SemantJournals American Journal of Education and Evaluation Studies 2997-9439, Vol 03, No. 05, 2026

Article

The Impact of Adopting The Materials Flow Costing Accounting Technique on Developing The Cost of Sustainability Awareness And Its Effect on Reducing Waste: A case study of the General Company for Pharmaceutical Industries and Medical Supplies in Samarra

Wissam Abdulkadhum Abdulridha [1]

AL-Furat AL-Awsat Technical University (ATU), Al-Qadisiyah Polytechnic College, Iraq,
Email: dw.wsm@atu.edu.iq

Abstract: The current research aims to examine the impact of adopting the Materials Flow Costing accounting technique on developing cost of sustainability awareness and its reflection on waste reduction at the General Company for Pharmaceuticals and Medical Supplies in Samarra. This objective was set to address the problem: (What is the effect of adopting the Materials Flow Costing accounting technique on developing cost of sustainability awareness and its reflection on waste reduction in the investigated companies?). To address this problem, a quantitative analytical approach was adopted to determine the level of variables in the investigated company for the year 2025. Excel and the statistical package SPSS.V.29 were used to analyse the data and test the hypotheses. Several indicators were relied upon, including (material inputs, commodity outputs, and non-commodity outputs). The research produced several results, the most important of which is the presence of a correlation and impact between the Materials Flow Costing accounting technique, Developing Cost of Sustainability Awareness, and Reducing Waste. This indicates that the General Company for Pharmaceuticals and Medical Supplies in Samarra prioritises focusing on reducing waste by adopting modern technologies to make informed decisions, which helps economic units implement appropriate changes to their practices and operations. The research also recommends the necessity of fully adopting Materials Flow Costing accounting within the General Company for Pharmaceuticals and Medical Supplies in Samarra due to its role in tracking material flows and accurately identifying sources of wastage and spoilage, contributing to cost reduction and improved production efficiency.

Keywords: Materials flow costing accounting technique, Developing cost sustainability awareness, Reducing Waste, Samarra General Company for Pharmaceutical Industries and Medical Supplies.

This is an open-access article under the CC-BY 4.0 license

1. Introduction

The trend towards adopting environmental management accounting tools, such as the material flow cost accounting system, aims to enable managers to improve their decisions related to waste reduction and rational use of available resources. Numerous researchers have demonstrated the significant importance

of the material flow cost accounting system in achieving quantitative and financial resource savings by providing sufficient information about waste sources, allowing efforts to be directed towards waste management and improved resource utilisation [1].

The Materials Flow Costing Accounting (MFCA) technique is one of these modern techniques which differs from traditional cost accounting that allocates all costs to the final product. In traditional accounting, the cost of wasted materials is concealed within the product cost or overheads, as it is not treated separately. MFCA does not only allocate costs to final and secondary products but also to wasted materials, referred to as negative products. This approach helps to identify areas of inefficiency, addressing competitive challenges, meeting industrial company aspirations, improving product quality, reducing costs, minimising material and energy flow usage, limiting waste, eliminating non-value-adding activities, and categorising products into positive and negative products. This approach seeks ways to enhance the quality of positive products and thus reduce their costs, while also aiming to minimise negative products and eliminate them by linking physical unit data with financial units [2].

International competition and customer demands have led to radical changes in manufacturing, and accordingly, companies around the world that recognise the importance of being part of the global market are seeking operational methods to enhance their competitiveness through the use of innovative production systems, as traditional manufacturing models are being challenged and new manufacturing principles developed, which has prompted companies to focus increasingly on delivering the products that customers need faster than their competitors and meeting or exceeding quality requirements [3].

Part One: Research Methodology

First: Research Problem

All industrial, commercial, and service units, especially in Iraq, face a significant challenge in improving efficiency. This includes reducing the consumption of materials and energy, which leads to waste and resource loss, as well as challenges related to environmental pollution and inefficient resource use, resulting in lower productivity and higher costs. To achieve this, Iraqi units should utilise modern and advanced technologies, most notably Materials Flow Costing Accounting (MFCA). The MFCA system, as a strategic managerial accounting approach, enhances efficiency in material and energy flows by tracking them from inputs to outputs, identifying weaknesses and deficiencies that lead to environmental waste. It also reduces resource and energy consumption, minimises waste, and produces environmentally friendly products, thereby improving financial and environmental performance [4].

In light of the rapid developments that have occurred recently in the business environment and the intensification of competition among economic units, the management of economic units has become in urgent need of keeping pace with the changes and developments in the surrounding environment, enabling them to survive and grow in a competitive market and support their competitive capabilities. Consequently, companies lack the mechanisms that allow them to utilise and pay little attention to modern approaches and techniques in cost and management accounting, including Materials Flow Costing Accounting (MFCA) by industrial companies in the local environment. This is evident through a review of previous studies, and it negatively affects the ability to address problems in the contemporary business environment and, therefore, the achievement of competitive advantage in terms of cost and time, by providing relevant information about areas of waste and loss in the manufacturing process and resource utilisation, and reducing the maintenance of high inventory levels [2]. Consequently, the problem of waste and the suboptimal use of available resources represents an issue faced by many establishments, and the persistence of this problem results in harms such as increased costs, misuse of resources, and environmental damage. To address this, various techniques are used to help achieve this goal, including Materials Flow Costing Accounting, which provides information on costs represented by waste in raw materials, water, and energy by measuring and presenting them to management for the purpose of avoiding or reducing them [1]. Accordingly, the research problem can be formulated as an important question: What is the effect of adopting the Materials Flow Costing Accounting technique on developing cost of sustainability awareness and its impact on reducing waste in the surveyed companies? To address the raised problem, several other questions must also be answered:

1. What is the nature of material flow costing (MFC) techniques, and what are the best ways and means to improve company capabilities?
2. Can frameworks and mechanisms be provided to enable companies to better utilize resources to reduce waste?
3. How can sustainability awareness be fostered by adopting MFC techniques for waste reduction in the companies under study?

