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Geometric pattern infill influence on pentagonal cupola mechanical behavior subject to static external loads

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Abstract. Every day we are surrounded, and we enter in contact with tens or maybe even hundreds of objects, whether they serve us as tools in carrying out certain activities, or whether they have a purely decorative role, they are part of our lives and have become indispensable to humanity. But how many times have we thought about the fact that these objects are based on simple geometries or intersections of geometric bodies that together make up an assembly which, later can be built and used for its designed purpose. This article aims to analyse the mechanical behaviour of the pentagonal cupola when applying static loads, considering several geometric filling patterns, but also the empty and the full structure of the polyhedron.

Keywords: pentagonal cupola, Johnson solids, static simulation, geometric pattern

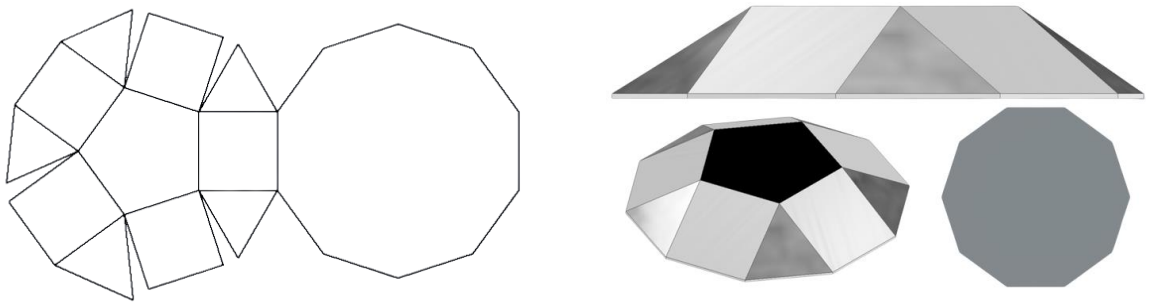
1. Introduction

There are a multitude of polyhedra that have been described over time and that are part of the construction of certain structures, objects or mechanical parts, each having particularities related to the typology of geometric two-dimensional shapes used as their basis (triangle, square, pentagon, hexagon, octagon, etc.) or the angle formed by the intersection of these geometric shapes at the vertex which can determine whether a polyhedron is convex or not. These polyhedra were categorized according to their geometric function, but also according to the personalities who contributed to the foundations of geometry as we know it today, thus, this is how Archimedean polyhedra [1], Platonic polyhedra or Johnson polyhedra appeared.

The polyhedra that are part of the category of Johnson polyhedra are geometries that contain a combination of regular polygonal faces, with the condition that the polyhedron is convex, so it does not imply the use of the same polygons as faces of the polyhedron like the Platonic polyhedra (tetrahedron, cube, icosahedron, dodecahedron etc.) [2]. Norman Johnson described a series of 92 convex polyhedra with regular polygonal faces dividing them into families and categories according to geometric characteristics (pyramids, cupola and rotundas) [3, 4]. The vast majority of the polyhedra described by Johnson are generated together with Archimedean, Platonic polyhedra or by using antiprisms or prisms, but they are formed based on precise descriptive formulas.

Depending on their shape, the cupola can serve in the construction of various objects or structures, whether is the cupola of a building, or urban furniture for children's play spaces, decorative objects or even their integration into the structure of geodesic domes.

One such geometry that was studied in this article is the pentagonal cupola (J_5), which is part of the category of Johnson's solids and is built from a pentagon, a decagon and five equilateral triangles, respectively five squares [3]. We can also obtain the pentagonal cupola by sectioning a rhombicosidodecahedron, an Archimedean solid.



a. **b.**

Figure 1. Pentagonal cupola. **a.** Pentagonal cupola net; **b.** Views of the pentagonal cupola.

The pentagonal cupola contains 15 vertices and 25 edges, that can be characterized according to the sphere radius in which it can be circumscribed, and the edge length used in polyhedron construction. Thus, the following formulas are proposed for the pentagonal cupola [5, 6]:

- Circumscribing radius of the pentagonal cupola:

$$R = \left(\frac{1}{2}\sqrt{11 + 4\sqrt{5}}\right) \cdot l \approx 2.2329 \cdot l \tag{1}$$

Where l is the edge length of the polygons.

- Pentagonal cupola height:

$$h = \sqrt{\frac{5 - \sqrt{5}}{10}} \cdot l \cong 0.5257 \cdot l \tag{2}$$

- Pentagonal cupola surface area:

$$A = \left(\frac{1}{4} \cdot \left(20 + 5\sqrt{3} + \sqrt{5\left(145 + 62\sqrt{5}\right)}\right)\right) \cdot l^2 \cong 16.5797 \cdot l^2 \tag{3}$$

- The volume of the pentagonal cupola:

$$V = \left(\frac{1}{6} \cdot \left(5 + 4\sqrt{5}\right)\right) \cdot l^3 \cong 2.324 \cdot l^3 \tag{4}$$

Thus, using the formulas described above, geometric characterizations of a pentagonal cupola can be determined, which, we can later integrate, for example, into a geodesic dome type structure, and can be also analysed in a virtual environment using simulations such as finite element analysis to determine the weak points of the structure [7].

2. Methods used

In this study, it was decided to use a small-scale pentagonal cupola that can later be manufactured using 3D printing equipment that provides printing beds of relatively small dimensions.

An edge of 50 mm was used for the polygons that are part of the pentagonal cupola construction. With the help of this known size of the regular polygon edges, the following was determined: the circumscription radius of ~ 111.6475 mm using formula (*1*); cupola height of ~ 26.2865 mm using formula (*2*); the pentagonal cupola volume of ~ 290506.25 mm^3 using formula (*4*). This information is useful in designing the pentagonal cupola and verifying its geometry.

2.1. Geometry generation

The geometry was generated with the help of Autodesk Inventor 2023 software, that allows the generation of solid geometric models, and which contains an analysis module of CADs by performing simulations based on the finite element method.

