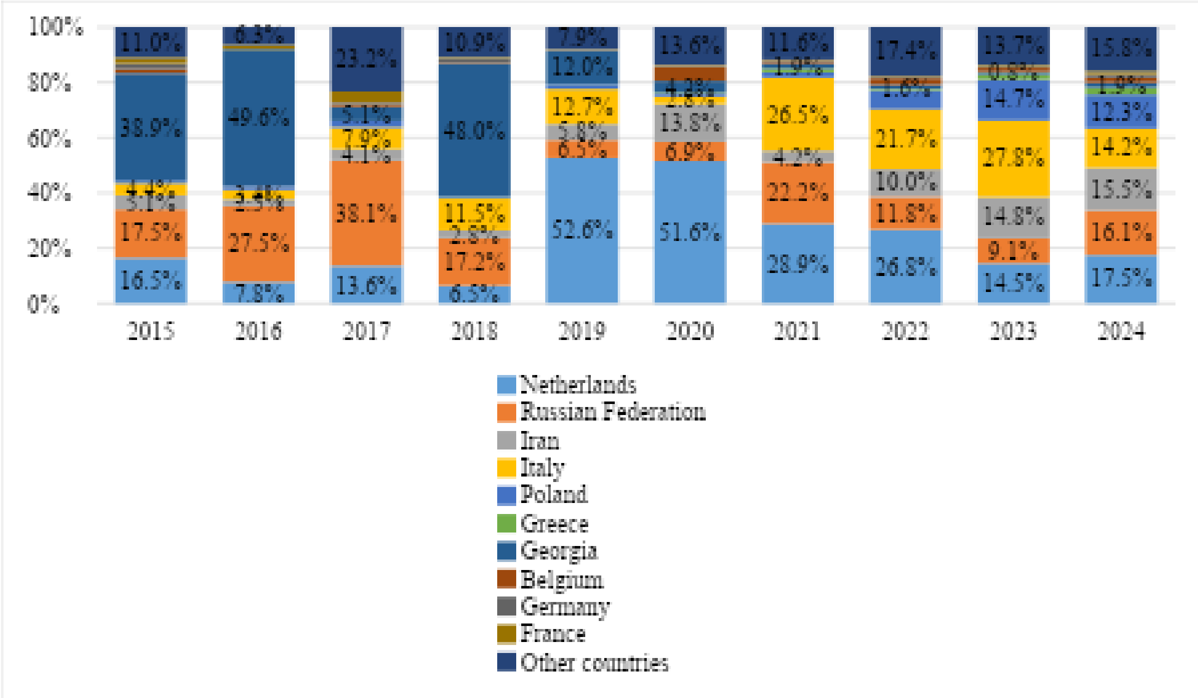


Source: UN Comtrade data

The supplier structure of these biological inputs has evolved considerably. In the earlier years, imports were more concentrated among neighboring countries, particularly Georgia and the Russian Federation. Over time, however, sourcing became more diversified. By 2024, imports were distributed relatively evenly among several key partners: the Netherlands (17.5%), the Russian

Federation (16.1%), Iran (15.5%), Italy (14.2%), and Poland (12.3%). While this diversification reduces excessive dependence on a single supplier, Armenia remains structurally dependent on imported high-quality genetic material essential for fruit, vegetable, and grape production.

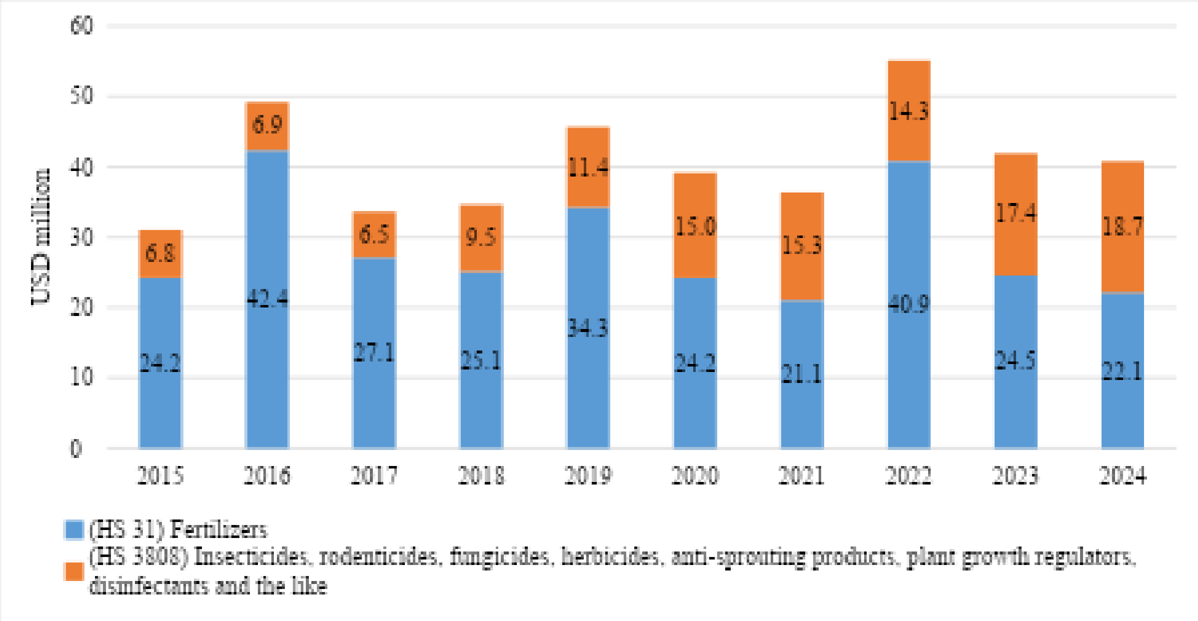
Figure 49. Supplier Structure of Armenia's Imports of Seeds and Planting Material (HS 0602, HS 1209), 2015–2024 (%)



Source: UN Comtrade data

Auxiliary inputs are represented by fertilisers (HS 31) and plant protection products (HS 3808), which ensure crop productivity and mitigate production risks. In contrast to biological inputs, fertiliser imports are substantially larger in absolute value and display considerable volatility. Over 2015–2024, fertiliser imports fluctuated between USD 21–42 million annually, with peaks in 2016 and 2022 reflecting global commodity price shocks. In 2024, fertiliser imports amounted to USD 22.1 million, slightly below mid-period levels. Imports of plant protection products followed a more stable upward trajectory, increasing from USD 6.8 million in 2015 to USD 18.7 million in 2024 (approximately +175%), indicating intensification of agricultural practices and greater reliance on crop protection measures.

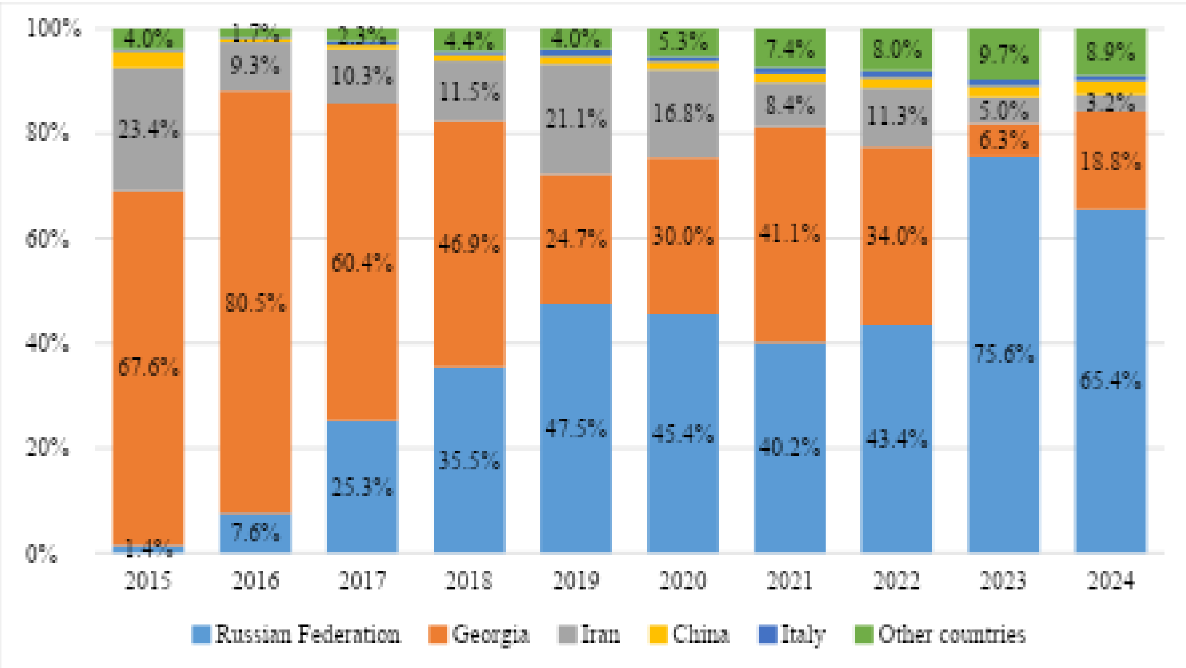
Figure 50. Imports of Chemical Agricultural Inputs (HS 31, HS 3808), Armenia, 2015–2024 (USD million)



Source: UN Comtrade data

The supplier structure of chemical inputs remains more concentrated and geopolitically sensitive. Georgia dominated imports in the early period, accounting for up to 80% in 2016, while the Russian Federation's share expanded significantly after 2017. By 2023, Russia accounted for 75.6% of fertiliser and agrochemical imports and remained dominant in 2024 with 65.4%. Such concentration increases exposure to regional trade dynamics and external supply disruptions.

