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Integrated Information System using the Kanban Methodology for the reuse of waste in the footwear industry

Sakibaru Mauricio, Luis Alberto, Doctor[1]; Castillo Paredes, Omar Tupac Amaru, Magister[1]; Zapata Villar, Loyo Pepe, Doctor[1]; Gutierrez Huayra, Richard Smith, Magister[1]; Vilchez Inga, César, Doctor[1]; Casazola Cruz, Oswaldo Daniel, Magister[1]; Holgado Quispe, Ana Maria, Doctora[2]; [1]Universidad Nacional del Callao, Perú, lasakibarum@unac.edu.pe, otacastillop@unac.edu.pe, lpzapatav@unac.edu.pe, rsgutierrezh@unacvirtual.edu.pe, cvilchezi@unac.edu.pe, odasazolac@unac.edu.pe, [2]Universidad Nacional Federico Villareal, Perú, aholgadoq@unfv.edu.pe.

Abstract-The objective of this scientific article is to propose the implementation of an integrated information system between companies in the same sector, such as the recycling of footwear due to wear that favors the decision to reuse and recycle them by the industrial companies that make up this sector. The universe of this research is made up of the companies that belong to the footwear cluster. The sample selected for this research will be extracted from the universe of the company that has little success in the market because it is very difficult for them to compete with the hunted coming from China. It is applied, causal correlational, non-experimental, carried out in the field, using the survey technique and a questionnaire as an instrument. Kolmogorov - Smirnov K - S was applied because $n > 50$ ***(***$n = 132$***). P - Value is less than*** $0{,}05$ ***(***$p = 0{,}001$ ***for both variables), where it does not present normal distribution.***

The results show a statistically significant association between the integrated information system based on the Kanban methodology and the intention to reuse footwear waste. However, due to the non-experimental and cross-sectional design, the findings should be interpreted as correlational evidence and not as proof of causal impact.

Keywords: Integrated Information System, Kanban Methodology, Recycling, Footwear.

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I. INTRODUCTION

Currently, many Peruvian companies try to improve their processes, competing directly with Chinese products that cover the national market because they are cheap and limits Peruvian companies and some of them leave the market due to the lack of technology, of applying methodologies in the improvement process, as well as; training of personnel that would demonstrate to an organization to be competitive. Leather, textile links and components were the first and largest generators of hazardous waste. That is why the possibilities found were the recovery and reuse of waste or disused footwear. However, this study presents an experimental stage which will be developed through surveys of those involved in this field. This is why many industries are looking for quick and efficient ways to discard the waste generated in a production process, such as companies trying to find reuse of products discarded due to wear and tear. It can be concluded that the footwear industry still has a way to go in terms of flow optimization, reduction of unnecessary emissions and reuse of defective or unused products, applying the Kanban methodology which helps to improve its processes and avoid the increase in waste, which covers the reuse of unused footwear. Therefore, this study revealed that the efforts of the footwear chain to reduce impacts derived from the waste generated throughout its production process have been carried out in an incremental and segmented manner, and the knowledge accumulated on the subject to date is scarce. This disarticulation highlights the need for comprehensive studies to systematize this knowledge.

Today the reuse of waste or waste in production processes is a challenge to avoid environmental pollution, since through this degradation in the environment it has determined impacts that demonstrate irreparable damage such as global warming and damage that is generated in the course of the time.

This study should be understood as a preliminary and exploratory diagnosis focused on one footwear company in Trujillo. Therefore, its results are not intended to be generalized to the entire footwear industry, but to provide initial evidence for a future pilot implementation of an integrated Kanban-based information system.

II. THEORETICAL FRAMEWORK

According to [1], waste present in seas, rivers, and lakes contributes to climate change, altering weather patterns and affecting key areas such as health, food and energy security, exacerbating poverty, and fostering conflicts and migrations. Therefore, implementing environmental care policies that promote sustainable business models prioritizing the use of reusable materials is a priority, as suggested by [2].