Second: The importance of the research

The importance of the research lies in adopting a significant system in accounting thought, represented by the Materials Flow Costing accounting technique, as it is one of the most important accounting tools adopted by functional and governmental bodies and organisations, including the International Accounting Federation. Additionally, this topic represents a key pillar for developing cost of sustainability awareness by helping to reduce waste and guiding companies to utilise available resources, thereby achieving acceptable financial savings.

The importance of research also stems from keeping up with the changing business environment in order to achieve competitive advantage by reducing product costs and shortening time in economic units due to the lack of research on the aforementioned modern approaches. Therefore, this study represents a scientific contribution in this field and aims to improve the productive efficiency of economic units by enabling them to identify material waste costs (providing financial information), energy and material waste, reduce costs, and shorten the time that allows the economic unit to achieve these advantages and make optimal use of available resources.

Third: The objectives of the research

Based on the nature of the research problem and the importance highlighted, the current study aims to reveal the impact of adopting the Materials Flow Cost Accounting technique on developing cost of sustainability awareness and its reflection on reducing waste. The research also aims to:

1. To identify the nature of material flow costing techniques and determine the best ways and means to improve company capabilities.
2. To provide frameworks and mechanisms that enable companies to better utilize resources to reduce waste.
3. To determine the importance of fostering sustainability awareness by adopting MFC techniques for waste reduction in the companies under study.

Fourth: Research Hypotheses

Based on the problem, significance, and objectives of the research, several hypotheses can be developed to clarify the relationship between the variables and to identify the mechanisms and methods through which the proposed issues can be addressed. The research variables are:

Independent variable: Materials flow costing accounting.
Moderating variable: Developing cost of sustainability awareness.
Dependent variable: Reduce Waste.

Based on the above, several hypotheses can be developed:

1. The use of the Materials flow costing accounting technique leads to developing cost of sustainability awareness.
2. The use of the Materials flow costing accounting technique leads to reducing waste.
3. Developing cost of sustainability awareness leads to reducing waste.
4. The use of the Materials flow costing accounting technique leads to developing cost of sustainability awareness and reducing waste.

Part Two: Theoretical Aspects

First: Materials Flow Costing Accounting

1. The Concept of Materials Flow Costing Accounting

The concept of Materials Flow Costing Accounting was developed by Professor Bernd Wagner and his colleagues in the late 1990s in Augsburg, Germany, as an accounting technique aimed at environmental protection, since it focuses on tracking waste, by-products and non-commodity outputs, and helps improve both environmental and economic performance. Materials Flow Costing Accounting is also

referred to as material and energy accounting or flow cost accounting, and its main goal is to identify the flows of materials and energy through a value creation system over a specific period. It includes assessing the potential for cleaner production at the facility level and the preliminary estimation of waste generation costs [5].

Materials flow costing accounting (MFCA) is an extension of material flow accounting (MFA), through which material and energy flows in a process are tracked, helping to enhance transparency in material and energy use practices. This is done by expressing these flows in cost terms [6]. Materials flow costing accounting can identify material losses at each step of the process, thereby helping to improve efficiency [7]. Musa believes that relying on Materials flow costing accounting to measure and manage the physical flow of materials provides a clear basis for the company and supplies management with the necessary data and information that can be used to support decision-making, seek corrective actions for material flows, and propose measures that may lead to increased production process efficiency [2].

Materials flow costing accounting (MFCA) is a new accounting approach that provides information to help economic units better understand the financial and economic impacts of their practices and operations in the consumption of materials and energy [8]. This technique involves tracking and evaluating the physical flow of materials within the unit and allocating the appropriate costs associated with this flow. According to the information provided [9], this technique enables informed decision-making, helping economic units to implement appropriate changes to their practices and operations [10]. In turn, this allows for the desired improvements and assists managers in identifying financial savings opportunities and mitigating the negative effects of resource consumption. Thus, this technique complements existing practices in managerial accounting [11].

Materials flow costing accounting is an effective tool that helps economic units better understand the financial impacts of the materials and energy used. This approach aims to improve the production process, focusing on reducing waiting times, waste, and defects [12]. Materials flow costing accounting differs from material flow accounting, which focuses on studying material flows at the national or regional level. It is sometimes referred to as material flow analysis at the national economic level and is usually conducted by national statistical offices [13].

2. Benefits of Materials Flow Costing Accounting

The Materials Flow Costing accounting technique offers a range of benefits that can accrue to companies. These benefits are:

a. Problem identification: The material flow cost system highlights physical losses and helps detect economic losses (waste, machine downtime, production process errors, theft) that cannot be verified or discovered using traditional cost accounting. This system quantifies and materially identifies these losses, leading to a reduction in physical waste [14].

b. Identifying improvement points: Although units are aware of their physical losses, they often fail to implement improvement measures under traditional cost systems. The material flow cost system assists unit management in applying improvement measures by identifying and tracking the quantity of waste and by-products in material flows during the production process, and working to reduce and limit them [15]. This ensures maximum benefit from the unit's resources through optimal utilisation of available resources, as inefficient use of resources leads to their depletion. Identifying improvement points ensures optimal use [4].

c. c. Reducing costs and increasing the profits of economic units: The positive economic outcomes achieved by Materials Flow Costing Accounting are attributed to this technique's ability to provide detailed and accurate information, contributing to more informed decisions in waste reduction [16].

d. Improving the unit's image in the community: The Materials Flow Costing Accounting technique serves as a mechanism for fulfilling social responsibility for economic units and enhancing their community image [17].

e. By helping economic units reduce waste and emissions, negative impacts on the environment and society will decrease [18].

f. Supporting decision-making processes within economic units in the field of process technology.

g. Quality management, production planning, and supply chain management.

h. mproving communication and coordination regarding material and energy consumption.
i. Providing information focused on reducing the amounts of materials and energy consumed in the manufacturing process.
j. Working to minimise product defects as much as possible and eliminating unnecessary costs [19].