To design the polyhedron, in this case the decagon base was created first with a side of 50 mm, then the height of the cupola was determined, creating a plane located at the calculated distance from the base and sketching inside a pentagon with a side of 50 mm. One by one, the five triangular faces and the five square faces of the cupola were built. Ten variants of the pentagonal cupola were made, the difference between them being strictly related to the way of filling its volume. These are:

- Solid pentagonal cupola with full volume (*Figure 2* ***a.***);
- Hollow pentagonal cupola with a face thickness of 0.3 mm (*Figure 2* ***b.***);
- The pentagonal cupola filled with a circular pattern, starting from a circle with a diameter of 3 mm, the radius of the pattern increasing progressively and being located at 0.5 mm distance from each other, with a pattern wall thickness of 0.5 mm (*Figure 2* ***c.***);
- The pentagonal cupola with an ellipsoidal pattern, starting from an ellipse with a large diameter of 3 mm, the pattern increasing progressively and located at 0.5 mm from another, with a pattern thickness of 0.5 mm (*Figure 2* ***d.***);
- The pentagonal cupola filled with a slot-type pattern, starting from a slot with a length of 5 mm and width of 3 mm, the dimensions increasing progressively, with the distance between the pattern and wall thickness of 0.5 mm (*Figure 2* ***e.***);
- The pentagonal cupola with a triangular pattern, starting from an equilateral triangle, having a side of 3 mm and respecting the distance between the pattern and its thickness of 0.5 mm (*Figure 2* ***f.***);
- Pentagonal cupola with a rectangular pattern, starting from a square with a 3 mm side, a wall thickness of 0.5 mm and an equidistant distance of 0.5 mm between the inside structures (*Figure 2* ***g.***);
- The pentagonal cupola with a pentagonal pattern, starting from a pentagon, with a side of ~ 1.85 mm and a distance between the inside structures of 3 mm, respecting the *offset rules* of the pattern mentioned previously (*Figure 2* ***h.***);
- The pentagonal cupola with a hexagonal pattern, starting from a hexagon with a side of ~ 1.73 mm and with one of the distances between the sides of 3 mm, respecting the *offset rules* between the inside structures described above (*Figure 2* ***i.***);
- The pentagonal cupola with a decagon pattern, based on a decagon with a 0.97 mm side and the distance between the sides of 3 mm, respecting the *offset rules* described above in the other CAD models (*Figure 2* ***j.***).

The dimensions of the inside structure polygons and the distance between them were chosen in such a way as to ensure a relatively uniform layout of the model in each case and trying to ensure a uniform distribution of the filling percentage for each geometric model.

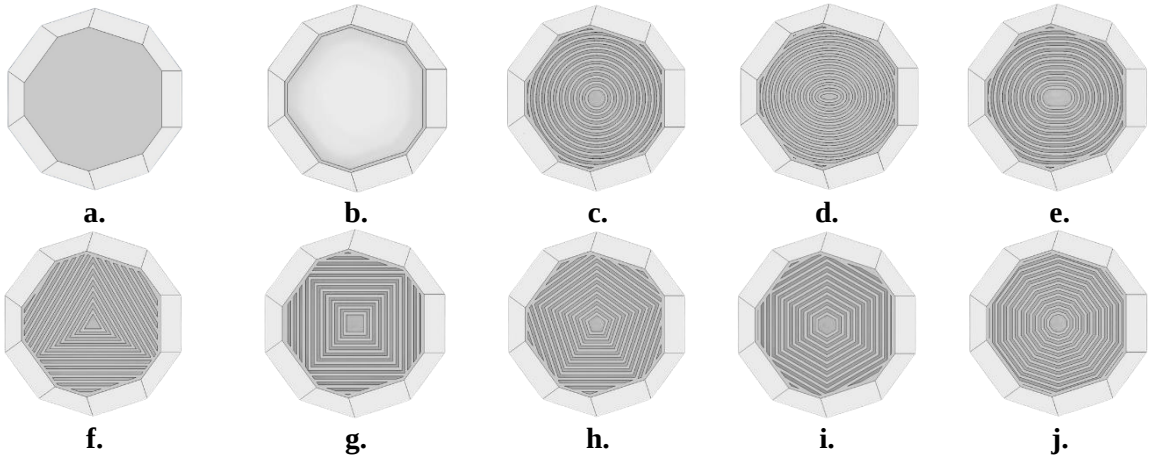


Figure 2. Pentagonal cupola filling pattern. **a.** Solid cupola; **b.** Empty cupola; **c.** Circular pattern; **d.** Ellipsoidal pattern; **e.** Slot-type pattern; **f.** Triangular pattern; **g.** Rectangular pattern; **h.** Pentagonal pattern; **i.** Hexagonal pattern; **j.** Decagonal pattern.

2.2. The material used in the FEA study

For this study, the use of ABS (Acrylonitrile Butadiene Styrene) [8]plastic material was chosen to use due to its popularity among additive manufacturing that uses the FDM (Fused Deposition Modeling) method, being an easily accessible material and presenting a relatively low cost of purchase [9]. It has a wide field of applicability, such as various components of household appliances, decorative elements from the automotive industry, children's toys, or various decorative elements, even interior furniture [10]. The properties of the ABS used in the static simulations carried out in this study can be observed in *Table 1*. It should also be specified that in this study, the material has a linear, isotropic, and homogeneous behavior.

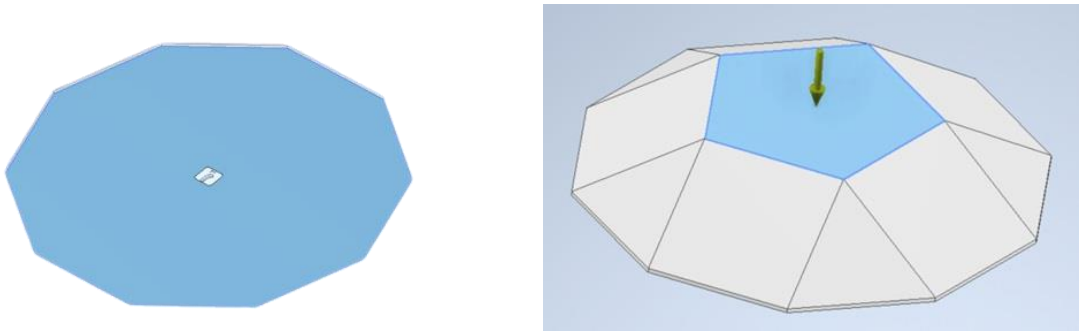
Table 1. ABS plastic material properties [*Autodesk Inventor Material Library*]