Figure 51. Supplier Structure of Armenia's Imports of Fertilisers and Plant Protection Products (HS 31, HS 3808), 2015–2024 (%)



Source: UN Comtrade data

Overall, the input supply stage of Armenia's fruit and vegetable processing value chain is characterized by high import dependence for both primary and auxiliary inputs, partial diversification in biological sourcing, and persistent concentration in chemical inputs. This configuration shapes the economic resilience, risk profile, and material intensity of the entire value chain.

The structure and scale of input use at this upstream stage directly influence the volume and quality of agricultural output generated at the farming level. The following section therefore examines how these inputs translate into primary production patterns and material flows within Armenia's fruit and vegetable farming system.

5.2.2 Primary Production (Farming)

Primary production of fruits and vegetables in Armenia is characterized by a predominantly smallholder-based agricultural structure. According to the Statistical Yearbook of Armenia (Armstat), the total land area of the country amounts to 2,974.3 thousand hectares, of which 2,042.5 thousand hectares (approximately 69%) are classified as agricultural land. Farm sizes are generally small: about 60% of farms are less than 1 hectare, nearly 80% are below 2 hectares, and only around 1% exceed 10 hectares[148]. This structure strongly shapes production patterns, market access, and material flows along the value chain.

Fruit production, viticulture, and vegetable cultivation constitute Armenia's traditional high-value agricultural activities, many of which are closely linked to downstream processing.

Table 3. Primary Production of Vegetables, Fruits (Excluding Grapes), and Grapes in Armenia, 2015–2024 (thousand tons)

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
VEGETABLES AND MELONS	1294,4	1204,8	1076,8	755,0	749,5	819,4	751,4	735,2	724,2	772,0
TOMATO	320,2	298,1	234,2	138,1	158,8	183,7	206,1	186,1	158,6	187,4
MELONS	286,8	236,1	215,8	126,8	128,0	126,6	131,8	124,6	116,7	122,7
CUCUMBER	92,1	84,9	74,3	50,6	44,1	43,2	58,7	56,5	69,4	76,0
EGGPLANT	77,3	78,6	84,5	51,3	43,9	62,4	65,1	57,3	56,4	65,3
PAPPER	80,2	79,9	83,3	50,1	48,8	54,9	59,4	60,1	63,2	61,0
CABBAGE	141,8	134,5	117,1	89,5	79,5	74,9	56,5	64,8	64,3	54,4
ONION	52,0	53,9	48,9	39,3	37,0	43,8	29,0	34,7	38,1	39,2
GREEN BEANS	18,0	17,2	18,9	17,8	15,2	18,4	19,5	17,3	16,9	16,5
CARROT	24,6	24,2	18,8	16,7	13,2	13,7	12,3	15,8	16,7	14,3
CAULIFLOWER	15,5	13,2	16,8	14,9	15,1	16,5	13,8	10,3	7,9	8,3
GARLIC	13,2	14,2	12,6	10,5	10,1	8,6	9,1	8,3	8,3	7,1
GREEN PEAS	0,6	0,8	0,7	1,2	0,6	0,9	1,3	1,5	0,6	1,3
POTATOES	607,7	606,3	547,4	415,1	404,1	437,2	364,6	351,4	364,5	337,7

[148] FAO (2023). *Overview of the fruit and vegetable sector in Eurasian and Economic Union countries*.
*Overview of the fruit and vegetable sector in Eurasian and Economic Union countries

FRUIT AND BERRY(EXCEPT GRAPES)	377,1	242,6	361,6	343,4	290,6	274,3	323,0	346,3	361,2	343,8
APRICOT	116,3	62,1	87,3	104,0	68,1	53,2	86,9	113,6	114,5	98,7
APPLE	127,0	62,6	116,1	109,9	81,7	84,7	87,9	87,5	94,8	95,5
PEACH	49,9	50,1	73,2	52,2	62,7	53,5	65,7	49,7	62,2	61,6
PLUM	18,0	15,7	24,0	21,2	23,2	25,0	25,0	34,2	29,8	28,7
PEAR	19,7	13,1	18,2	14,2	12,5	13,7	14,6	13,5	12,5	12,4
SOUR CHERRY	14,4	12,1	8,4	12,5	12,8	10,9	9,6	11,8	12,0	10,0
CHERRY	4,1	3,8	4,1	4,7	3,2	2,7	2,8	2,2	2,9	2,8
QUINCE	2,3	1,4	2,1	2,3	1,6	1,6	2,5	2,1	1,9	2,2
GRAPES	309,2	178,8	210,0	179,7	217,5	283,2	237,1	225,8	213,4	195,8
Total production	**2588,4**	**2232,5**	**2195,8**	**1693,2**	**1661,7**	**1814,1**	**1676,1**	**1658,7**	**1663,3**	**1649,3**

Source: Statistical Committee of the Republic of Armenia (Armstat)

Table 3 presents the dynamics of primary agricultural production forming the raw material base of Armenia's fruit, vegetable, and grape processing value chain in 2015–2024. The data illustrate both the scale and volatility of biomass generation at the farm level, which directly determines the volumes of raw materials entering subsequent stages of collection, trading, and industrial processing.

Over the reviewed period, total production across the listed crop groups declined from 2,588 thousand tons in 2015 to 1,649 thousand tons in 2024, representing a decrease of approximately 36%. This structural contraction, accompanied by pronounced year-to-year fluctuations, reflects the sensitivity of Armenia's agricultural sector to climatic variability, yield instability, and shifts in production incentives. From a value chain perspective, this implies a narrowing domestic raw material base, directly affecting processing capacity utilization and export potential.

Vegetables and melons account for the largest share of primary production. Their output decreased from 1,294 thousand tons in 2015 to 772 thousand tons in 2024 (approximately –40%). It is important to note that, in accordance with Armstat methodology, potatoes are not included in the aggregated category "vegetables and melons" and are reported separately. Consequently, total vegetable biomass in the economy exceeds the volume shown under "vegetables and melons."

Potato production, in its turn, declined from 608 thousand tons in 2015 to 338 thousand tons in 2024 (–44%), indicating a substantial contraction in this segment. Tomato production also demonstrates significant volatility, decreasing from 320 thousand tons in 2015 to 187 thousand tons in 2024 (–42%), despite temporary recovery periods. Other vegetable crops — including cucumbers, peppers, eggplants, and cabbage — show moderate year-to-year fluctuations but do not offset the overall downward trend. These dynamics underline the seasonal and climate-dependent nature of vegetable production and the associated instability in raw material inflows to processing facilities.

Fruit and berry production (excluding grapes) appears comparatively more stable at the aggregate level, although individual crops exhibit considerable interannual variability. Total output declined from 377 thousand tons in 2015 to 344 thousand tons in 2024 (–9%). Apricots and apples remain key crops, important both for fresh markets and processing. Apricot production is highly weather-sensitive and therefore volatile, while apple production has shown relative stabilization in recent years. Such fluctuations are critical for enterprises engaged in canning, jam production, and purée manufacturing, as raw material inflows are concentrated within short seasonal windows.

Grape production, which serves as the raw material base for winemaking and distillation, declined from 309 thousand tons in 2015 to 196 thousand tons in 2024 (–37%). Despite a temporary peak in 2020, the overall trend indicates reduced volumes entering the wine and spirits segments. Given the export orientation and high value added of grape-based products, fluctuations in grape production directly influence processing intensity and the seasonal concentration of biomass flows at specific facilities.

However, the volume of fresh agricultural supply in the economy is not determined solely by domestic production. Imports also play a complementary role, supplementing the internal raw material base and influencing the overall balance of material flows.