3. Elements of Materials Flow Costing Accounting

Materials flow costing accounting consists of three important elements, as shown in Figure 1:

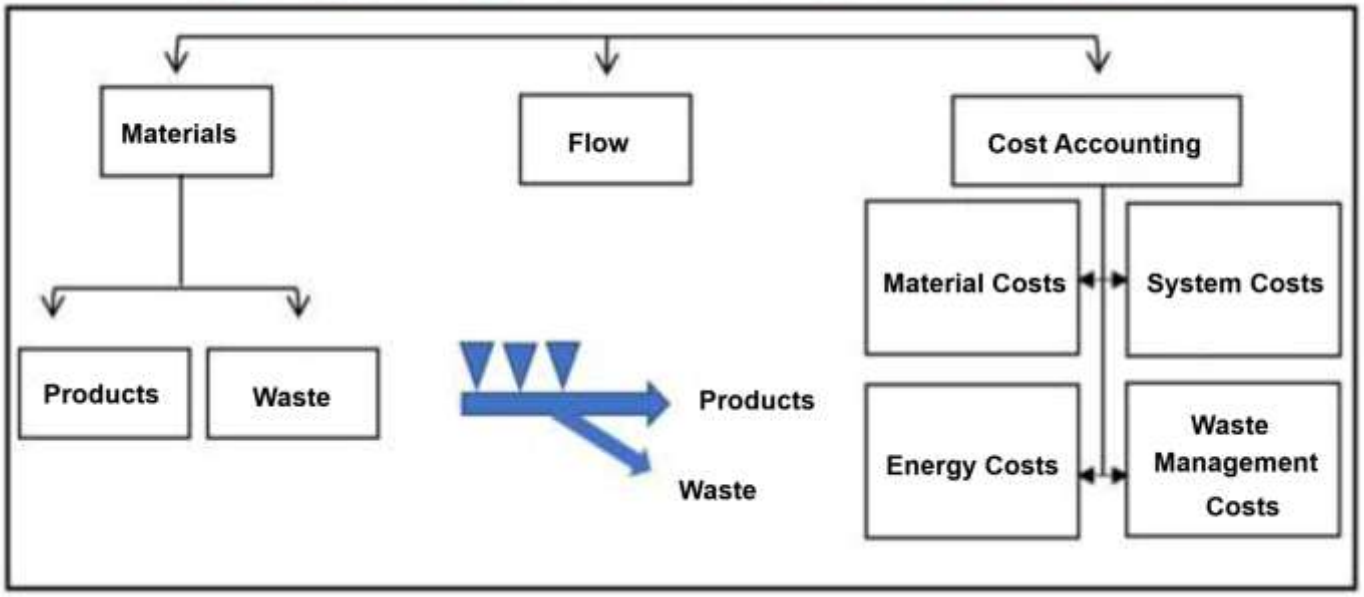

Figure 2: Materials flow costing accounting

Source: Astuti, R. S. D., Astuti, A. D. & Hadiyanto, H., (2018). Preliminary design of industrial symbiosis of smes using material flow cost accounting (MFCA) method. In E3S Web of Conferences (Vol. 31, p. 04008). EDP Sciences [20].

a. **Materials**: Within the framework of the concept of materials in computing (MFCA), materials refer to any substance, whether raw, auxiliary, component, or part, used in the process of manufacturing a product. Materials that do not become part of the final product are considered material losses. In any production process, material losses occur at different stages, including: loss of materials during processing; materials remaining in manufacturing equipment after assembly; auxiliary materials such as solvents and cleaners used for equipment cleaning; defective products; impurities; water; and raw materials that become unusable for any reason [21].

b. **Flow**: Materials flow costing accounting tracks the flows of inputs passing through production processes and measures the quantity of products and wasted materials using physical units through the following equation: Inputs = Products + Wasted materials [1]

c. **Cost accounting**: According to Materials Flow Costing Accounting, the flows and stocks of materials within the organisation are tracked and their quantities are determined using physical units (such as mass and volume), and then the associated costs are calculated. Under the MFCA law, there are four types of costs: material costs, system costs, energy costs, and finally waste management costs (ISO 14051, 2014).

Second: Developing Cost of Sustainability Awareness

1. The Concept of Developing Cost of Sustainability Awareness

Sustainability is considered a fundamental pillar in modern societies, as it plays a vital role in balancing economic, social, and environmental demands [22]. In this context, accountants and academic auditors play a pivotal role in guiding institutions towards adopting sustainable practices to ensure innovation and the prosperity of corporate projects [23]. This, in turn, highlights the importance of raising awareness of sustainability as a driving force to reduce waste and build the capacity to seize opportunities by promoting a sustainability-oriented approach [24]. According to [25], sustainability represents the integration of environmentally friendly practices, such as proper waste management, rational energy

consumption, and the use of renewable resources, into achieving company goals to ensure the long-term sustainability of systems.

The issue of environmental protection is of great international importance and represents one of the most critical issues of the modern era, if not the most critical of all, due to its close connection with the future of humanity and the fate of the human race. The tragic state of pollution that the Earth has reached, as a result of excessive use of natural resources and their mismanagement, along with the increasing and concerning pollution it faces, threatens human civilisation and foreshadows a comprehensive environmental disaster manifested in phenomena such as global temperature rise, depletion of the ozone layer, freshwater shortage, pollution crisis, and the decline of natural forests [26].