	Mechanical Properties
Young's Modulus	2.240 GPa
Poisson's Ratio	0.38
Shear Modulus	805 MPa
Density	1.060 g/cm^3
	Strength Properties
Yield Strength	20 MPa
Tensile Strength	29.6 MPa

2.3. FEA boundary conditions

For the static simulations of all 3D pentagonal cupola models, the following boundary conditions were established:

- *Fixture*: the base of the pentagonal cupola was fixed (the decagon face, *Figure 3* ***a.***).
- *Applied force*: two typologies of forces, one of 500N and one of 2000N, were applied to all generated CAD models to study the change in the mechanical behavior in both cases for all geometric models. The force was applied perpendicular to the pentagonal face of the cupola, being uniformly distributed over its entire surface (*Figure 3* ***b.***).



a. **b.**

Figure 3. Static simulation boundary conditions. **a.** Pentagonal cupola fixture; **b.** Direction and face of the applied force.

For the mesh was used an average element size (fraction of model diameter) of 0.1, a minimum element size (fraction of average size) of 0.2, a grading factor of 1.5, a maximum turn angle of 60°, summarizing a high-quality mesh of the models used in this study.

3. Results

Following the simulation to which, a force of 500 N was applied, two predictable results can be observed (*Table 2*), the solid pentagonal cupola which, presents the lowest Von Mises Stress value, and the CAD model of the empty pentagonal cupola, with walls of 0.3 mm having the highest Von Mises Stress value among all models. Analyzing the other patterns between these two extreme results, the model with the infill pattern based on the ellipses had the following Von Mises Stress value after the solid pentagonal cupola, followed by the triangle infill pattern, then the pentagon, hexagon pattern, circle pattern, decagon pattern, square and slot-type pattern.

The displacement results can be classified starting from the lowest value obtained during the application of the 500 N force (*Table 2*), as follows: solid model, then infill pattern ellipse, triangle pattern, pentagon pattern, circle pattern, hexagon pattern, decagon pattern, square pattern, slot-type pattern and finally the empty pentagonal cupola CAD model.

After analyzing the equivalent strain results, the following classification was obtained (*Table 2*), starting from the lowest value: solid model, ellipse pattern, triangle pattern, pentagon pattern, hexagon pattern, circle pattern, decagon pattern, square pattern, slot-type pattern and the empty model of the pentagonal cupola.

In *Figure 4* we can observe the graphic representation of the static simulation results following the application of 500 N force on each analyzed pentagonal cupola CAD model.

Regarding the results of the static simulation of 2000 N force applied, the pentagonal cupola models tend to follow the same behavior (*Table 3*), as expected, the results of the values increased considerably in all cases by approximately 4 times compared to the simulations performed with the applied force of 500 N.

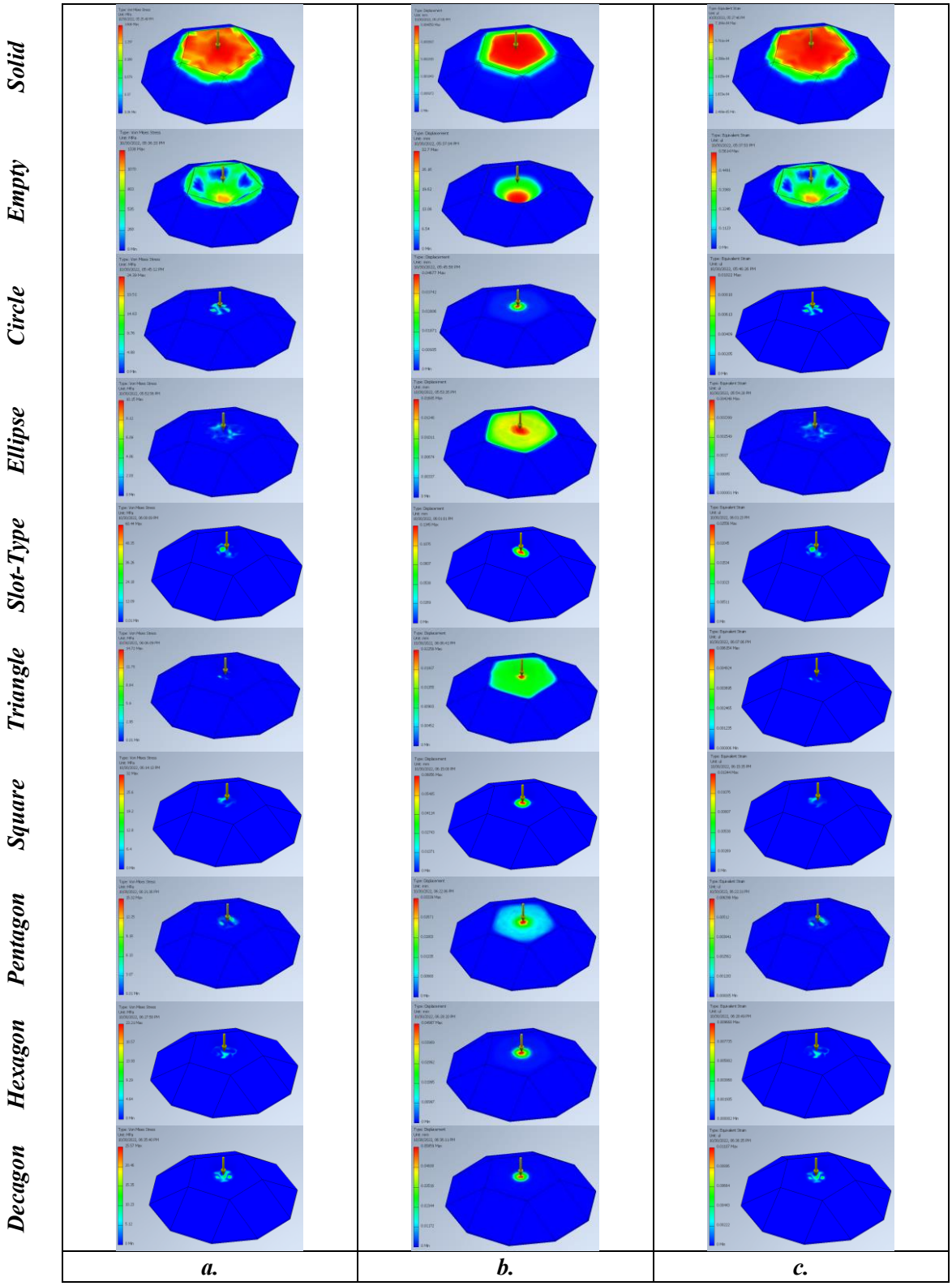


Figure 4. Results of static simulation for 500 N load applied. **a.** Von Mises Stress results for all types of infill pattern; **b.** Displacement results for all types of infill pattern; **c.** Equivalent Strain results for all types of infill pattern.