Table 4. Production, Trade and Utilisation of Fresh Fruits, Vegetables and Grapes in Armenia, 2020–2024 (thousand tons)

	2020	2021	2022	2023	2024
	Production, thousand tons				
POTATOES	437,2	364,6	351,4	364,5	337,7
VEGETABLES AND MELONS	819,4	751,4	735,2	724,2	772,0
FRUIT AND BERRY(EXCEPT GRAPES)	274,3	323,0	346,3	361,2	343,8
GRAPES	283,2	237,1	225,8	213,4	195,8
Total	**1814,1**	**1676,1**	**1658,7**	**1663,3**	**1649,3**
	Import, thousand tons				
POTATOES	10,6	15,3	19,4	21,4	15,9
VEGETABLES AND MELONS	54,6	62,5	81,6	108,4	102,9
FRUIT AND BERRY(EXCEPT GRAPES)	103,7	105,5	107,1	103,1	114,7
GRAPES	4,4	3,3	4,8	3,0	5,8
Total	**173,3**	**186,6**	**212,9**	**235,9**	**239,3**
Total supply	**1987,4**	**1862,7**	**1871,6**	**1899,2**	**1888,6**
	Export, thousand tons				
POTATOES	15,5	53,6	13,7	18,4	35,6
VEGETABLES AND MELONS	85,0	102,7	96,2	89,1	99,5
FRUIT AND BERRY(EXCEPT GRAPES)	98,6	146,2	113,8	114,1	116,5
GRAPES	25,5	18,1	18,9	16,2	12,7
Total	**224,6**	**320,6**	**242,6**	**237,8**	**264,3**
	Food consumption, thousand tons				
POTATOES	179,6	184,2	186,0	182,0	180,3
VEGETABLES AND MELONS	541,9	544,3	547,2	561,2	586,1
FRUIT AND BERRY(EXCEPT GRAPES)	261,8	258,1	318,9	319,8	327,2
GRAPES	12,5	12,1	12,2	12,1	11,9
Total	**995,8**	**998,7**	**1064,3**	**1075,1**	**1105,5**

Source: Statistical Committee of the Republic of Armenia (Armstat)

As shown in the table, primary production in 2020–2024 fluctuated within the range of 1.65–1.81 million tons per year. At the same time, total supply (including imports) amounted to 1.86–1.99 million tons annually. Imports accounted on average for approximately 9–13% of total supply (173–239 thousand tons per year), confirming the dominant role of domestic agriculture in generating the biomass entering the value chain.

The highest import share is observed in fruits and berries (excluding grapes), where in 2024 imports (114.7 thousand tons) represented more than 30% of domestic production. For vegetables and melons, imports also show an upward trend, particularly in 2022–2024, which may be associated with seasonal shortages of certain crops and yield fluctuations. Imports of grapes and potatoes remain relatively limited and do not exert a systemic influence on the overall structure of the raw material base.

The distribution of total supply reflects a complex pattern of fresh product utilisation. In 2020–2024, exports ranged between 224 and 320 thousand tons annually, corresponding to approximately 12–17% of total supply. The strongest export orientation is observed in fruits and berries (excluding grapes), where in certain years export volumes accounted for a significant share of domestic production. Grapes also demonstrate stable export volumes; however, their key role within the value chain is primarily linked to subsequent processing rather than fresh export.

Domestic food consumption remains the principal channel of utilisation. In 2020–2024, food consumption amounted to 996–1,106 thousand tons per year, equivalent to approximately 53–59% of total supply. This indicates that more than half of the fresh biomass is consumed without entering industrial processing.

The remaining portion of supply is allocated to industrial processing, seed use, feed use, stock changes and recorded losses. Food balance statistics also register volumes of waste and losses arising from product spoilage, seasonal concentration of supply, limited storage infrastructure and logistical constraints. These flows create additional material pressure within the system; however, they are not disaggregated by value chain stage in this section.

It should be emphasized that official statistics do not explicitly identify the volume of fresh produce directed to industrial processing. Consequently, the actual volume of raw material reaching processing facilities depends not only on the scale of production but also on the structure of internal flow allocation within the economy.

5.2.3 Collection, Trading and Farm-to-Processor Linkages

The collection and movement of agricultural raw materials from farmers to processors in Armenia take place through a combination of intermediaries, collectors, aggregators, agricultural cooperatives (where they are effectively functioning), as well as through the procurement schemes of processing

plants and wineries themselves. In many cases, processors source from specific regions and rely on seasonal contracts or informal arrangements with producers.
This stage of the value chain represents the critical interface between highly seasonal primary production and relatively fixed processing capacities. Underdeveloped post-harvest infrastructure—particularly the limited availability of cold storage, grading, and temporary storage facilities—makes rapid transportation essential to prevent spoilage and quality deterioration. As a result, raw materials must often be delivered to processing facilities within very short timeframes after harvest, reducing overall chain flexibility.

According to interview findings, a significant share of the harvest is transported in bulk, without the use of specialized containers or prior sorting. Raw materials are frequently unloaded directly from tipper trucks, which increases the risk of mechanical damage and accelerates physiological degradation processes. During peak delivery periods, queues for unloading may form at processing facilities, leading to prolonged waiting times. Under such conditions, trucks loaded with fresh produce can remain exposed to direct sunlight for extended periods, further increasing the risk of spoilage — particularly for highly sensitive crops such as apricots, tomatoes, and grapes. These practices contribute to the emergence of primary losses already at the collection and transport stage.

During peak harvest periods, especially in years of high yields for crops such as apricots or grapes, the volume of raw material entering the collection system can exceed both processing capacity and immediate market absorption. This imbalance contributes to downward pressure on farmgate prices, the accumulation of unsold surpluses, and increased risk of material losses at the collection and transport stage.

While such losses and inefficiencies are structurally significant, the present analysis does not attempt to quantify stage-specific loss volumes. They are referenced here to illustrate systemic bottlenecks in aggregation logistics and their implications for the stability and reliability of material flows entering the processing segment.

Market relationships at this stage remain largely informal. The bargaining position of producers—particularly smallholders—is generally weak, as they have limited influence over pricing and delivery conditions while remaining highly dependent on stable market outlets. Consequently, the collection and trading stage emerges as one of the most structurally vulnerable segments of the value chain, shaping both the scale and concentration of material flows entering the processing stage.

5.2.4 Processing and Manufacturing

Processing is the central node of the value chain in both value added generation and material transformation. At this stage, fruits and vegetables are converted into shelf-stable products through a sequence of operations—typically including receiving and quality sorting, washing and trimming, peeling/coring/pitting, crushing/pressing, thermal processing (cooking, pasteurization/sterilization), fermentation and distillation (for wine and grape spirits), concentration/drying, and final filling and

packaging. The stage is dominated by industrial processors (canneries, juice plants, dried fruit producers, wineries, distilleries), supported by service providers (labor, transport, maintenance) and packaging suppliers.
The total availability of fresh fruits and vegetables in the domestic market is determined by combining domestically produced quantities with imports and subtracting exports:

Remaining in domestic market = Domestic production + Imports – Exports

From this remaining volume, the allocation across different uses is considered. Part of the fruits and vegetables is consumed directly by households in fresh/raw form, another portion is used for seeds or other non-production purposes, and the remainder enters the processing and manufacturing stage:

Processing and manufacturing volume = Remaining in domestic market − (Household consumption + Seed use and other activities)

Table 5 presents the industrial output of fruit, vegetable and grape processing and manufacturing sector.

Table 5. Industrial Output of Selected Products in the Fruit, Vegetable and Grape Processing Sector by NACE Activity, Armenia, 2024 (physical units)

Code	Industrial Product	Unit of Measurement	January–December 2024
10.32.11	Tomato juice	thousand litres	630.3
10.32.16	Apple juice	thousand litres	359.0
10.32.17	Mixtures of fruit and vegetable juices	thousand litres	21,446.5
10.32.19	Other fruit and vegetable juices	thousand litres	109.3
10.39.12	Vegetables preserved for short-term storage	tons	10,832.6
10.39.17	Other vegetables (excluding potatoes), prepared or preserved without vinegar or acetic acid, excluding prepared vegetable dishes	tons	4,972.3
10.39.23	Nuts and peanuts, roasted, salted or otherwise processed	tons	3,230.6
11.02	Wine of fresh grapes	thousand litres	10,029.6
11.01	Distilling, rectifying and blending of spirits	thousand litres	26,418.3

Source: Statistical Committee of the Republic of Armenia (Armstat)

Juice production included 21,446.5 thousand litres of mixed fruit and vegetable juices, 630.3 thousand litres of tomato juice, and 359.0 thousand litres of apple juice. Vegetable preservation amounted to 10,832.6 tons of vegetables preserved for short-term storage and 4,972.3 tons of other vegetables prepared or preserved without vinegar. Production of roasted and processed nuts reached 3,230.6 tons.

In the grape-processing segment, wine production totalled 10,029.6 thousand litres in 2024, while distilling, rectifying and blending of spirits reached 26,418.3 thousand litres (in terms of 100% alcohol equivalent). These figures confirm the industrial scale and material intensity of grape processing relative to other crop categories.A defining feature of the processing stage is the structural formation of by-products and bio-residues. For many fruit and vegetable processes, a material share of incoming biomass is separated as peels, seeds, pits, stems, pomace, skins, and trimmings. These organic by-product streams constitute the core focus of the present circular economy analysis.