Promoting sustainability awareness among researchers and academics requires a deep understanding of the interrelationship between human activities and ecosystems, as well as the effective promotion of sustainable practices through academic work [27]. This includes integrating sustainability principles into research methodologies, enhancing interdisciplinary approaches, and encouraging awareness of environmental, social, and economic impacts [28]. Researchers also focus on contributing knowledge that enriches policies and stimulates action towards long-term environmental balance and social justice [29]. This process also involves self-reflection on individual environmental footprints, advancing education, and engaging with local communities to promote sustainable values and behaviours [30].

According to Al-Dhabawi & Al-Masoudi [31], the importance of developing sustainability awareness arises when an individual recognises the significance of the environment and the necessity to care for and preserve it and its components, a concern as old as humanity itself. This awareness forms a strategic necessity for environmental consciousness, which is essential to meet the requirements of executive action plans aimed at building and developing positive human behaviour towards the environment, in order to achieve sustainable development goals. Most commercial institutions have turned to environmental management as a result of changes over the past two decades due to environmental and industrial pollution worldwide, which has led to significant degradation, damage, and depletion of natural resources.

2. The Importance of Developing Cost of Sustainability Awareness

The importance of developing cost of sustainability awareness is highlighted through several key criteria:

a. The potential use of advertisements and other communication means to raise environmental awareness and preserve the environment generates sufficient interest among a large segment of the population.

b. The value of sustainability awareness is measured by the use of knowledge and facts, and this value includes multiple ways of determining how stakeholders understand the concept of sustainability, why they understand it, and the extent of their understanding [32]

c. Sustainability awareness represents a challenge due to the numerous stakeholders and the environmental constraints imposed on society, as sustainability has become a matter of critical global importance [31].

d. An individual's awareness of the elements surrounding them within the scope of time and place, understanding their significance, and anticipating their state in the near future.

e. It represents a conscious and dynamic reflection of the situation by the individual. That is, it provides dynamic guidance for the situation and an opportunity to express not only the past, present, and future, but also the potential characteristics of the situation.

f. It works to achieve stability in the ecosystem that generates knowledge and behaviour [33].

Third: Reduce Waste

1. The Concept of Reduce Waste

Reduce Waste is considered an ideal concept for addressing waste issues in our society, and the idea is being developed and implemented across various sectors, including waste management and processing, mining, and manufacturing. Policymakers have adopted these practices because they encourage sustainable production and consumption, achieve optimal recycling, and resource recovery. However, specialists in management systems and Reduce Waste recognise and apply it in different ways. Waste is a symbol of inefficiency in any modern society and a representation of unallocated resources. Therefore,

business organisations aim to make significant progress in reducing and limiting waste [3].

The concept of Reduce Waste is considered an important management and production concept through which organisations aim to achieve optimal use of available resources and reduce damage resulting from misuse, spoilage, or unnecessary consumption of materials [34]. This concept refers to a set of practices and procedures aimed at minimising waste at various stages of work and production, contributing to improved operational efficiency, reduced costs, and increased productivity (Jiang et al., 2019). Waste can appear in multiple forms, including material damage due to poor storage, unplanned use of resources, operational errors leading to rework or material damage, as well as production residues that are not utilised optimally [35]. Therefore, modern organisations seek to adopt management and technical methods that help in reducing waste by improving planning processes, inventory control (Senanayaka, 2025), training employees in the efficient use of materials, and benefiting from recycling and reuse processes [36].

The concept of Reduce Waste in materials is a modern idea that has gained significant attention in the fields of management, production, and services, due to its fundamental role in enhancing performance efficiency and optimising the use of available resources [37]. Reduce Waste refers to a set of activities and measures adopted by organisations to minimise material and resource losses during operational, production, and administrative processes [38], thereby ensuring the greatest possible benefit with the least cost, effort, and time [39].

2. The Importance of Reduce Waste

The importance of reducing waste in materials is highlighted by its contribution to lowering operational costs and improving product quality, in addition to its role in conserving resources and achieving environmental sustainability [40]. This concept is also linked to lean production principles, which focus on eliminating unnecessary activities and achieving the highest possible value with the least amount of resources and waste [41].

Organizations that succeed in reducing waste are often more adaptable to modern changes and challenges, as they rely on proper planning, continuous monitoring, and ongoing improvement [42]. Thus, reducing waste is viewed as a strategic tool that helps organisations achieve operational efficiency, sustainability, and enhance performance quality across various activities and processes [43]. The importance of waste reduction in materials lies in many aspects, including lowering operational costs, increasing profits, and improving productivity, in addition to strengthening the organisation's competitiveness and improving the quality of offered products [44]. It also helps preserve natural resources and reduce the environmental impacts resulting from excessive consumption or improper disposal of waste, making it a concept linked to sustainable development and the environmental responsibility of organisations [45].

Part Three: The Practical Aspect

The practical aspect of the research involves conducting a case study on the General Company for Pharmaceuticals and Medical Supplies in Samarra to test the research hypothesis by applying the Materials Flow Costing Accounting model by the researcher to develop cost of sustainability awareness and reduce waste for the company under study as follows:

First: By using the Materials Flow Costing Accounting technique, quantitative data will be converted into an analysis of cost centres for waste and finished products, as this technique relies on dividing outputs into:

1- Positive Product: materials that ended up in the final product.
2- Negative Product: materials that turned into waste or were damaged.

Since the available data is only quantitative (without prices), we will focus on the material balance and the percentage of quantitative waste, which is the cornerstone for building financial reports later.