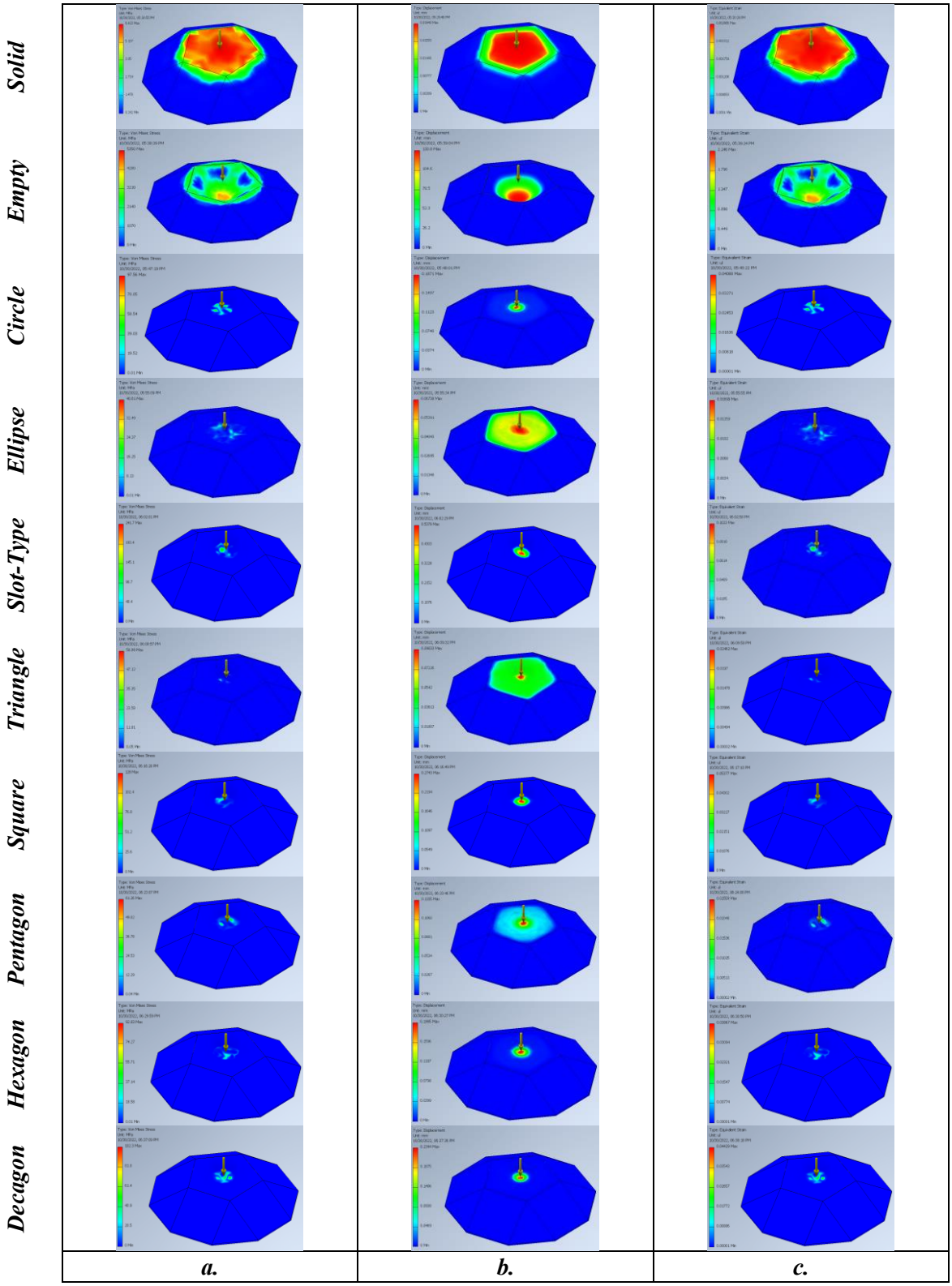


Figure 5. Results of static simulation for 2000 N load applied. **a.** Von Mises Stress results for all types of infill pattern; **b.** Displacement results for all types of infill pattern; **c.** Equivalent Strain results for all types of infill pattern.