As previously noted, empirical evidence indicates that the non-edible or technologically separated fraction generated during the industrial processing of fruits and vegetables typically accounts for approximately 10–50% of the weight of fresh raw material, depending on the product type and the processing technology applied. In Armenia, the most concentrated by-product streams typically arise in fruit canning/jam production (peels, cores, pits), juice production (pomace), and wine/brandy production (grape pomace, skins, stems, seeds generated immediately after pressing). These flows matter because they are produced in bulk, at specific sites, and within short seasonal windows, which makes them both a management challenge and a practical entry point for valorisation solutions.

5.2.5 Distribution and Marketing

After processing, finished products are allocated between export markets and domestic consumption. The distribution stage functions as the structural interface between industrial output and final demand, translating processed goods into market-ready products under specific commercial, logistical, and regulatory conditions.

A substantial share of processed output in Armenia is export-oriented. Export distribution is typically organized through specialized trade intermediaries, long-term commercial partnerships, and established distribution networks. Access to external markets requires compliance with formalized product quality, food safety, labeling, packaging, and logistics standards. These requirements influence not only distribution practices but also upstream production specifications, including packaging formats, material choices, batch uniformity, and traceability procedures. As a result, export markets exert a structural influence on the configuration of the processing stage.

The remaining share of output is absorbed by the domestic market. Distribution within Armenia operates along two principal dimensions.

From an organizational perspective, products are supplied through wholesale intermediaries, retail chains, and specialized distributors. Large supermarket networks play an increasingly important role in shaping product presentation, packaging formats, and shelf standards. At the same time, independent wholesalers continue to serve smaller retail outlets and regional markets.

From a trade format perspective, sales occur through traditional channels (open markets, small grocery stores, and specialized shops) as well as modern retail formats. Online and direct-to-consumer sales remain relatively limited but are gradually emerging, particularly in urban areas.

In the domestic market, processed fruit and vegetable products compete both with imported alternatives and with other domestic producers. Compared to export markets, regulatory and standardization requirements are generally less stringent; however, modern retail chains increasingly apply their own quality and packaging specifications. Price sensitivity remains a defining factor in domestic market positioning, particularly for mid- and lower-priced product segments.

Overall, the distribution and marketing stage plays a coordinating role within the value chain. It determines how industrial output is allocated between export and domestic markets, shapes packaging and compliance requirements, and influences the stability and predictability of demand faced by processors. Consequently, distribution is not merely a logistical function but a structurally important element affecting production planning, product differentiation, and market access conditions across the sector.

5.2.6 Consumption (End Use)

At the consumption stage, processed fruit, vegetable, and grape products are delivered to final users, including households and the HoReCa sector (hotels, restaurants, and catering).

For analytical purposes, consumption at this stage includes both intermediate consumption and final consumption.

Intermediate consumption refers to the use of processed fruit and vegetable products as inputs in further manufacturing processes. Examples include dried fruits used in confectionery production, tomato paste used in sauce manufacturing, fruit preparations used in dairy products, and grape-based materials used in beverage production. At this level, additional material losses may occur due to technological trimming, expired stocks, or quality rejection during secondary processing.

Final consumption refers to the direct use of products by households and the HoReCa sector. At this stage, material flows complete their functional use and transition into post-consumption waste streams.

From a material flow perspective, waste generated at the consumption stage consists primarily of:

- food residues (expired, partially consumed, or improperly stored products), and
- packaging waste associated with processed fruit and vegetable products (glass jars and bottles, metal cans, plastic containers, composite packaging).

Food waste at this stage is weakly monitored and typically disposed of together with mixed municipal waste. Losses arise from expired products, portioning inefficiencies, inadequate storage conditions, and consumer behaviour patterns, both at household level and within the HoReCa sector.

Although this analysis does not quantify post-consumption waste volumes, the consumption stage represents the terminal point of material flows within the current linear configuration of the value chain. Both residual food and packaging exit economic circulation at this point, unless captured by separate collection, reuse, or recycling systems.

5.2.7 Waste Management

Waste management reflects the cumulative outcome of material flows generated across all stages of the fruit, vegetable, and grape processing value chain. Within the framework of this analysis, primary attention is given to organic residues generated at the industrial processing stage, as this is where the largest, most concentrated, and technologically homogeneous waste streams are formed.

During processing, a substantial share of incoming biomass is technologically separated in the form of non-edible or residual fractions, including peels, skins, seeds, pits, stems, pomace, marc, and trimmings. Unlike losses occurring at the agricultural production stage or food waste generated at the consumption stage, these residues possess several characteristics that make them a priority focus for circular economy assessment.

First, they are spatially concentrated, being generated directly at processing facilities rather than dispersed across numerous small farms or households. This concentration significantly reduces transaction costs related to collection and aggregation.

Second, these streams are relatively homogeneous in composition and physicochemical properties, as they arise from standardized technological operations (e.g., grape pomace after pressing, fruit pomace from juice extraction, pits separated during fruit processing). Such homogeneity increases the predictability of secondary raw material quality and facilitates the implementation of technological solutions for valorisation.

Third, these residues are generated in substantial volumes within relatively short seasonal windows. While this creates temporary pressure on storage and handling systems, it simultaneously makes investments in specialized treatment and recovery solutions—such as drying, extraction of valuable compounds, or bioenergy production—more economically justifiable due to economies of scale.

In contrast to dispersed and less controllable losses at farming or consumption stages, processing-stage residues represent a structurally manageable segment of the value chain where circular interventions have the highest potential for scalability and return on investment.

At present, the management of organic processing by-products in Armenia remains largely non-systemic and oriented toward low-value utilisation pathways. According to interview findings, the most common practice involves transferring organic residues—such as fruit pomace, grape marc, and vegetable trimmings—to nearby livestock farms for use as animal feed. This represents a long-established cost-minimisation reuse model. It allows processors to reduce disposal expenses while providing livestock producers with lower-cost feed inputs.

However, such arrangements are typically informal, seasonal, and geographically constrained. They are rarely supported by formal supply contracts, standardized quality control procedures, or predictable logistics. As a result, although part of the biomass is diverted from landfill or mixed waste streams, this practice does not constitute an institutionalised circular model. Where nearby farms are absent or absorption capacity is exceeded, residues may be temporarily stockpiled, directed to mixed waste streams, or disposed of without structured valorisation.

In addition to feed reuse, selective valorisation of higher-potential by-products is observed among a limited number of processors. These practices include oil extraction from apricot kernels and grape seeds, as well as pilot or experimental efforts to develop secondary products from processing residues. Such initiatives indicate increasing awareness of circular economy opportunities and emerging innovation capacity within certain segments of the sector. Nevertheless, their scale remains constrained by limited processing infrastructure, restricted access to finance, and underdeveloped markets for higher-value bio-based products.

In a small number of cases, pilot composting and soil amendment initiatives have been implemented, often supported by donor-funded programmes or local community projects. These initiatives demonstrate the technical feasibility of converting organic residues into compost and highlight their potential relevance for improving soil fertility and reducing dependence on imported fertilisers. However, the absence of industrial-scale composting infrastructure, segregated organic waste collection systems, and stable market demand for compost products prevents these pilots from evolving into commercially viable and system-wide solutions.

Overall, waste management within Armenia’s fruit, vegetable, and grape processing sector remains predominantly linear. While reuse practices and early-stage valorisation initiatives exist, they are fragmented, largely informal, and limited in scale. At the same time, the seasonal concentration and spatial localisation of organic residues at processing facilities indicate significant untapped potential for more structured valorisation models. Unlocking this potential will require coordinated action, investment in bio-waste management infrastructure, and a clearer institutional framework capable of supporting the transition from episodic practices to scalable circular solutions.

5.3 Mapping of Circular Economy Stakeholders

Transitioning Armenia's fruit and vegetable processing sector toward circularity in relation to organic waste generated during processing requires the coordinated involvement of a diverse set of stakeholders directly connected to these material flows. Their roles, levels of influence, and incentives differ substantially, and current practices related to the management and utilisation of processing-stage organic residues remain fragmented rather than systemic.

The stakeholder mapping below focuses exclusively on actors involved in the generation, handling, regulation, reuse, or potential valorisation of organic waste arising during fruit and vegetable processing activities. It assesses these actors in terms of their relative influence and interest, providing a basis for identifying leverage points for systemic intervention within this specific waste stream.

Government and Policy Makers

Public authorities represent high-power stakeholders in the management of organic waste generated during fruit and vegetable processing. Their decisions determine the legal classification of such residues, the regulatory requirements applicable to their handling, and the permissible pathways for their reuse or disposal.

The Ministry of Environment is responsible for the implementation of waste legislation and environmental oversight; the Food Safety Inspectorate Body establishes sanitary and traceability requirements for potential secondary uses of residues (including animal feed or soil amendments); and the Ministry of Economy shapes the economic framework through industrial development policies, enterprise modernization programs, and investment support instruments. Although no dedicated policy instruments specifically target the valorisation of processing-stage organic waste, the combined regulatory and institutional framework defines the conditions under which such residues may be managed or reintroduced into economic circulation.