During the COVID-19 pandemic, recycling in Peru decreased by 30-40 % [3], highlighting the lack of integrated information systems to measure and manage generated waste, affecting sectors such as the glass and plastic industries. On the other hand, the United Nations Environment Programme [4] emphasizes that "Cleaner Production" aims to prevent environmental impacts through integrated strategies in processes and products, increasing industrial competitiveness and ensuring economic viability.

In the realm of eco-efficiency, the World Business Council for Sustainable Development [5] highlights the importance of optimizing the ratio between added value and environmental impact, promoting practices such as the recycling of industrial waste. This approach is particularly relevant in industries like footwear, where the absence of efficient reprocessing limits the reuse of materials. Implementing systems like Kanban and integrated databases would allow for optimizing recycling frequency and reusing waste in new production processes.

Additionally, waste management involves comprehensive planning that covers everything from collection to the final destination of waste, reducing its environmental impact and maximizing the use of raw materials (World Health Organization, 2021). The adoption of innovative technologies and methodologies can transform waste into new products or energy sources, contributing to industrial sustainability and profitability [4].

In conclusion, advancing toward more sustainable management models requires not only technological improvements but also a cultural and organizational shift that values reuse and fosters the development of new industrial solutions.

The article [6], published in Revista GEPROS, highlights how the implementation of the Kanban system can optimize the rouse of industrial waste through the systematization of communication. This approach enables better management of residual materials, promoting sustainable practices and increasing competitiveness in the industry.

The study demonstrates that the use of ECO-Kanban not only reduces environmental impact but also improves production processes by integrating efficient management methods and strategic communication. This theoretical framework is highly relevant for adapting the model to other industries, such as footwear, with the aim of reusing waste and fostering business sustainability [7].

A. Solid Waste

This refers to materials discarded during their useful life, which therefore lack economic value. Solid waste arises from the residues of materials used in the transformation of raw materials as well as from consumed products.

Solid waste is classified based on its specific characteristics:

- **Toxic Waste:** Defined by its physical or chemical properties, concentration, and exposure duration, causing harm or death to living beings and contributing to environmental pollution. [8].
- **Hazardous Waste:** Waste that, due to improper handling or disposal, can cause death, diseases, or pose risks to health and the environment [9].
- **Non-Hazardous Waste:** Waste found in public or private spaces that does not pose harmful effects on human health.

B. Reverse Logistics

This concept encompasses operations related to the reuse of products and materials, including all logistical activities such as collection, disassembly, and processing of used materials or products and/or their components. The aim is to ensure sustained ecological recovery [10].

Reverse logistics plays a vital role in minimizing waste and maximizing resource efficiency, aligned with circular economy principles [11].

C. Information System

Defined as the management of a set of data that interact with each other to support a process. In practice, it is applied to projects for the purpose of collecting, processing, storing, and transmitting information, ensuring user accessibility, solving problems, and meeting needs. To implement an information system, it is necessary to develop solutions aligned with desired objectives.

Each component of an information system serves a specific function, and they are interconnected toward achieving a common goal. A key feature is the conversion of raw data into information, enabling knowledge acquisition essential for more accurate decision-making. This is particularly relevant in managing the vast amounts of data available on the internet.

D. Eco-Design

This is a creative activity aimed at determining the multifaceted qualities of objects, processes, services, and their systems throughout their life cycle. Eco-design plays a central role in the innovative humanization of technology and serves as a critical factor in cultural and economic exchange. Its objectives include prioritizing global sustainability and ethical protection, while offering tangible benefits.

The concept emerged to guide the creation of consumer goods for mass production, focusing on technological innovations and the development of functional, marketable, desirable, and profitable products. As a tool, eco-design promotes the development of products using materials and manufacturing processes that are less harmful to the environment. It also adds market and social awareness value, making products more competitive in an era of increasingly informed and demanding consumers [12].

E. Kanban

This is a method of information management using visible records, typically cards, to authorize the movement of products within a production plant or distribution center. It increases flexibility in producing a specific quantity of products [13].