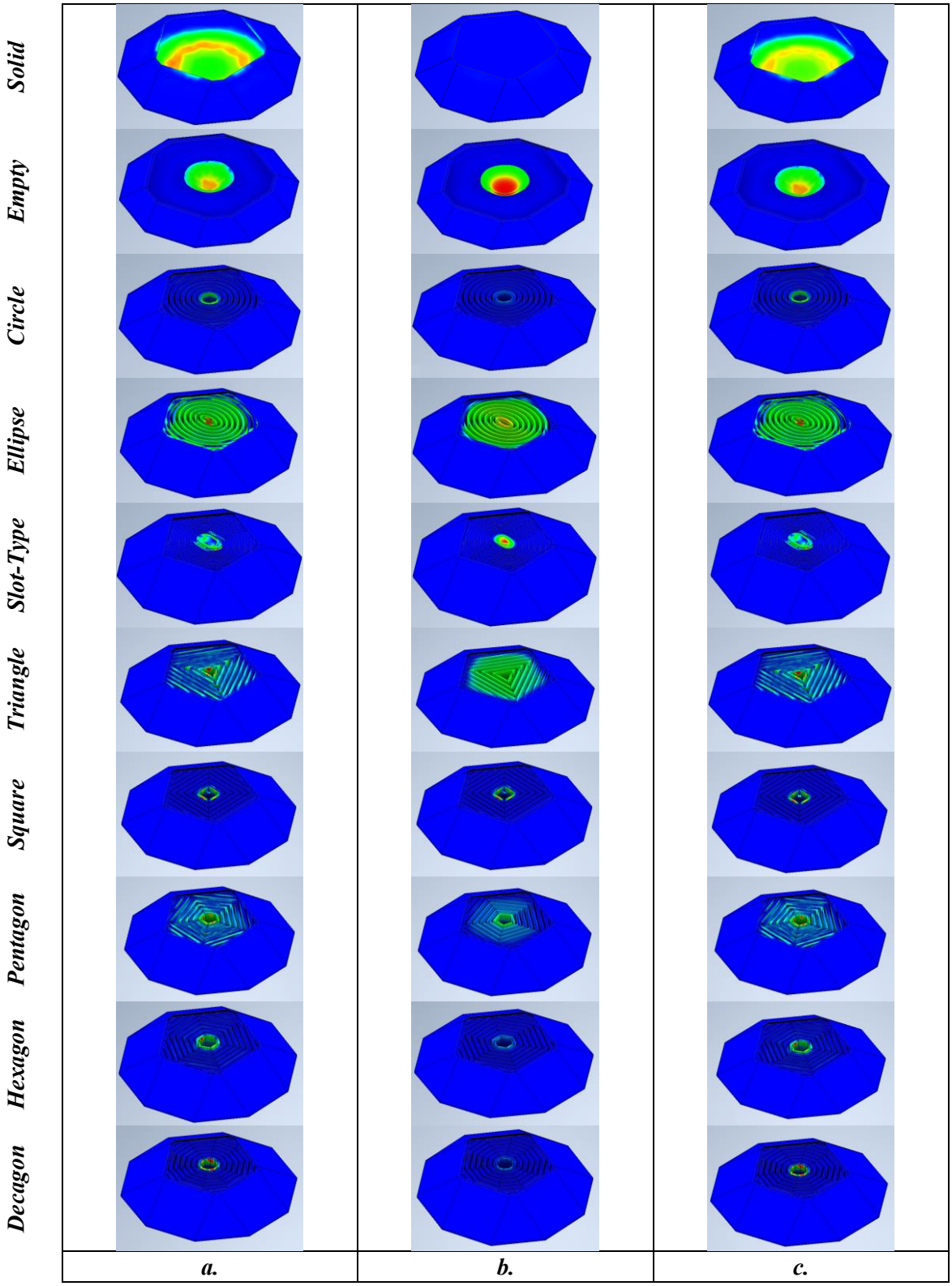


Figure 6. Sectioned pentagonal cupola static results simulation for 2000 N load applied. **a.** Von Mises Stress results for all types of infill pattern; **b.** Displacement results for all types of infill pattern; **c.** Equivalent Strain results for all types of infill pattern.

Table 2. Results of static simulation for 500 N load applied in case of all infill patterns

Pattern	*Von Mises Stress [MPa]*		*Displacement [mm]*		*Equivalent Strain [ul]*	
	Minimum	*Maximum*	*Minimum*	*Maximum*	*Minimum*	*Maximum*
Solid	0.06	1.606	0	0.004858	$2.499 \cdot 10^{-5}$	$7.164 \cdot 10^{-4}$
Empty	0.00	1338	0	32.70000	0.000000	0.561400
Circle	0.00	24.39	0	0.046770	0.000000	0.010220
Ellipse	0.00	10.15	0	0.016850	0.000001	0.004248
Slot-Type	0.01	60.44	0	0.134500	0.000000	0.025560
Triangle	0.01	14.72	0	0.022580	0.000006	0.006154
Square	0.00	32.00	0	0.068560	0.000000	0.013440
Pentagon	0.01	15.32	0	0.033390	0.000005	0.006398
Hexagon	0.00	23.21	0	0.049870	0.000002	0.009668
Decagon	0.00	25.57	0	0.058590	0.000000	0.011070

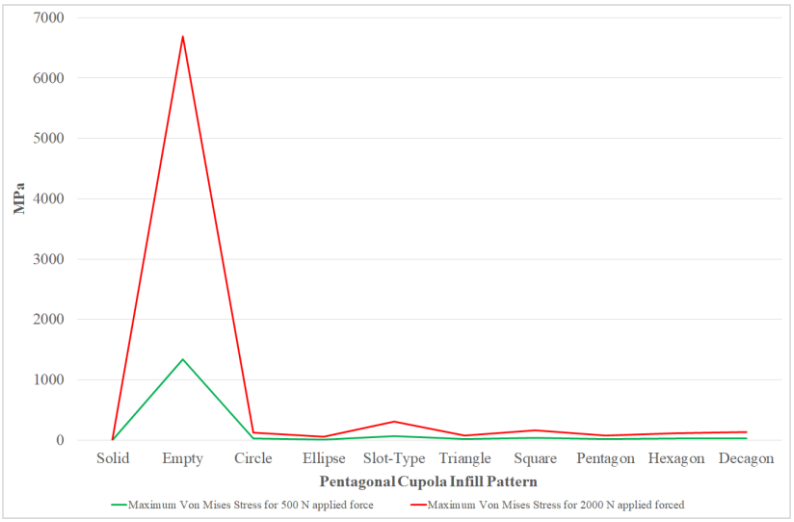
In *Figure 6*, the CAD model sections are shown to visualize the simulation results for the 2000 N force applied on the pentagonal cupola.