Overall, government actors combine high regulatory authority with a moderate but gradually increasing interest in resource efficiency. Their institutional coordination and policy choices are decisive in determining whether organic processing residues remain within conventional waste management practices or transition toward more structured circular economy models.

Processing Companies

Processing enterprises constitute the primary operational stakeholders with respect to organic waste generated during fruit and vegetable processing, as they retain direct control over the generation, separation, and handling of these material flows.

Their level of engagement in recovery or valorisation activities varies depending on production scale, market orientation, and underlying economic conditions. In practice, most processing-stage residues continue to be managed through conventional disposal channels or low-value reuse arrangements, while more structured and higher-value utilisation pathways remain limited in scope.

From a stakeholder perspective, processing companies combine high operational influence over material streams with heterogeneous strategic incentives, positioning them as pivotal actors whose decisions ultimately determine whether this waste stream remains within traditional management practices or progresses toward scalable circular economy solutions.

Waste Management and Recycling Sector

Waste management operators represent a potentially relevant stakeholder group in relation to organic waste generated during fruit and vegetable processing, particularly in cases where such residues are transferred outside processing facilities for treatment or disposal. Their role becomes more significant where processing enterprises lack internal capacity to manage organic residues independently.

Based on conducted interviews and available information, systematic industrial infrastructure specifically dedicated to the regular and commercially sustainable treatment of agro-industrial organic residues appears to be either limited or at an early stage of development in Armenia. Existing composting or organic waste initiatives tend to be small-scale or project-based and do not yet constitute a stable, market-driven system.

From a stakeholder-mapping perspective, waste management operators currently exercise limited structural influence over processing-stage organic waste flows due to infrastructural and market constraints. However, the development of specialised treatment capacity and economically viable business models could significantly expand their role within future circular economy frameworks.

NGOs, Academia, and International Organizations

Non-governmental organizations, academic institutions, and international partners play an important enabling role through research, policy analysis, pilot initiatives, and technical assistance. Their activities contribute to evidence generation, awareness raising, policy design, and the testing of innovative approaches that may later be scaled through public or private sector engagement.

International development partners have supported resource efficiency, cleaner production, waste governance reforms, and capacity building across multiple sectors, including agri-food processing. Academic research has contributed to identifying structural barriers and opportunities for circular economy adoption, particularly by documenting enterprise-level practices and constraints.

However, the translation of research and pilot results into commercially viable and scalable circular solutions remains limited, reflecting weak linkages between research, industry, and investment mechanisms. These actors typically combine high interest with limited direct influence, positioning them primarily as facilitators and knowledge providers rather than primary drivers of systemic change.

Farmers and Raw Material Suppliers

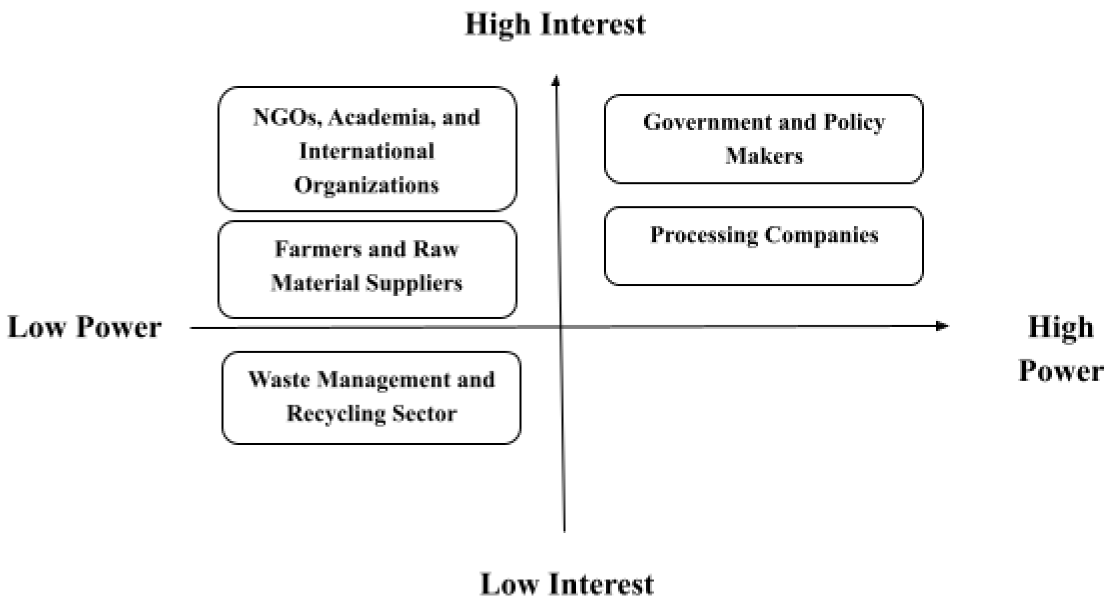
Although farmers are not directly involved in the generation or regulation of processing-stage organic waste, they constitute an important downstream stakeholder where processing residues may be reused as animal feed or soil amendments. Their role is relevant insofar as by-products are transferred to agricultural users under informal or semi-formal arrangements.

Such material loops demonstrate the practical feasibility of local reuse pathways; however, they remain limited in scale, geographically constrained, and largely dependent on informal coordination between processors and nearby farms.

In stakeholder terms, farmers represent a high-interest but structurally low-power group whose participation in circular solutions depends on regulatory clarity, coordination mechanisms, and economically viable residue supply chains.

A useful way to visualize these stakeholders is through a power–interest grid, which maps each actor's level of influence over processing-stage organic waste flows against their level of vested interest in circular economy outcomes.

Figure 52. Stakeholder power–interest grid for organic waste in Armenia's fruit and vegetable processing sector



Source: Ameria team analysis based on stakeholder consultations with industry representatives and public institutions

Overall, the current stakeholder configuration indicates that progress toward more structured circular models for managing processing-stage organic residues will depend primarily on regulatory clarity, effective institutional coordination, and the development of economically viable mechanisms for reintegrating these materials into productive use. In particular, alignment between regulatory authorities, processing enterprises, and potential downstream users will be essential to reduce uncertainty, lower transaction costs, and enable more predictable material flows.

Without clearer classification frameworks, coordinated implementation mechanisms, and market-based incentives, organic residues are likely to remain within conventional waste management pathways or informal reuse arrangements. A transition toward scalable circular solutions therefore requires not only technical feasibility but also institutional coherence and economically sustainable value chains built around this specific waste stream.

5.4 Circularity Gaps and Pain Points

Despite the presence of emerging circular economy initiatives, Armenia's fruit and vegetable processing value chain remains significantly distant from international best practices. The existing system continues to be dominated by linear material flows, resulting in environmental externalities, lost economic value, and missed opportunities for innovation and diversification. The main circularity gaps can be grouped into four interrelated dimensions: technological and infrastructural, market and scale-related, regulatory and institutional, and financial and economic.

5.4.1 Technological and Infrastructure Gaps

A fundamental constraint is the absence of appropriate technologies and infrastructure for bio-waste valorisation. Most Armenian processing enterprises lack on-site or nearby facilities to convert organic residues—such as peels, cores, seeds, pomace, and grape marc—into higher-value outputs. In international practice, such residues are routinely processed through anaerobic digestion, industrial composting, extraction of oils and bioactive compounds, or conversion into bioenergy and bio-based materials[149]. In Armenia, by contrast, a substantial share of processing waste is discarded or informally reused, rather than systematically valorised.

The environmental consequences are significant. Organic waste disposed of in landfills undergoes anaerobic decomposition, generating methane and other landfill gases, with methane being a major contributor to the sector's climate footprint—greenhouse gases with a much higher global warming potential than carbon dioxide[150]. From an economic perspective, this represents a clear loss of feedstock that could otherwise be used to produce energy, fertilizers, animal feed, or specialty ingredients.

In addition, outdated processing equipment and limited access to resource-efficient technologies further constrain circular performance at the industrial stage. Older machinery often results in lower extraction efficiency, reduced product recovery rates, and higher proportions of residual biomass per unit of finished output. In contrast, modern processing technologies applied in advanced agri-food systems are designed to optimize raw material utilization, minimize technological losses, and enhance the quality and consistency of by-product streams suitable for further valorisation. However, such equipment remains largely inaccessible to Armenian small and medium-sized processors due to capital constraints and limited technological upgrading capacity.

5.4.2 Market and Scale Gaps

The fragmented and small-scale structure of Armenia's processing sector presents a major barrier to circular solutions. Many circular technologies require a minimum and stable throughput to be economically viable. Enterprise-level survey evidence from a sample of 40 small and medium-sized

[149] FAO (2019). *The State of Food and Agriculture 2019: Moving Forward on Food Loss and Waste Reduction.* https://www.fao.org/3/ca6030en/ca6030en.pdf
[150] IPCC (2019). 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories – Volume 5: Waste. https://www.ipcc-nggip.iges.or.jp/public/2019rf/vol5.html

fruit processing enterprises (primarily dry fruit and jam producers) indicates that nearly half (47.5%) identify low production volumes as a major barrier to implementing waste management and by-product valorisation practices[151]. Individual firms typically generate insufficient quantities of organic residues to justify investments in biogas, composting, or extraction facilities, while mechanisms for collective aggregation of waste streams remain underdeveloped.