Three types of Kanban are identified based on their characteristics:

- **Production Kanban:** Specifies the quantities of a specific product to be produced in a company.
- **Movement Kanban:** Authorizes the transfer of a product to the next phase or directly to the end customer.
- **Withdrawal Kanban:** Manages product delivery through transportation. [14].

F. Polution

This is a factor in both national and international issues, stemming from demographic changes, weak legislation, and economic growth. It is primarily the result of human production activities, particularly in industrial sectors involving high-risk processes. Pollution has significant negative effects on health and the environment [15].

Industrial practices lead to two primary types of impacts:

- **Point Impact:** Effects are highly localized and of great magnitude.
- **Partial Impact:** Arises from continuous processes that consistently increase risk over time at the affected location [8].

G. Environmental Management

Though not universally defined, this concept involves directives and administrative activities aimed at achieving objectives with positive environmental effects. These include planning, directing, controlling, and allocating resources to reduce or eliminate harm caused by human actions. Environmental management departments in organizations are often responsible for meeting regulatory requirements and suggesting appropriate equipment or devices for environmental control [16].

H. Environmental Sustainability

This concept has emerged within the context of globalization as a boundary or guideline to redirect humanity's civilization process. It is defined as a normative criterion aimed at reconstructing economic order to ensure human survival and support sustainable development. It challenges traditional production bases and advocates for a durable, balanced growth framework [17].

The three key types of Kanban each serve distinct purposes in streamlining workflows:

1. **Production Kanban:** Specifies the quantity of a product to be manufactured, ensuring production aligns with demand.
2. **Movement Kanban:** Authorizes the transfer of items to the next phase, optimizing the flow within production processes or distribution.
3. **Withdrawal Kanban:** Facilitates the retrieval of finished products for delivery, ensuring timely transportation and customer satisfaction.

III. METHODOLOGICAL ASPECTS

According to [18, p. 38], he gives a classification of the types of research according to the objective and the methods used, which is why he separates applied research and basic research. Regarding these definitions, this study is determined to be of an applied type, since new knowledge is not going to be created or modified, what is proposed is to demonstrate knowledge that already exists, that is, to demonstrate that an integrated information system using Kanban methodology helps companies reuse waste from the footwear industry, which makes them competitive, improving the relationship with the customer through appropriate promotions.

However, [18, p. 4] determines the research approaches, based on the theory provided, of which this research work presents a quantitative approach, because a theory will be demonstrated, which is applying an integrated system of information using the Kanban methodology and for this a problem has been formulated, posing objectives and hypotheses that will be analyzed and demonstrated through data and surveys.

[18, p. 122] also determines the scope of the research and based on that theory it is determined that the research work has a correlational scope, because the relationship that exists between the two variables is analyzed, Integrated Information System using the Kanban Methodology (independent) and waste reuse (dependent), it also presents an explanatory scope, because the relationship between these two variables is explained. [18] also determines that a research that depends on its objectives can present more than one scope, which is why this research work presents two scopes.

According to [18, p. 127], the design of this research work presents a non-experimental design, because it will not influence the determined variables, what is done is to analyze the data that are obtained in the real result. of each variable, therefore, it is analyzed whether by applying an integrated information system using the Kanban methodology the waste will be reused in the footwear industry, which means that the data will be analyzed and no experiments will be carried out with them.

This non-experimental design can be divided, according to [18, p. 154], which is why our design complements a cross-sectional non-experimental design, because the data were obtained at a certain time, after implementing an integrated system of information using the Kanban methodology and the influence it had with respect to the reuse of waste is analyzed.

The design according to [18, p. 155] continues to be subdivided and it can be said that this research also has a causal correlation classification, since it analyzes the relationship that exists between two variables (integrated information system using the Kanban methodology and reuse of waste), due to them, a non-experimental transversal causal correlational design is concluded.

Therefore we can define our investigative method, taking into account the theory proposed by [19, p. 61], determining that our method is hypothetical deductive, this because we have 4 hypotheses, where we will try to demonstrate its validity through analysis of data.