In *Figure 7* ***a.*** the graphic evolution of Von Mises Stress results is presented in case of both application forces, 500 N and 2000 N. The displacement results can be visualized in a graphic form in *Figure 7* ***b.*** and the equivalent strain results are represented graphically in *Figure 7* ***c.***

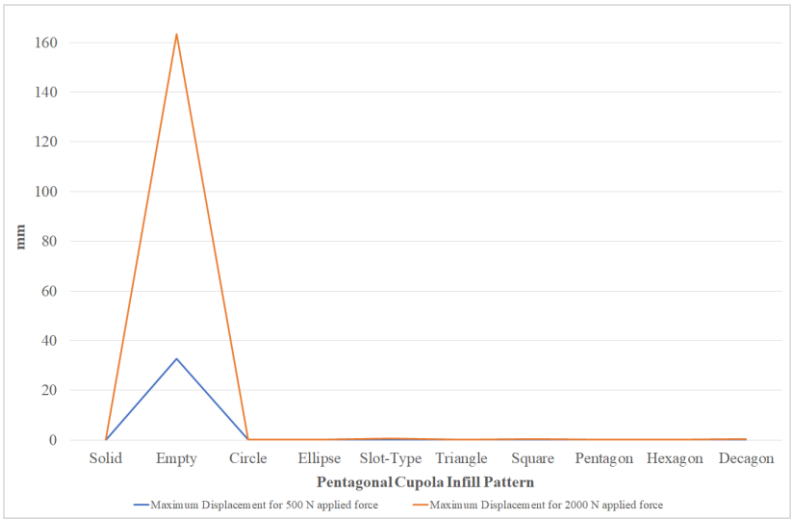
The biggest result gab can be seen at the empty CAD model of the pentagonal cupola, which, is built only by the simple constant wall thickness of 0.3 mm, thus obtaining very high values of Von Mises Stress results, and some displacements beyond the limit.

Table 3. Results of static simulation for 2000 N load applied in case of all infill patterns

Pattern	*Von Mises Stress [MPa]*		*Displacement [mm]*		*Equivalent Strain [ul]*	
	Minimum	*Maximum*	*Minimum*	*Maximum*	*Minimum*	*Maximum*
Solid	0.242	6.423	0	0.01943	0.00010	0.002866
Empty	0.00	5350	0	130.800	0.00000	2.246000
Circle	0.01	97.56	0	0.18710	0.00001	0.040880
Ellipse	0.01	40.61	0	0.06738	0.00000	0.016990
Slot-Type	0.00	241.7	0	0.53790	0.00000	0.102300
Triangle	0.05	58.89	0	0.09033	0.00002	0.024620
Square	0.00	128.0	0	0.27430	0.00000	0.053770
Pentagon	0.04	61.26	0	0.13350	0.00002	0.025590
Hexagon	0.01	92.83	0	0.19950	0.00001	0.038670
Decagon	0.00	102.3	0	0.23440	0.00001	0.044290



a.



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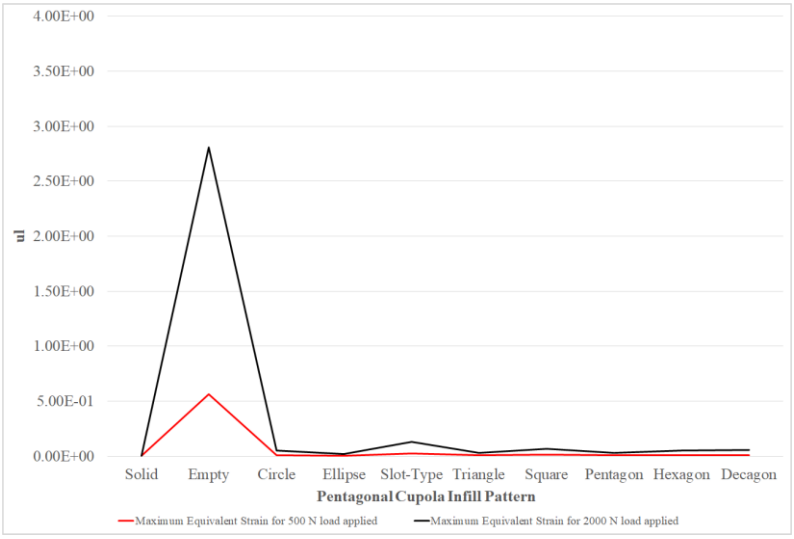

c.

Figure 7. Graphic representation of the static simulation results for both loads **a.** Von Mises Stress results; **b.** Displacement results; **c.** Equivalent Strain results.

4. Conclusions

Although we often do not give importance, polyhedra and intersections of polyhedra are an integral part of our lives in different forms, either as objects that surround us with a decorative or functional role, or as metal structures like geodesic domes and not only. Observing the mechanical behaviour of the pentagonal cupola in case of different filling patterns, gives us information that we can use, especially when we choose this geometric shape to be manufactured by using 3D printing. Depending on the field and the purpose of the designed shape, we can choose the infill pattern by considering the forces to which it can be subjected.

Although the results of the static simulation were predictable regarding the solid model of the pentagonal cupola by showing the best results in the case of both applied forces, a possible option if we want to use less material, can be the ellipsoid pattern, but is worth noting that the triangular and pentagonal filling patterns offered also better results compared to the other filling patterns used in this study.

The choice of using a filling pattern in the case of additive manufacturing and a filling percentage as low as possible reduces the amount of material used in the realization of a shape, the printing time and implicitly the energy used to manufacture the part, but at the same time it decreases its resistance at external loads.

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Sustainability as a pivotal point in packaging design. Innovative oil packaging case study.

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Abstract. This paper aims to present a possible solution of reducing the quantity of waste cooking oil and exposes the design process of an innovative oil packaging concept that facilitates the collection of it after the container is empty. The innovation resulted as solution to the tedious process of collecting oil and consists in a bottle stopper that functions as a funnel when reversed. The bottle stopper/funnel (designed with a no leakage geometry) contains a detachable strainer which retains the impurities. The packaging is designed for 3 quantities (1, 2 and 5 liters) and is designed to be manufactured from recycled PET and ABS. The approach of the concept focuses on identifying alternative solutions that develop new methods and approaches to change mindsets and behaviours through objects.
Keywords: *packaging, innovation*, *sustainability, recycling, waste cooking oil*

Introduction

According to statistics, approximate 15 million tonnes of waste vegetable oils are produced each year in the world, from which 1 million within the European Union [1], which equals less than 1 kg per inhabitant per year [1]. In addition, it is a kwon fact that a single litre of waste cooking oil pollutes a million liters of water and according to statistical data 25% of water pollution is caused by waste oil and in the European Union. The quantity of waste cooking oil is increasing due to the large preparation of food not only in households, but mainly in fast food chains, restaurants or hotels. Oil that is not properly collected often ends up in rivers, creating a film on its surface that blocks the transmission of oxygen and affects aquatic life. Although the fact that filtering oil from water produces substantial costs with a real economic impact and that the European Union created a specific directive (namely 2008/98/EC), waste oil is not treated like a priority from an environmental point of view. Furthermore, as reported by the American Petroleum Institute recycling just 7,57 kg of waste oil can be create enough electricity to run household approximate 24 hours.