Seasonality further amplifies these scale constraints. Harvest and processing cycles generate short, highly concentrated peaks of organic residues (e.g., during apricot, grape, or tomato seasons), followed by long off-season periods with limited feedstock availability. As a result, valorisation infrastructure is difficult to utilise year-round, weakening investment viability unless inputs are diversified (e.g., through co-digestion with manure or aggregation across multiple processors and regions)[152].

Closely related to scale constraints is the limited institutional and commercial structuring of markets for higher value-added products derived from processing by-products. Although certain initiatives in deep processing exist, the corresponding markets remain weakly formalised and insufficiently integrated into stable industrial value chains. Standardised sales channels, long-term contractual mechanisms, and predictable pricing environments are largely absent, increasing commercial uncertainty.

In contrast, in countries with more advanced circular bioeconomy ecosystems, fruit and vegetable residues are embedded in structured supply chains serving nutraceutical, cosmetic, feed, and biorefinery industries under stable quality requirements and formalised contractual arrangements [153]. In Armenia, such downstream linkages are still in an emerging phase. As a result, revenue streams from valorised products remain less predictable, transaction costs are comparatively higher, and the investment attractiveness of large-scale deep processing technologies is correspondingly lower.

At the same time, export-oriented processors face emerging risks. International markets—particularly the European Union—are progressively tightening requirements related to recyclable packaging, environmental performance, and carbon footprint disclosure[154]. Armenian producers that fail to adapt may face reduced competitiveness or market access barriers in the medium term.

5.4.3 Regulatory and Institutional Gaps

Regulatory and institutional weaknesses further constrain circularity. Armenia currently has a system of source separation and organic waste collection that remains limited and fragmented, without

[151] Markosyan, D. (2022). Enterprise-Level Analysis on Awareness, Practices and Barriers of Circular Economy in the Fruit Processing Sector in Armenia. Humboldt University Berlin. *https://www.researchgate.net/publication/363081235_ENTERPRISELEVEL_ANALYSIS_ON_AWARENESS_PRACTICES_AND_BARRIERS_OF_CIRCULAR_ECONOMY_IN_THE_FRUIT_PROCESSING_SECTOR_IN_ARMENIA*

[152] OECD (2020). *Business Models for the Circular Economy: Opportunities and Challenges for SMEs.* *https://www.oecd.org/en/topics/resource-efficiency-and-circular-economy.html*

[153] MDPI (2021). *Valorisation of fruit and vegetable by-products*. https://www.mdpi.com

[154] European Commission (2022). *Proposal for a Regulation on Packaging and Packaging Waste (PPWR)* https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52022PC0677

nationwide coverage and consistent enforcement mechanisms. Without segregated waste streams, the feasibility of composting, recycling, or bio-waste valorisation is severely limited. Although pilot projects for waste separation have been launched in selected municipalities, these initiatives remain small in scale and have not yet translated into systemic change.

Enforcement of existing waste legislation is also weak. Landfilling continues to represent the most accessible and economically convenient disposal pathway in many cases, while monitoring and enforcement capacity varies across regions. Where disposal fees remain relatively low and compliance procedures comparatively straightforward, firms face limited economic incentives to invest in alternative waste management, reuse, or valorisation solutions. This undermines the economic rationale for circular investments and penalizes early movers who might otherwise adopt more sustainable practices.

Additional regulatory uncertainty surrounds the reuse of materials within food systems. Although general sanitary and food safety legislation is in place, publicly consolidated sector-specific guidelines and streamlined procedures for recognising processing by-products (e.g., for use in animal feed or soil amendments) remain limited. The absence of clearly structured and easily accessible procedural guidance may increase perceived legal and compliance risks, thereby discouraging firms from developing higher-value circular applications.

Finally, coordination across policy domains remains limited. Circular economy objectives are not yet fully integrated into agricultural, industrial, and export promotion policies, resulting in fragmented interventions and missed synergies.

Institutional coordination challenges are compounded by limited data availability. Available statistical information on processing by-products remains partial, non-standardised, and not disaggregated by composition, seasonality, or end-use pathways. Monitoring systems are therefore limited in their ability to provide a consistent evidence base for quantifying feedstock potential, designing aggregation mechanisms, or assessing investment feasibility. These data constraints also complicate the development of practical instruments such as by-product exchange platforms, benchmarking tools, or targeted support schemes for residue valorisation.

5.4.4 Financial and Economic Gaps

Financial constraints constitute one of the most frequently cited barriers to circular economy adoption. Enterprise-level survey results indicate that lack of financial resources — including barriers to agricultural credits — is among the most significant obstacles reported by Armenian fruit processors, particularly in relation to energy efficiency investments and waste management practices[155]. High upfront capital costs, limited availability of concessional finance, and risk-averse

[155] Markosyan, D. (2022). *Enterprise-Level Analysis on Awareness, Practices and Barriers of Circular Economy in the Fruit Processing Sector in Armenia*. Humboldt University Berlin. https://www.researchgate.net/publication/363081235_ENTERPRISE-LEVEL_ANALYSIS_ON_AWARENESS_PRACTICES_AND_BARRIERS_OF_CIRCULAR_ECONOMY_IN_THE_FRUIT_PROCESSING_SECTOR_IN_ARMENIA

lending practices restrict investments in biogas units, recycling lines, or sustainable packaging systems.
The lack of economies of scale further undermines cost competitiveness. Circular solutions often entail higher unit costs in small markets, particularly when demand for outputs such as compost or recycled materials is weak. Without targeted subsidies, tax incentives, or risk-sharing mechanisms, many circular investments fail to meet acceptable return-on-investment thresholds for private firms[156].

In addition, there remains a perceptual and informational gap. Waste management is still widely viewed as a cost center rather than a potential source of value creation. Opportunities to develop new product lines—such as seed oils, bio-based ingredients, or energy from waste—are poorly understood and perceived as risky. This mindset limits innovation and contributes to the underutilisation of Armenia's biomass resources.

These financial constraints are reinforced by capability gaps. Many processors have limited technical know-how related to residue stabilisation, quality control, extraction processes, and the development of market-ready by-product-based goods. Linkages between processors, research institutions, and potential innovators remain weak, limiting applied R&D, piloting, and the translation of academic knowledge into commercially viable circular solutions.

Environmental and Economic Consequences

The cumulative effect of the identified technological, market, regulatory, and financial gaps is substantial and mutually reinforcing.

From an environmental perspective, the continued reliance on landfilling and low-value disposal pathways for organic residues contributes to greenhouse gas emissions, localised soil and water contamination risks, and broader public health concerns. The absence of systematic valorisation mechanisms means that biodegradable industrial residues remain a pressure factor rather than a managed resource stream.

From an economic standpoint, the sector continues to forfeit considerable embedded value contained in organic by-products rich in oils, proteins, fibres, and bioactive compounds. Underutilisation of these streams reflects not only technological limitations, but also structural weaknesses in market development, finance, and institutional coordination.

At the same time, the persistence of inefficient processing technologies, limited economies of scale, and evolving environmental compliance requirements in export markets collectively reduce the long-term competitiveness and resilience of Armenian fruit, vegetable, and grape processors. Without structural adjustments, the sector risks falling further behind emerging circular bioeconomy standards.

[156] OECD — Business Models for the Circular Economy
https://www.oecd.org/environment/waste/business-models-for-the-circular-economy.pdf

In sum, Armenia’s fruit, vegetable, and grape processing value chain exhibits a structural and multidimensional gap between its current predominantly linear configuration and a more circular, resource-efficient development model.
Technological limitations, market and scale constraints, regulatory and institutional weaknesses, and financial and capability barriers do not operate in isolation. Instead, they interact systemically, constraining investment feasibility, limiting innovation, and reinforcing path dependency within existing production models.

Seasonality, fragmented biomass streams, incomplete data systems, and weak cross-sector linkages further reduce investment predictability and increase perceived risk. As a result, the transition toward higher-value bio-based utilisation remains constrained despite identifiable resource potential.

Bridging these interdependent gaps will require coordinated interventions across infrastructure development, regulatory refinement, financial instruments, market structuring, and capability upgrading.

5.5 Opportunities for Circular Interventions

Despite the multidimensional circularity gaps identified in Section 5.4, Armenia's fruit, vegetable, and grape processing sector presents a set of technically feasible and economically relevant opportunities for advancing circular bioeconomy solutions — particularly in relation to organic residues generated at the industrial processing stage.

As demonstrated in Sections 5.2 and 5.4, processing-stage residues (e.g., grape pomace, fruit pomace, peels, seeds, trimmings) are spatially concentrated, relatively homogeneous, and generated in significant volumes within short seasonal windows. These characteristics make them structurally more manageable than dispersed agricultural or post-consumption waste streams and position them as priority entry points for scalable circular interventions.