A- Materials Balance Analysis for Product Mass

1- Total Material Inputs (Raw and Auxiliary Materials)

We add up all input weights (in kilograms):

17500 + 110 + 10250 + 100 + 800 + 320 + 100 + 100 + 1700 + 3400 + 5500 + 1190 + 1000 = 42070

Table (1) Quantity of physical inputs and outputs for the (Flow Out) product for the year 2022

physical inputs		**commodity outputs**	
Statement	**Quantity**	**Statement**	**Quantity**
Ingredients: Paracetamol	17500 kg	Foo Out Production	40409kg
Chlorphenamine	110 kg	**non-commodity outputs**	
Excipients: Maize starch	10250 kg	Damaged cardboard	
Aerosil	100 kg	Damaged unprinted aluminum	250 cartons
PVC	800 kg	Damaged PVC	6000 meters
Talc	320 kg	Damaged cardboard cutter	1500 cutters
Mg. stearate	100 kg	Damaged 50-pack of tape	1000 packets
Glycerin	100 kg	Damaged tape closeer	5 rolls
PHB	1700 kg	Environmentally impactful waste	1661 kg
M.HB	3400 kg		
Sugar	5500 kg		
Cross Caramel	1190 kg		
Endragit	1000 kg		
Energy (Electric)	10528005 kW		
Energy (Fuel and Oils)	360000 L		
Packaging (Carton)	6250 cartons		
Packaging (50-Strip Pack)	100000 packets		
Packaging (Unprinted Aluminum)	120000 meters		
Packaging (PVC)	120000 meters		
Packaging (Cardboard Cutter)	100000 meters		
Packaging (Closer Tape)	100 rolls		

Source: Financial data provided by the company

2. Total Output (Commodities and Waste)

-Commodity Output (Flow Out Production): 40,409 kg

-Non-Commodity Output (Waste with Environmental Impact): 1,661 kg

-Total Output = 40,409 + 1,661 = 42,070 kg

Therefore, the material balance is exactly the same, meaning that the material conversion efficiency is:

40,409 ÷ 42,070 = 96.5%

That is, the material waste rate is: 3.95%

Table (2) shows the percentage of loss for each item

Statement	**Quantity received:**	**Damaged quantity**	**Loss Percentage (%)**
Cardboard	6250 cartons	250 cartons	%4
Aluminum (Printed)	120,000 meters	6,000 meters	%5
PVC	120,000 meters	6,000 meters	%5
Cardboard Cutter	100,000 cutters	1,500 cutters	%1.5
Closer Tape	100 rolls	5 rolls	%5

Third: Energy Cost Allocation

According to Materials flow costing accounting, the energy consumed to produce "waste" is a wasted cost.

1- Electricity: 1,052,805 kW

2- Fuel and Oils: 360,000 liters

A- Share of Passive Product (Waste) Energy:

Since the waste percentage in the mass is 3.95%, the company consumes "wasted" energy to produce waste estimated as follows:

1,052,805 x 3.95 = 4,158,579.75 kW (amount of wasted electricity)

360,000 x 3.95 = 1,422,000 kW (amount of wasted fuel)

Table (3) shows the percentage of each element in the production of the Flow Out product for 2022

Item	**Weight/Quantity**	**Percentage**	**Administrative Recommendation:**

Positive Product (Useful)	40.409 kg	%96.05	Maintaining Quality Standards
Negative Product (Waste)	1.661 kg	%3.95	Exploring Methods for Recycling Environmental Waste
Packaging Waste (Average)	-	%4.1	Inspecting Packaging Machines to Reduce Damage

The results in the table above indicate that 3.95% of the cost of raw materials and 4.1% of the packaging material cost, along with a corresponding portion of operating costs (energy), all go into producing nothing (negative product). In traditional cost accounting, these losses are included within the product cost, whereas in Materials Flow Costing accounting, they are shown separately to guide management towards reducing waste and improving environmental and economic efficiency. The table illustrates the link between the figures and corrective decisions to reduce spoilage.

Table (4) Corrective measures to reduce waste

Item	**Impact on sustainability awareness:**	**Action to Reduce Waste**
Negative Product (3.95)	Recognizing the extent of waste in essential raw materials.	Adjust mixing ratios or improve quality standards to minimize chemical waste.
Packaging Waste (4.1)	Recognizing losses in auxiliary materials that increase costs without benefit.	Inspection of Machines: Perform immediate preventative maintenance on production lines to reduce the 12,000 cubic meters of wasted aluminum and PVC.
Cardboard Cutter (1.5)	Demonstrating relative efficiency in this item compared to others.	Extend the handling or storage experience demonstrated in this item to other materials.

Based on Table (4), the adoption of the Materials Flow Costing Accounting technique contributes to:

1- Converting hidden costs into visible costs: Management now clearly sees that metres and kilograms are being wasted, which promotes 'sustainability awareness'.

2- Directing investment: Instead of looking for cheaper raw materials, awareness focuses on reducing waste through machine maintenance (reducing the 5% in packaging).

3- Achieving economic and environmental sustainability: Reducing waste by just 1% in this factory will save hundreds of kilograms of materials, reducing costs and supporting the environment at the same time.

Fourth: Hypothesis testing

1. The use of the Materials Flow Costing accounting technique leads to developing cost of sustainability awareness.

The results in Table 5 show that the use of the Materials Flow Costing accounting technique contributes to developing cost of sustainability awareness, in other words, increasing the use of the Materials Flow Costing accounting technique contributes to achieving 0.501 of the development of cost of sustainability awareness, with a standard error of 0.033. This indicates a strong correlation of 0.801, which has enhanced the ability of the Materials Flow Costing accounting technique to explain 0.642 of the value of developing cost of sustainability awareness. This means it is necessary to work on developing control systems for raw materials and packaging materials, especially materials that recorded high waste rates such as printed aluminium, PVC, and chlorine tape, by adopting more efficient storage and handling methods.