Taking all this statistical data into account, it is imperative to find new solutions that can improve the environment not only through legislation or education, but also through oil packaging that can facilitate the collection of waste cooking oil by the end user, generating a substantial behavioural change.

Premises of the creation process

Developed by product designer Alexandra Ghioc in collaboration with mechanical engineer Dragos Mititelu, the innovative oil packaging was first presented as a contest proposal that was held in 2020 in a digital form, on a design platform. Entitled „Distruptive Plastic Packaging Challange", the competition

aimed to find new product concepts that were exclusively realised through stretch blow moulding and were manufactured from Polyethylene terephthalate (PET). The concept proposals should have adressed enviromental issues and a circular economy focusing on the bottle-to-bottle recycling techonologies. The beneficiary was an Italian company that provoked international designers and studios to imagine a better usage of PET containers by creating a secondary function or usage after the consumption of the content. Although the project was not initially awarded, the idea was further developed and improved in 2021 by the two authors.

Taking the brief into account product designer Alexandra Ghioc and Engineer Dragos Mititelu designed an innovative oil packaging that would help users with the collection of waste cooking oil. The proposal is based on the patent registered by Dragos Mititelu at State Office for Inventions and Trademarks (No.RO116247 (B1) from 29th of December 2000) (figure 1).

The invention consists in a multifunctional container designed for straining, measuring, storing and transferring liquids that include a funnel, a graduated cup, a separator/strainer and a cap. The product can be either used as an assembly or as individual parts that can be used separately.

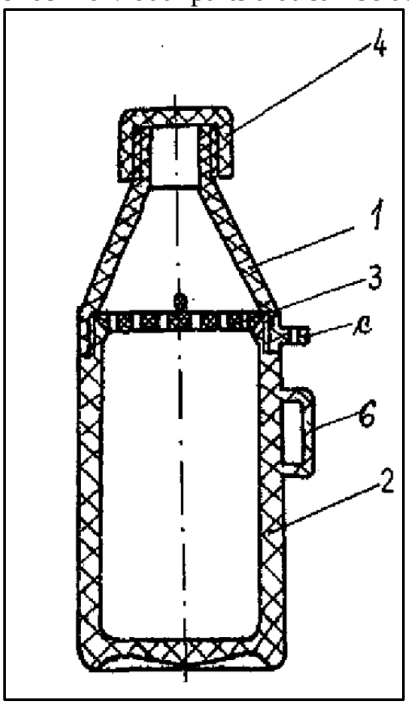

Figure 1. Image of the patent registered by Dragoș Mititelu in 2000

The innovative oil packaging. Case study

Instead of collecting the used cooking oil in a separate container which should be later stored in collection centres, most of the users throw it in the sewage systems (sink or toilets) or in the general garbage disposal. This behavioural pattern is mostly due to the complicated collection process of waste cooking oil that implies the usage and cleaning of a dedicated container, a strainer and a separate funnel in order to strain impurities and prevent leakages. The innovative and ecological packaging concept for oil that designer Alexandra Ghioc and engineer Dragos Mititelu created facilitates the collecting of waste cooking oil after the container is empty (figure 2).

The innovative solution consists in a bottle stopper that functions as a funnel when reversed. The assembly containing the bottle stopper and funnel also contains a detachable strainer which retains the impurities and facilitates the recycling of the waste oil (figure 3).

In the user scenario, the end customer buys the oil bottle needed and consumes the containing oil. After its consumption, the empty bottle is used for recycling the waste cooking oil creating a circular behaviour and encouraging the end user to extend the basic functionality of a PET Bottle.

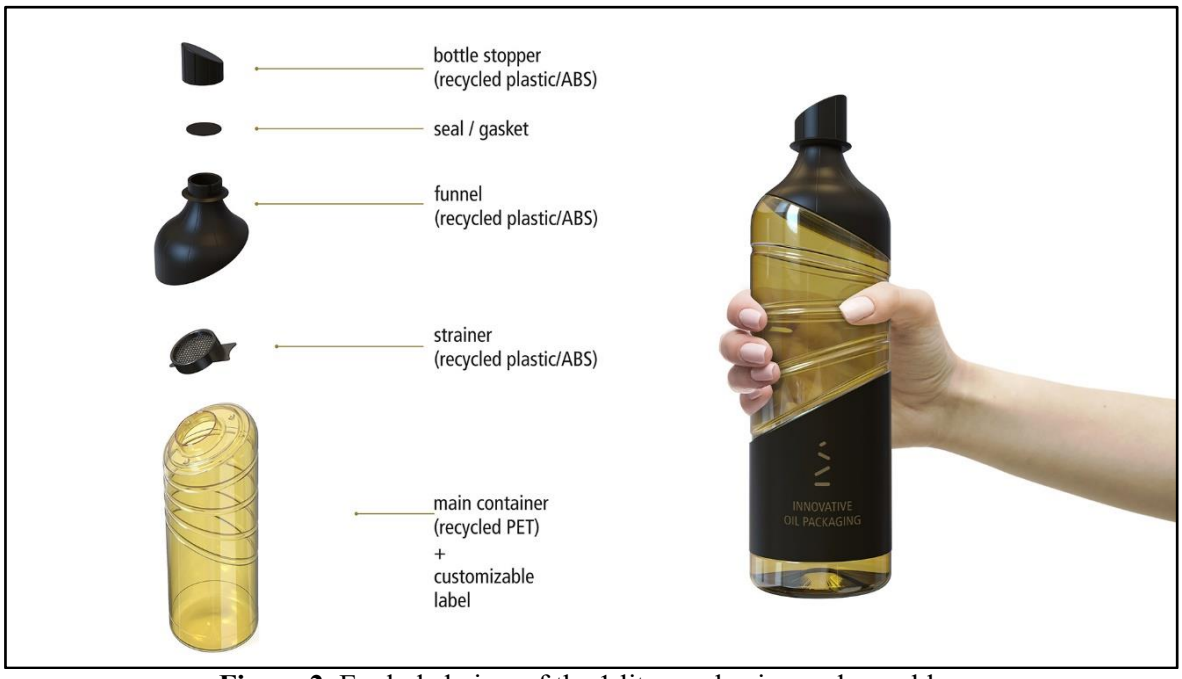

Figure 2. Exploded view of the 1 liter packaging and asambley

The optimal ergonomics were taken into consideration when designing the oil packging, which is provided not only through the diameter of the main container or handle of the strainer in relation with the general dimension of fingers and hand, but also through ease of manouvering, assembly and disassembly, cleaning each component of the packaging.