TABLE I:
TYPE AND RESEARCH DESIGN

Abstract	Description
Type:	Applied (technological)
Approach:	Quantitative
Scope:	Explanatory correlational
Design:	Non-experimental / cross-sectional / correlational causal
Method:	Correlational deductive hypothetical

Note: Type and design of research used in this research work

Applying a convenience sample, in this case it was the industrial footwear company located in Trujillo that has around 260 workers, 205 will be surveyed. This company was chosen because it provided us with access to its information and to meet with its workers to carry out this work.

To calculate the sample size, the simple type of sampling will be used, since, knowing the size of the population, those who are present in the organization carrying out the work shift will be taken into account. To calculate the sample size, a simple random calculation will be used to understand the size of the population, with a confidence level of 95 % and a margin of error of 5 %, as follows:

Formula to use:

$$n = \frac{Z^2PQN}{NE^2 + Z^2PQ} \tag{1}$$

Replacing the data:

$$n = \frac{(1{,}96)^2(0{,}4)(0{,}6)(205)}{(205)(0{,}05)^2 + (1{,}96)^2(0{,}4)(0{,}6)} = 132 \tag{2}$$

Therefore; The sample $n = 132$ workers, including professionals and operators.

Since the data were collected from a single footwear company, the results are limited to this organizational context. This limitation is recognized because the study uses a convenience sample and does not compare several companies. For this reason, the findings are presented as evidence for a case-based exploratory study

To apply the reliability of the instrument, it is divided into two scales, of which the first scale analyzes the Integrated Information System variable, which is composed of 04 items, and the second variable is the Kanban Methodology, composed of 08 items. According to them, the reliability will be calculated. reliability and validity in each of them

TABLE II:
REALITY OF VARIABLES

Scale	Cronbach's alpha	item number
Comprehensive Information System	0,803	04
Kanban Methodology	0,803	08

Based on these tests, the normality graphs obtained and the hypothesis testing are made, which determine whether its distribution is normal. Then, the sample obtained is greater than 50 ($n = 132$), the first test that was explained above was chosen.

To perform the non-parametric test, the null hypothesis (H0) must present a homogeneous distribution, therefore, it will be rejected if the p value is $< \,$,05. Accordingly, if the opposite of what was mentioned above turns out to be true, it is stated that the selected sample has a normal distribution, its significance level tends to be $\geq$,05.

$p_{value} \geq 0{,}5$: Accept H0: The random variable has a normal distribution.

$p_{value} < 0{,}5$: Accept H1: The random variable does not have a normal distribution.

Analyzing the dimensions of the Integrated Information System Variable and the Kanban methodology Variable, according to the questions posed, the following tables are observed:

TABLE III:
NORMALITY TESTS

Variables	Kolgomorov-Smirnova			Shapiro-Wilk		
	Stat.	gl	Sig.	Stat.	gl	Sig.
Integrated Information System	0,156	132	0,000	0,961	132	0,001
Kanban Methodology	0,259	132	0,000	0,839	132	0,000

When observing this table we see that the Kolmogorov – Smirnov (K-S) has to be applied because $n > 50$.

We see that the p_{value} is less than 0,05, hypothesis H1 is accepted; That is, the random variable does not have a normal distribution.

Analysis of the General Hypothesis:

* Null hypothesis (H0): The implementation of an integrated information system between companies in the same sector such as the recycling of footwear due to wear and tear does not favor the decision to reuse and recycle them by the industrial companies that make up this sector.

* Investigative Hypothesis (H1): The implementation of an integrated information system between companies in the same sector such as the recycling of footwear due to wear and tear favors the decision to reuse and recycle them through the Kanban Methodology by the industrial companies that make up this sector.

The Chi – Square test is applied to test hypotheses (Hernández et al, 2017).