2. The use of the Materials Flow Costing accounting technique leads to reducing waste.

The results of Table 5 indicate that the use of the Materials Flow Costing accounting technique contributes to reducing waste, in other words, an increase in the Materials Flow Costing accounting technique contributes to achieving a reduction of (0.253) in waste, with a standard error of (0.113). This shows a correlation strength of (0.449), which helped enhance the ability of the Materials Flow Costing accounting technique to explain (0.202) of the reduction in waste. This indicates the necessity of regular maintenance and continuous inspections of production and packaging machines to reduce technical failures and operational errors that lead to increased levels of damaged and wasted materials.

3. Developing cost of sustainability awareness leads to reducing waste.

The results of Table 5 show that the use of Developing cost of sustainability awareness contributes to Reduce Waste, in other words, an increase in Developing cost of sustainability awareness contributes to achieving a value of (0.894) of Developing cost of sustainability awareness, with a standard error of (0.048). This indicates a strong correlation of (0.783), which has enhanced the ability of Developing cost of sustainability awareness to explain (0.613) of the Reduce Waste value. This means that it is important to adopt modern quality control systems at various stages of the production process, helping to detect deviations and errors early and reduce the percentage of defective products and industrial waste.

4. The use of the Materials Flow Costing accounting technique leads to developing cost of sustainability awareness and reducing waste.

The results in Table 5 show that the use of the Materials Flow Costing accounting technique contributes to developing cost of sustainability awareness, which in turn reflects on reducing waste. In other words, an increase in the use of the Materials Flow Costing accounting technique contributes to achieving 0.701 of the development of cost of sustainability awareness and waste reduction, with a standard error of 0.057. This indicates a strong correlation with a coefficient of 0.874, which enhances the ability of the Materials Flow Costing accounting technique to explain 0.764 of the value of developing cost of sustainability awareness and reducing waste. This means that the public company for the manufacture of pharmaceuticals and medical supplies in Samarra prioritises focusing on reducing waste through the adoption of modern techniques in order to make informed decisions, which helps economic units implement appropriate changes to their practices and operations.

Table (5) Hypothesis Test Results

The path					Standard weight	standard error	Critical value	**R**	**R^2**	**Sig.**
Materials flow costing accounting technique	--->	**Developing cost of sustainability awareness**			0.501	0.033	15.182	0.801	0.642	0.001
Materials flow costing accounting technique	--->	**Reduce Waste**			0.253	0.113	2.239	0.449	0.202	0.001
Developing cost of sustainability awareness	--->	**Reduce Waste**			0.894	0.048	18.625	0.783	0.613	0.001
Materials flow costing accounting technique	-->	**Developing cost of sustainability awareness**	-->	**Reduce Waste**	0.701	0.057	12.298	0.874	0.764	0.001

Part Four: Conclusions and Recommendations

First: Conclusions

1. The General Company for the Manufacture of Medicines and Medical Supplies in Samarra prioritises focusing on reducing waste by adopting modern technologies to make informed decisions, which helps economic units implement appropriate changes to their practices and operations.
2. The results indicated varying levels of damage in the materials used in the production process, with PVC and printed aluminium recording a waste rate of 5%, one of the highest losses, suggesting significant opportunities to improve material usage efficiency through the application of the materials flow costing accounting technique.

3. The results show that cardboard recorded a loss rate of 4%, reflecting material losses that can be minimised by tracking material flows and analysing the causes of damage at the production, storage and transportation stages.
4. The data indicated that the lowest damage rate was in the cardboard cutter material, at 1.5%, which suggests higher efficiency in managing this material compared to others, and this could be used as a model to improve the management of other materials within the company.
5. The results showed that the chlorine tape recorded a damage rate of 5%, indicating the need to develop control and supervision procedures for packing processes to reduce waste and achieve optimal resource utilisation.
6. The 2022 table results showed that the percentage of positive (intact) products was 96.05% of total production, which is an indicator of the company's ability to achieve good levels of quality and production, although the continued existence of waste and damaged rates requires the adoption of modern tools to manage losses more accurately.
7. The results showed that the proportion of negative product (waste) reached 3.95%, weighing 1,661 kg, reflecting the extent of environmental and economic losses resulting from spoilage, and emphasising the importance of adopting Materials Flow Costing Accounting techniques to enhance sustainability awareness and reduce industrial waste.
8. The results indicate that the average packaging waste amounted to 4.1%, indicating issues related to filling processes or the efficiency of the machines used, necessitating regular maintenance and continuous inspection of the filling machines to minimise spoilage and reduce costs.

Second: Recommendations

Based on the research findings, the company should:

1. The necessity of adopting Materials Flow Costing Accounting comprehensively within the General Company for Pharmaceuticals and Medical Supplies in Samarra, due to its role in tracking material flows and accurately identifying sources of waste and spoilage, thereby contributing to cost reduction and improving production efficiency.
2. Working on developing control systems for raw materials and packaging materials, especially those with high wastage rates such as printed aluminium, PVC, and chlorine tape, by adopting more efficient storage and handling methods.
3. The necessity of conducting regular maintenance and continuous inspections of production and packaging machines to reduce technical malfunctions and operational errors that lead to increased material spoilage and wastage.
4. Work on raising environmental awareness and sustainability among employees through organising training programmes and workshops that highlight the importance of reducing waste, conserving resources, and their impact on lowering costs and improving institutional performance.
5. It is important to adopt modern quality control systems at various stages of the production process to help detect deviations and errors early, and reduce the proportion of defective products and industrial waste.
6. Work on utilising waste and by-products from production processes through recycling or reuse whenever possible, contributing to reducing environmental impact and achieving economic savings for the company.
7. Encourage senior management to adopt sustainable production strategies based on continuous improvement and efficient resource use, with clear performance indicators to measure waste and defects and monitor them regularly to achieve sustainability and operational efficiency goals.
8. The necessity of adopting the Materials Flow Costing accounting technique in a way that contributes to enhancing sustainability awareness within the company by accurately identifying sources of waste and spoilage, which helps management make more efficient decisions to reduce costs, conserve resources, and improve the company's environmental and production performance.