The opportunities outlined below are structured around two core intervention areas:

1. Bio-waste valorisation pathways, focusing on energy, nutrient, and high-value compound recovery from processing residues;
2. Enabling policy, financial, and institutional instruments, aimed at reducing investment risk and improving implementation feasibility.

This structure reflects the specific waste stream analysed throughout the chapter and aligns with the systemic constraints identified in Section 5.4.

5.5.1 Bio-waste Valorisation Opportunities

Anaerobic Digestion and Bioenergy Recovery

Anaerobic digestion (AD) represents one of the most established technological pathways for the treatment of agro-industrial organic residues. According to the International Energy Agency Bioenergy Task 37, anaerobic digestion is widely applied for organic residues from the food and beverage industry, producing biogas for energy recovery and digestate suitable for nutrient recycling[157].

Similarly, the European Environment Agency identifies anaerobic digestion as one of the principal biological treatment options for separately collected bio-waste in Europe. The process enables the conversion of biodegradable residues into renewable energy while stabilising organic matter and reducing methane emissions that would otherwise occur during uncontrolled decomposition.[158]

From a climate perspective, landfilling of biodegradable waste generates methane through anaerobic decomposition, which has a significantly higher global warming potential than carbon dioxide.

[157] IEA Bioenergy Task 37 (2022). The role of anaerobic digestion in the food and beverage industry. https://task37.ieabioenergy.com/
[158] European Environment Agency (2020). Bio-waste in Europe — turning challenges into opportunities. https://www.eea.europa.eu/publications/bio-waste-in-europe

Capturing methane via controlled digestion therefore represents both a waste management and greenhouse gas mitigation strategy[159].

In the Armenian context, the structural concentration of grape-processing residues — particularly grape pomace generated during wine and spirit production — creates a technically suitable feedstock base for anaerobic digestion systems. While full-scale centralised facilities may require feedstock aggregation mechanisms, modular or regionally coordinated digestion systems located in high-concentration processing areas (e.g., Armavir and Ararat marzes) could enhance feasibility.

Importantly, such systems should be evaluated not solely on energy output, but on their combined environmental functions:

- methane emission avoidance,
- organic matter stabilisation,
- renewable energy substitution, and
- nutrient recovery via digestate application.

Given the export orientation and industrial scale of grape distillation in Armenia, the wine and brandy segment may represent a particularly relevant pilot domain for such interventions in subsequent phases of sectoral analysis.

Composting and Soil Nutrient Recovery

Composting represents a lower-technology yet well-established biological treatment pathway for organic residues. The European Environment Agency confirms composting as a principal bio-waste recycling option across European waste management systems[160].

The Food and Agriculture Organization (FAO) describes composting as an aerobic biological process that converts organic waste into a stabilised product which, when properly applied, can improve soil structure, nutrient content, and water retention capacity[161].

In Armenia's agricultural context — characterised by smallholder structures and soil fertility challenges — compost derived from processing residues such as fruit pomace or grape marc may contribute to:

- improved soil organic matter content,
- enhanced water retention capacity,

[159] Bogner, J., M. Abdelrafie Ahmed, C. Diaz, A. Faaij, Q. Gao, S. Hashimoto, K. Mareckova, R. Pipatti, T. Zhang, Waste Management, In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg3-chapter10-1.pdf
[160] European Environment Agency (2020). Bio-waste in Europe — turning challenges into opportunities.
https://www.eea.europa.eu/publications/bio-waste-in-europe
[161] FAO (2015). On-farm composting methods.
https://www.fao.org/3/i3388e/i3388e.pdf

- partial substitution of imported mineral fertilisers, and
- closure of nutrient loops between processing and farming.

Unlike anaerobic digestion, composting requires lower capital intensity and may be implemented through cooperative or regionally coordinated models involving processors and agricultural users.

However, scalability depends on:

- source separation and contamination control,
- quality standards for compost products,
- predictable demand from agricultural users, and
- clear regulatory classification of composted material.

Given the seasonal concentration of biomass streams, composting facilities would need appropriate storage and handling infrastructure to ensure year-round processing capacity.

High-Value Compound Extraction from Processing Residues

Beyond energy and nutrient recovery pathways, fruit and vegetable processing by-products represent concentrated sources of bioactive compounds. Scientific evidence confirms their richness in polyphenols, carotenoids, dietary fibre, and other functional constituents, with documented applications in food and nutraceutical products and emerging relevance in cosmetic and health-oriented formulations[162].

Grape pomace, in particular, is internationally recognised as a source of polyphenols and antioxidants, while apricot kernels and grape seeds contain oils used in cosmetic and specialty food markets. These applications represent higher value-added pathways compared to feed or compost routes, but they require:

- quality-controlled separation processes,
- drying and stabilisation infrastructure,
- extraction technologies, and
- access to structured downstream markets.

In Armenia, limited pilot initiatives in oil extraction from apricot kernels and grape seeds indicate existing entrepreneurial capacity. Scaling such activities would require stronger linkages between processors, research institutions, and market actors.

Importantly, this pathway should not be framed as an immediate large-scale solution, but rather as a targeted innovation domain, particularly relevant for the grape-processing segment where residue streams are homogeneous and industrially concentrated.

[162] Carvalho, F., Aitfella Lahlou, R., & Silva, L. R. (2025). Exploring Bioactive Compounds from Fruit and Vegetable By-Products with Potential for Food and Nutraceutical Applications. Foods, 14(22), 3884. https://www.mdpi.com/2304-8158/14/22/3884

5.5.2 Enabling Policies, Finance, and Capacity Building

Technological feasibility alone is insufficient to unlock circular transition. As identified in Section 5.4, financial constraints, fragmented scale, regulatory ambiguity, and weak coordination mechanisms limit implementation.

Successful deployment of bio-waste valorisation pathways will therefore depend on enabling instruments specifically tailored to processing-stage organic residues.

Regulatory Clarity and Waste Classification

Clear differentiation between waste and by-products is essential to reduce compliance uncertainty and facilitate reuse pathways. Transparent procedural guidance for recognising processing residues as secondary raw materials (where sanitary conditions are met) would reduce perceived legal risk and transaction costs.

Economic Incentives and Financing Instruments

High upfront capital costs remain a primary barrier. Access to concessional finance, climate-aligned funding instruments, or blended finance models could reduce investment risk. International financial institutions such as EBRD and EIB have existing frameworks supporting resource efficiency and renewable energy investments in agro-processing sectors, which could be leveraged.

Gradual economic signals — such as differentiated landfill tariffs for untreated organic waste — may further improve the relative attractiveness of valorisation options, provided enforcement capacity is strengthened.

Aggregation and Coordination Mechanisms

Given Armenia's fragmented processing structure (particularly in NACE 10.3), aggregation platforms for residue pooling could improve economies of scale. Formalised supply agreements among processors would enhance feedstock predictability and investment bankability.

For the grape-processing segment, where production is more concentrated, structured valorisation models may be comparatively easier to implement and could serve as demonstration cases for wider sector replication.

Knowledge Transfer and Capability Development

Capability gaps identified in Section 5.4 — particularly related to residue stabilisation, extraction technologies, and quality assurance — require targeted training, demonstration projects, and applied research collaboration. Strengthening university–industry linkages would enhance technological upgrading and reduce perceived innovation risk.

Taken together, the Armenian fruit, vegetable, and grape processing sector possesses structurally identifiable and technically feasible pathways toward improved circular performance — particularly through the valorisation of processing-stage organic residues.

Priority should be given to interventions that:

- address concentrated biomass streams,
- align with existing industrial structures (notably grape processing),
- combine environmental benefits with measurable economic rationale, and
- can be piloted at regional scale before broader replication.

Early-stage implementation may focus on composting and controlled feed optimisation models, while anaerobic digestion and higher-value extraction pathways can be phased in as aggregation mechanisms, regulatory clarity, and financing instruments mature.

Importantly, these interventions do not contradict the sector's current structure; rather, they build upon its spatial concentration of residues and export-oriented industrial base.

In this regard, the grape-processing segment — characterised by large, homogeneous residue streams — represents a particularly promising entry point for deeper circular bioeconomy integration in subsequent analytical phases.

5.6 International Benchmarks

To place Armenia's transition toward a circular economy in the fruit, vegetable, and grape processing sector into an international context, it is appropriate to examine documented examples where processing-stage organic residues were systematically integrated into resource models rather than remaining linear waste streams.

Two complementary international cases are presented below:

- a system-level national example (The Netherlands);
- a technology and value-chain example (the EU Horizon 2020 AGRIMAX project).

Both cases directly relate to the structural constraints identified for Armenia — fragmentation of processing, seasonality of biomass flows, ambiguity regarding by-product status, scale limitations, and weak structuring of downstream markets.