TABLE IV:
CHI TABLE - SQUARE. GENERAL HYPOTHESIS

	Valor	df	Asymptotic significance (bilateral)
Pearson chi-square	58,837a	9	0,000
Likelihood ratio	62,617	9	0,000
Linear-by-linear association	42,194	1	0,000
N of valid cases	132		

a. 12 cells (75,0 %) have expected a count less than 5. The minimum expected count is 0,14.

When interpreting the table, we see that the significance level less than 0,05 (0,000 $<$ 0,05) we reject the null hypothesis and accept the alternative hypothesis, it is concluded that at a significance level of 0,05 it shows that implementing a system Integrated information sharing between companies in the same sector, such as the recycling of footwear due to wear and tear, favors the decision to reuse and recycle them through the Kanban Methodology by the industrial companies that make up this sector.

Through the following table:

TABLE V:
CONTENGENCY COEFFICIENT TABLE.
GENERAL HYPOTHESIS

Symmetrical measurements		Value	Approximate significance
Nominal by Nominal	Contingency coefficient	0,555	0,000
N of valid cases		132	

We can interpret that the contingency coefficient shows us the relationship between the two variables, so the contingency coefficient is less than $0{,}05$ $(0{,}000 < 0{,}05)$, we reject the null hypothesis and accept the alternative hypothesis, concluding that at a level of significance of $0{,}05$, there is a strong relationship that implementing an integrated information system between companies in the same sector such as the recycling of footwear due to wear and tear favors the decision to reuse and recycle them through the Kanban Methodology by the industrial companies that make up this sector.

Three specific hypotheses were taken into account, which demonstrate that the data obtained are related to the general hypothesis.

* Specific hypothesis 1:

Null hypothesis (H0): The lack of statistical data in the entire footwear sector does not affect determining the frequency of waste generation.

Investigative Hypothesis (H1): The lack of statistical data in the entire footwear sector affects determining the frequency of was.

TABLE VI:
CHI-SQUARE TABLE. SPECIFIC HYPOTHESIS 1

	Valor	df	Asymptotic significance (bilateral)
Pearson chi-square	43,876a	12	0,000
Likelihood ratio	52,468	12	0,000
Linear-by-linear association	8,141	1	0,004
N of valid cases	132		

a. 9 boxes (45,0 %) have expected a count less than 5.
The minimum expected count is 0,76.

It is observed that the level of significance less than $0{,}05$ $(0{,}000 < 0{,}05)$ we reject the null hypothesis and accept the alternative hypothesis, it is concluded at a significance level of 0,05 demonstrates that the lack of statistical data throughout the footwear sector affects determining the frequency of waste generation.

* Specific Hypothesis 2:

Null hypothesis (H0): The recycling of footwear disused due to wear and tear cannot be used in the reprocessing of a product of the same category.

Investigative Hypothesis (H1): The recycling of footwear disused due to wear and tear can be used in the reprocessing of a product of the same category.

TABLE VII:
CHI-SQUARE TABLE. SPECIFIC HYPOTHESIS 2

	Valor	df	Asymptotic significance (bilateral)
Pearson chi-square	31,047a	12	0,002
Likelihood ratio	33,814	12	0,001
Linear-by-linear association	22,152	1	0,000
N of valid cases	132		

a. 9 boxes (50,0 %) have expected a count less than 5.
The minimum expected count is 1,33.

We see that the level of significance less than $0{,}05$ $(0{,}002 < 0{,}05)$ we reject the null hypothesis and accept the alternative hypothesis, it is concluded that at a level of significance of 0,05 it shows that the recycling of disused footwear by wear can be used in the reprocessing of a product of the same category.

* Specific Hypothesis 3:

Null hypothesis (H0): The lack of studies regarding waste by the footwear cluster cannot improve the environment. Investigative Hypothesis (H1): The lack of studies regarding waste by the footwear cluster can improve the environment.

TABLE VIII:
CHI-SQUARE TABLE. SPECIFIC HYPOTHESIS 3

	Valor	df	Asymptotic significance (bilateral)
Pearson chi-square	26,423a	12	0,009
Likelihood ratio	30,883	12	0,002
Linear-by-linear association	9,409	1	0,002
N of valid cases	132		

a. 10 boxes (50,0 %) have expected a count less than 5.
The minimum expected count is 0,73.