References

[1] S. A. S. Abbas and A. H. Al-Yamour, “Using materials flow costing accounting as an approach to

achieving optimal utilization of available resources," *Journal of Sustainable Studies*, vol. 6, no. 4, 2024.

[2] A. B. Musa, "Integration between materials flow costing (MFCA) and supply chain accounting techniques to achieve competitive advantage in industrial companies," Erbil Technical University, Administrative Technical College, 2023.

[3] F. A. Al-Anbari, "The impact of the DMAIC model on enhancing service quality and reducing losses through entrepreneurial strategic orientation: An analytical study of managers' opinions at Zain Iraq Telecommunications Company/Baghdad," Al-Qadisiyah University, 2025.

[4] Q. S. Thalij and T. S. Mahmood, "The impact of using ISO 14051 standard for material flow costing on the Iraqi market in light of the provision of environmentally friendly products," *Accounting & Financial Studies Journal*, vol. 20, no. 71, 2025.

[5] H. M. N. Awadallah Al-Amin, "Integrating materials flow cost accounting (MFCA) and resource consumption accounting (RCA) to support competitiveness in industrial enterprises," *Journal of Humanities and Natural Sciences*, vol. 6, no. 1, pp. 472–494, 2025.

[6] H. M. Aziz and H. H. Mohammed, "The Application Of Resource Consumption Accounting And Its Impact On Sustainable Competitive Advantage In Cement Sector At The Kurdistan Region Of Iraq," *Lex Localis*, vol. 23, no. S6, pp. 1894–1914, 2025.

[7] C. Walls, A. R. K. Putri, and G. Beck, "Material flow cost accounting as a resource-saving tool for emerging recycling technologies," *Clean Technologies*, vol. 5, no. 2, pp. 652–674, 2023.

[8] K. Kokubu, H. Kitada, K. Nishitani, and A. Shinohara, "How material flow cost accounting contributes to the SDGs through improving management decision-making," *J. Mater. Cycles Waste Manag.*, vol. 25, no. 5, pp. 2783–2793, 2023.

[9] H. Liang, "Modern Technology's role in accounting cost calculation of industrial enterprises: Informatization as a key strategy to improve management efficiency," *Heliyon*, vol. 11, no. 1, 2025.

[10] H. Movaffaghi and I. Yitmen, "Framework for dynamic circular economy in the building industry: integration of blockchain technology and multi-criteria decision-making approach," *Sustainability*, vol. 15, no. 22, p. 15914, 2023.

[11] D. Siepelmeyer, "Development of Material Flow Cost Accounting and Value Added Statements as Planning Instruments for Sustainability Management," *N/A*, 2023.

[12] T. A. N. Khotimah, N. Nurlaili, E. Evi, and S. Ersi, "The Effect of Green Accounting and Material Flow Cost Accounting on Corporate Sustainability in an Islamic Economic Perspective," in *Annual International Conference on Islamic Economics and Business (AICIEB)*, 2022, pp. 233–243.

[13] H. Schandl *et al.*, "Global material flows and resource productivity: The 2024 update," *J. Ind. Ecol.*, vol. 28, no. 6, pp. 2012–2031, 2024.

[14] M. Doorasamy, "The effectiveness of Material Flow Cost Accounting (MFCA) in identifying non-product output costs and its impact on environmental performance in paper manufacturing companies: A case study in Kwa-Zulu Natal," *The Journal of Accounting and Management*, vol. 3, pp. 51–69, 2014.

[15] R. H. N. Obaid and M. H. Ali, "Using resource consumption accounting and material flow costing accounting to achieve product sustainability in Iraqi economic units," *Journal of Accounting and Financial Studies (JAFS)*, vol. 20, no. 73, pp. 1–16, 2025.

[16] M. Dekamin, A. Nabavi-Pelesaraei, and H. Rezaei, "Economic and environmental dynamics of tea production through material flow cost accounting (MFCA)," *Clean. Eng. Technol.*, vol. 26, p. 100971, 2025.

[17] H. N. Dahi and H. S. Abdallah, "The impact of materials flow costing on reducing product costs: An applied study at Diyala General Company," *Journal of Accounting and Financial Studies (JAFS)*, vol. 18, no. 65, pp. 435–453, 2023.

[18] M. A. Mohsin and H. H. Mohammed, "Importance of implementing material flow cost accounting technique (MFCA) and its role to enhance environmental sustainability in industrial companies: An analytical study on a set of refining companies/Erbil," *Journal of Accounting and Financial Studies (JAFS)*, vol. 20, no. 71, pp. 491–504, 2025.

[19] H. Usul and E. B. Olgun, "An analysis of material flow cost accounting in companies using different cost accounting systems," *Heliyon*, vol. 11, no. 4, 2025.

[20] R. S. D. Astuti, A. D. Astuti, and H. Hadiyanto, "Preliminary design of industrial symbiosis of smes using material flow cost accounting (MFCA) method," in *E3S Web of Conferences*, EDP Sciences, 2018, p. 4008.

[21] R. A. S. Al-Jaff and H. H. H. Al-Zebari, "The Impact of the Application of Material Flow Cost Accounting (MFCA) Technology on Reducing Costs and Rationalizing Administrative Decisions," *Academic Journal of Nawroz University*, vol. 11, no. 4, pp. 266–283, 2022.