Case 1. The Netherlands: National Circular Economy Programming and Agricultural Loop Closure

The Netherlands represents a systemic example of how agro-industrial residues can be embedded into a national circular economy transition strategy rather than treated as isolated waste streams. Under the National Circular Economy Programme 2023–2030 (NPCE)[163], the government formalized the long-term objective of achieving a fully circular economy by 2050.

In official documentation, biomass and agri-food residues are defined as priority resource streams for value retention and loop closure in agriculture and industry.

Implementation moved beyond declarative strategy:

- Formal transition agendas were adopted for priority sectors, including biomass and the food industry.
- Circularity targets were integrated into agricultural, climate, and nitrogen policy, ensuring cross-sectoral coherence.
- The programme supported regional clustering and industrial symbiosis between producers, processors, and waste operators, while providing regulatory clarity regarding the status of secondary raw materials.

In practice, this led to a reframing of policy — from "waste management" toward "biomass as a resource."

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[163] National Circular Economy Programme 2023–2030 (Government of the Netherlands) https://www.rijksoverheid.nl/documenten/rapporten/2023/02/03/bijlage-2-nationaal-programma-circulaire-economie-2023-2030

- Processing residues and manure began to be aggregated at the regional level to reach economically viable scales for anaerobic digestion and composting.
- Nutrient recycling was embedded within broader agricultural transformation rather than treated as a stand-alone environmental measure.

The widespread deployment of anaerobic digestion within agri-food value chains demonstrates how scale coordination and regulatory predictability enable systemic diffusion of circular practices.

According to official reporting, the Netherlands achieved:

- High levels of nutrient recycling within agricultural systems;
- Widespread application of anaerobic digestion in agri-food chains;
- Integration of manure and processing residues into biogas production;
- Improved coherence between waste, agricultural, and climate policy.

Importantly, circularity in the Netherlands is defined not by isolated projects but by institutionalized system-level coordination.

For Armenia, this case provides three key structural lessons.

- First, circularity must be institutionalized rather than improvised. Without formal recognition of agro-industrial residues as secondary resources, investments remain episodic.
- Second, scale is achieved through clustering. In a fragmented structure similar to Armenia's NACE 10.3 segment (processing and preserving of fruit and vegetables), shared regional infrastructure is required.
- Third, regulatory clarity regarding the distinction between "waste" and "by-products" is critical for reducing investment risk.

In the Armenian context, this implies the creation of regional residue aggregation mechanisms in marzes with high processing concentration (Armavir, Ararat), integration of bio-waste into agricultural and climate policy frameworks, and clear procedural pathways for residue reuse.

Case 2. European Union — AGRIMAX (Horizon 2020): Biorefinery Valorisation of Processing Residues

If the Dutch example illustrates systemic governance integration, the AGRIMAX project represents a technology- and value-chain-oriented benchmark focused directly on processing-stage residues.

The AGRIMAX project (Agro-Food Wastes Multi-Product Valorisation)[164], funded under the Horizon 2020 programme, developed and piloted biorefinery concepts to convert fruit and vegetable processing residues into marketable products.

[164] European Commission CORDIS – AGRIMAX Project Factsheet https://cordis.europa.eu/project/id/720719

The project focused on processing residues such as citrus waste and tomato by-products, applying a cascading valorisation logic. Rather than directing biomass immediately toward low-value uses or energy recovery, priority was given to extracting high-value bioactive compounds (polyphenols, dietary fibres), after which remaining fractions were directed toward biomaterials or energy production. This approach aligns with the EU waste hierarchy principle, which prioritizes maximum value retention.

Demonstration pilots confirmed the technical feasibility of stabilization, drying, and extraction processes. Importantly, the project moved beyond laboratory validation and included economic assessment and integration into market value chains. Extracted components were linked to specific ingredient and materials markets, highlighting that extraction technologies alone do not generate value without structured demand and contractual mechanisms.

The key achievement of AGRIMAX was the integration of the value chain. Multi-product biorefinery models were demonstrated under real conditions, showing that cascading use of homogeneous residue streams improves overall economic efficiency.

For Armenia, three conclusions follow.

- First, the economics of valorisation improve when extraction of high-value components precedes composting or energy recovery.
- Second, homogeneous and concentrated streams — such as grape pomace — are more suitable for piloting circular models.
- Third, access to markets and certification infrastructure is decisive: without structured downstream channels, technologies do not scale.

5.7 Conclusions

Armenia's fruit, vegetable, and grape processing sector constitutes a structurally significant and export-oriented segment of the manufacturing industry, characterized by a stable production base and a clear specialization in higher value-added products. At the same time, value chain analysis indicates that the current configuration of the sector remains predominantly linear.

At the industrial processing stage, substantial volumes of organic by-products are generated — including pomace, press residues, peels, pits, seeds, stems, marc, and other fractions formed in spatially concentrated locations and within short seasonal periods. Despite the presence of certain reuse practices, such as the transfer of residues for animal feed or selective initiatives for oil extraction, the management of these flows remains fragmented, largely informal, and limited in scale. As a result, a significant share of the resource potential embedded in organic residues remains unrealized.

The barriers to transition toward a more circular model are systemic and mutually reinforcing. Technological constraints and the absence of specialized bio-waste treatment infrastructure are combined with the high fragmentation of the fruit and vegetable processing and preserving segment (NACE 10.3), where small and medium-sized enterprises with limited production volumes predominate. This reduces the ability to achieve economically viable scale for the implementation of more advanced technological solutions. Additional constraints include pronounced seasonality of biomass flows, regulatory ambiguity regarding the distinction between "waste" and "by-products," restricted access to finance, and underdeveloped markets for products derived from processing residues.

At the same time, the sector possesses several characteristics that create favorable conditions for circular transformation. Organic residues are generated at spatially concentrated processing facilities, reducing transaction costs associated with aggregation. The grape-processing segment demonstrates a higher concentration of production capacity and greater homogeneity of material flows, making it potentially more suitable for piloting systemic solutions. The sector's export orientation also generates long-term incentives to improve resource efficiency and comply with evolving international environmental requirements.

International experience indicates that sustainable circular models emerge when three conditions are aligned: institutional clarity, coordination of material flows, and the existence of structured downstream markets. A shift from a "waste management" logic to a "biomass as a resource" paradigm requires the integration of circular economy objectives into industrial, agricultural, and environmental policy frameworks, as well as the establishment of predictable conditions for investment in bio-residue valorisation.

In this context, the circular transformation potential of Armenia's fruit, vegetable, and grape processing sector is tangible. However, its realization depends on a systemic approach. The issue is not the isolated introduction of technological solutions, but the gradual formation of an institutionally coherent model in which organic residues are treated as secondary resources and their reintegration into economic circulation becomes part of a broader industrial and export strategy.

With effective coordination between public authorities, processing enterprises, and potential users of secondary resources, the sector can reduce its dependence on linear waste management pathways, increase value added, and strengthen its long-term resilience in a changing external environment.

ANNEX: Sector-Specific In-Depth Interviews (IDIs)

N	Name	Organization	Position
1	Ruben Sarukhanyan	National Expert in the Textile Sector	Certified EFQM Assessor
2	Elen Manukyan	Fashion & Garment Chamber of Armenia (FGC)	Founder
3	Erik Minasyan	Textile Industry Operator of Armenia	Acting Executive Director
4	Karen Gomtsyan	Lentex (one of Armenia's largest textile manufacturers)	Director
5	Tigran Gasparyan	Artiki PHK (Maralik) – Armenia's only textile waste sorting and recycling company	Founder
6	Armen Yeganyan	Ministry of Economy of the Republic of Armenia	Head of Department of Industrial Policy
7	Representatives of the company	Coca-Cola HBC Armenia CJSC	Public Affairs / Sustainability and Packaging (industry representatives)
8	Varuzhan Khalatyan	"OVAL PACK" ("OVAL" PLASTIC LLC)	Founding Director
9	Tigran Aleksanyan	Ministry of Economy	Head of Animal Husbandry Department
10	Gayane Hovsepyan	Ministry of Environment	Head of Water Resources Management Department
11	Ori Avetisyan	Ministry of Environment	Chief Specialist, Water Resources Management Department
12	Gor Mikayelyan	Ministry of Environment	Head of Waste and Atmospheric Emissions Management Department
13	Khachatur Moghrovyan	Ecologia LLC	Director
14	Gurgen Nikoghosyan	Meri Fish Yeghvard Compound Feed Factory	Founder Director
15	Artak Zadoyan	Armash Carp Pond Farms	Director
16	Tigran Vardanyan	Sevani Ishkhan	Director

17	Lusine Avetisyan	Ministry of Environment	Head of Strategic Policy Department
18	Liana Papakhchyan	Ministry of Environment	Head of Hazardous Substances and Waste Policy Department
19	Hrach Muradyan	ASCE (Armenian Steel Casting Enterprise) Group	Director
20	Arman Khojoyan	Ministry of Economy	Deputy Minister of Economy of RA
21	Zaruhi Muradyan	Vine & Wine Foundation of Armenia	Executive Director