We see that the level of significance less than 0.05 (0.009 ¡0.05) we reject the null hypothesis and accept the alternative hypothesis, it is concluded that at a significance level of 0.05 it shows that the lack of studies in relation to the waste by the footwear cluster can improve the environment.

IV. Discussion of Results

From an implementation perspective, the proposed system would require four basic components: a digital database of generated waste, a Kanban board for material flow control, user roles for operators and supervisors, and periodic reports on reuse indicators. The main indicators to monitor in a future pilot would be: percentage of reused waste, classification time, storage cost, amount of recovered material and reduction of discarded material.

The implementation costs would mainly include software configuration, staff training, data registration devices and maintenance of the information system. In future applications, the economic feasibility should be evaluated using indicators such as implementation cost, savings from reused materials, payback period and return on investment.

Possible barriers include limited technological infrastructure, resistance to change, lack of training and weak organizational culture regarding circular economy. To reduce these barriers, a gradual pilot implementation is recommended, beginning with one production area and later expanding to other areas or companies.

Through the data submitted to their respective analysis, an attempt has been made to show that an integrated information system and the kanban methodology can improve processes using reusable materials from the footwear industry, of which said study is established in carrying out a general hypothesis and three specific hypotheses, taking into account carrying out an instrument, which is divided into dimensions to affirm the hypotheses of which they were raised.

According to what was mentioned, data collection was carried out in a group of people dedicated to the footwear industry, from which it was verified if the data collected shows normality (Normality Test), due to this, it did not show normality. For this reason, non-parametric analysis was carried out, using chi-square since it complied with the analysis of the collected data.

When analyzing through chi-square, each of the specific hypotheses is verified that each of these specific hypotheses have high values and present significance that determines rejecting the proposed null hypotheses and that shows conformity of validity in each specific hypothesis. By validating the specific hypotheses, it shows that the general hypothesis verifies the relationship to the study carried out. Through this analysis it is concluded that, by demonstrating these hypotheses, the results suggest that footwear companies may consider applying the analyzed dimensions as part of a strategy to strengthen competitiveness and waste reuse management.

V. CONCLUSIONS

- Reuse is considered as that process that allows existing resources to be taken advantage of and a company's activities and their classification can be optimized.
- According to the interviewees, all the participants have been chosen for their years of experience in the footwear industry, to obtain real data, by focusing on whether these companies use eco-efficient products, we can determine that they do not use them, nor They have an idea of how to apply it in their processes, in addition to that there are no suppliers that offer reusable raw materials, and it shows that this this structure could create opportunities for differentiation, cost reduction and potential economic benefits for companies.
- Currently, many industrial footwear companies suffer when facing Chinese products, because the latter affects the national market, since it is difficult to compete with these products because they are cheap, which is why when carrying out this work it is important to explain to them. to industrial footwear companies nationwide to implement an integrated information system using the Kanban methodology, which will determine a collection and storage of databases that may contribute to improving decision-making and strengthening the competitiveness of footwear companies.
- The opportunities for new reused materials and the practical applicability of new products can be obtained through the concepts of Reverse Logistics and Circular Economy that are due to industrial waste demonstrating an increasingly solid path to be traveled, not only by the Product Design area, but also applied by Materials Engineering.
- With the scarcity of natural resources due to the unbridled increase in global consumption, the need to replace traditional raw materials with waste from the industry itself or elsewhere is an increasingly clear reality in the industrial world.
- In conclusion, the study provides preliminary statistical evidence that an integrated information system supported by the Kanban methodology is associated with better management of footwear waste reuse. Nevertheless, because the research design is non-experimental and cross-sectional, the results do not prove causal effects. Future research should include a pilot implementation, longitudinal monitoring, cost-benefit analysis and comparison across several footwear companies.

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