[22] N. P. Hariram, K. B. Mekha, V. Suganthan, and K. Sudhakar, "Sustainalism: An integrated socio-economic-environmental model to address sustainable development and sustainability," *Sustainability*, vol. 15, no. 13, p. 10682, 2023.

[23] H. M. Al-Hattami, K. Mady, and M. A. Al-Bukhrani, "Green digital accounting and sustainable entrepreneurship in emerging economies: impacts on financial sustainability and performance," *Cogent Business & Management*, vol. 13, no. 1, p. 2601944, 2026.

[24] W. Krara, A. Alzubi, A. Khadem, and K. Iyiola, "The nexus of sustainability innovation, knowledge application, and entrepreneurial success: Exploring the role of environmental awareness," *Sustainability*, vol. 17, no. 2, p. 716, 2025.

[25] I. Z. Hamid and R. H. Ibrahim, "Bridging the Knowledge Gap: A Cross-Sectional Study on Sustainability Awareness Among Nurses," *Mosul Journal of Nursing*, vol. 13, no. 1, pp. 377–388, 2025.

[26] A. Bouziane, B. Cheikh, C. Bousmaha, and C. A. Tiari, "The role of environmental awareness in building global environmental citizenship in Islamic law and international conventions," *N/A*, 2014.

[27] H. R. Perea, A. R. Piedrahita, and Ó. E. T. Alzate, "Models of environmental awareness: exploring their nature and role in environmental education–a systematic review," *Heliyon*, vol. 11, no. 13, 2025.

[28] M. D. Vaverková *et al.*, "Enhancing sustainable development through interdisciplinary collaboration: Insights from diverse fields," *Sustainable development*, vol. 33, no. 3, pp. 3427–3454, 2025.

[29] A. B. Khan, "Towards sustainable development: Social policies and environmental justice," *Journal of Political Stability Archive*, vol. 1, no. 1, pp. 34–41, 2023.

[30] N. Jaakkola, M. Karvinen, K. Hakio, L. A. Wolff, T. Mattelmäki, and M. Friman, "Becoming self-aware—how do self-awareness and transformative learning fit in the sustainability competency discourse?," in *Frontiers in Education*, Frontiers Media SA, 2022, p. 855583.

[31] F. M. Al-Dhabawi and M. F. Al-Masoudi, "'Environmental awareness and its role in achieving sustainable development': An applied study of the opinions of a sample of employees in the Directorate of Municipalities of Holy Karbala," *Journal of the Islamic University College*, vol. 1, no. 66, pp. 861–898, 2022.

[32] O. Enechi and P. Pattberg, "What determines participation in multi-stakeholder partnerships? Assessing sustainability awareness and knowledge," *Discover Sustainability*, vol. 6, no. 1, p. 104, 2025.

[33] T. Heijmeskamp, "Grasping the Situation: analyzing how situational dynamics shape agency," *Front. Psychol.*, vol. 15, p. 1392995, 2024.

[34] J. A. Balch *et al.*, "Methods and evaluation metrics for reducing material waste in the operating room: a scoping review," *Surgery*, vol. 174, no. 2, pp. 252–258, 2023.

[35] S. Tafesse, "Material waste minimization techniques in building construction projects," *Ethiopian Journal of Science and Technology*, vol. 14, no. 1, pp. 1–19, 2021.

[36] T. O. Adewuyi and T. O. Adewuyi, "Reduction potentials of material waste control construction methods on building sites in south-south, Nigeria," *International Journal of Advances in Scientific Research and Engineering (IJASRE)*, vol. 6, no. 8, pp. 100–120, 2020.

[37] R. Feng, J. Jiang, Z. Sun, A. Thakur, and X. Wei, "A hybrid of genetic algorithm and particle swarm

optimization for reducing material waste in extrusion-based additive manufacturing," *Rapid Prototyp. J.*, vol. 27, no. 10, pp. 1872–1885, 2021.

[38] K. R. Ririh, D. R. Ningtyas, and D. A. Utami, "Strategy for Reducing Material Waste of Ready-Mix Concrete Production through Analytical Hierarchy Process (A Case Study)," in *Proceedings of the 5th NA International Conference on Industrial Engineering and Operations Management*, 2020, pp. 3288–3296.

[39] R. Singh, "Transitioning vulnerabilities: From internal inflation to external shocks (2006–2026)," *Nat. Econ. Outlook*, vol. 4, no. 1, pp. 112–134, 2026.

[40] A. A. Hadi, "Investigation of Material Waste at Source in Offsite Construction: Quantification, Analysis, and Mitigation," Birmingham City University, 2026.

[41] Reinhart and P. Arumsari, "Analysis of Efficiency and Material Waste in the Implementation of Lean Construction in High Rise Building (Case Study: Nafiri Discipleship Church)," in *IOP Conference Series: Earth and Environmental Science*, IOP Publishing, 2025, p. 12049.

[42] J. Jiang, X. Xu, and J. Stringer, "Optimization of process planning for reducing material waste in extrusion based additive manufacturing," *Robot. Comput. Integr. Manuf.*, vol. 59, pp. 317–325, 2019.

[43] M. M. A. Abkar, R. Yunus, Y. Gamil, and M. A. Albaom, "Enhancing construction site performance through technology and management practices as material waste mitigation in the Malaysian construction industry," *Heliyon*, vol. 10, no. 7, 2024.

[44] M. M. Sesay, "Reducing Landfill Waste in Sierra Leone with Construction Industry Material Waste Management," *N/A*, 2022.

[45] P. Senanayaka, "Lean management techniques for reducing material waste: Finland evidence," *N/A*, 2025.