Figure 3. Steps in usage of the innovative oil packaging when collecting waste cooking oil

The main body of the package and the funnel are designed to be manufactured through PET stretch blow moulding technology, while the bottle stopper/funnel and the strainer can be produced using

injection technology. Withall, the proposed materials from the innovative oil packaging are recyled PET and ABS. Based on the elasticity of the materials, the asambley is designed in order to dismout, deform (when needed due to the designed grooves) clean and further recycle easely.

Figure 4. Images explaining the functionality when recycling waste cooking oil

Although the 1 liter packaging is one of the most frequently used and bought product, the concept was developed for 3 dimensions in connection with 3 quantities: 1 liter, 2 liters and 5 liters using Autodesk Inventor software (figure 5). The 3-dimensional modelling of the packaging made by the engineer Dragos Mititelu took several aspects into account such as calculation of the volume, the functional and ergonomic restrictions, the manufacturing technology, the number of parts resulting from the proposed design, the fitting of the assembly or the elasticity of the materials.

The stylistic outlook has been followed in all of the 3 packaging quantities, making the packaging easy recognisable in comparison with other products on the market. The overall shape of the oil package is neutral (not limited to a typology) and versatile offering the possibility of customization with various types of cooking oils (avocado, palm, sun flower oil etc.). Designed to stand out on the shelve due to the strong chromatic contrast between the yellow main container and the dark brown funnel and bottle stopper assembly, the packaging has a unique aesthetics which is enhanced by the distinction between the opaque and translucent materials.

In addition to the general design of the packaging, two more refined elements were inserted, namely the rings from the main container (which make the packaging more easily flexible and foldable) that are strategically positioned and shaped so that the overall appearance of the bottle would be more dynamic and the radial grooves on the funnel which subconsciously suggest the flow effect.

The concept has respected all the stages of the design process starting with a thorough research of the competitive market, a stylistic analysis on the typology of the product, an overview of how users recycle oil, a list of standards and requirements in manufacturing and continuing with numerous bi and three-dimensional sketches, the conception of the final digital model and technical data.

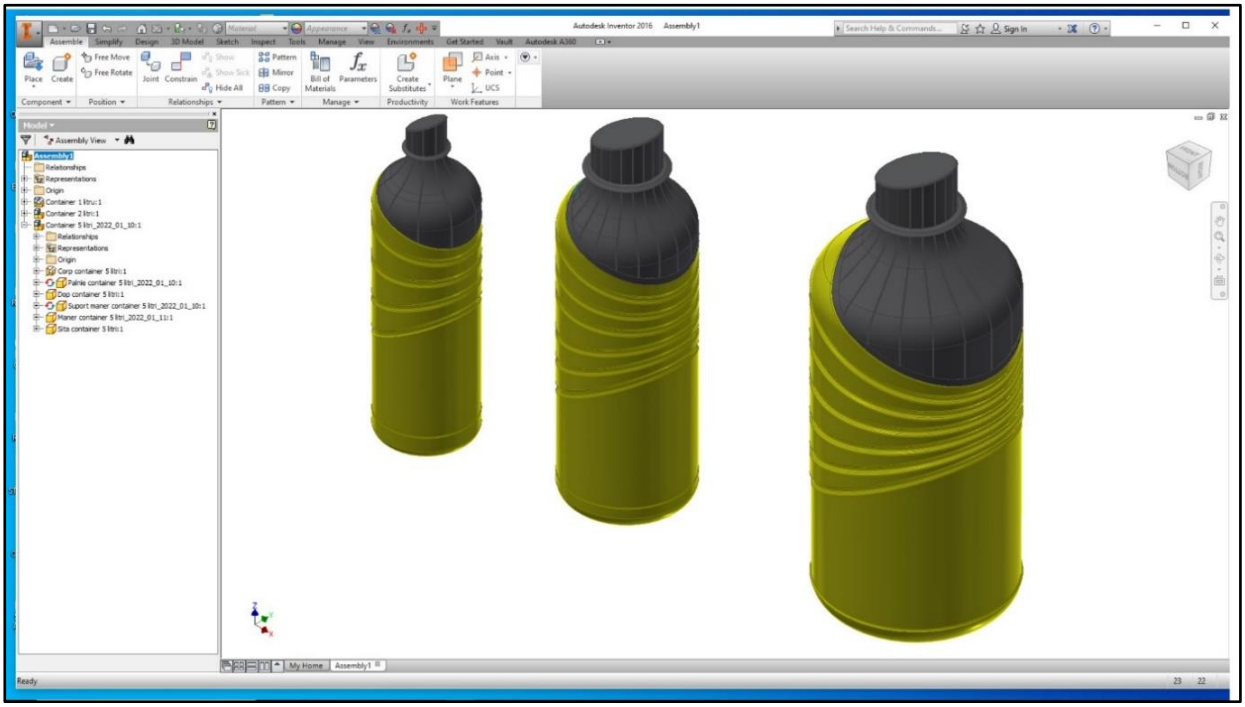

Figure 5. Print screen of the 3-dimensional packaging proposals (1, 2, 5 Liter) developed in Autodesk Inventor software

Figure 6. Images for 1,2 and 5 liter packaging

The package proposal for 2 and 5 liters contains a dedicated handle for easy manoeuvring. The handle slides from the edges of the funnel and is retractable offering the possibility of usage only when needed (figure 7).

Figure 7. Assembly and detail views for the retractable handle

Implementation

For a better understanding of the concept, a model of the 1liter concept was created using the 3-dimensional printing technology (figure 8). The model was materialized using CREATBOT printer (product code F430) in PETG as the main material (figure 9). Each part of the assembly was imported in Slicer Software and further designed and developed in order to prepare for the actual 3-dimensional printing. In this sense, a series of iterations with different adjusted parameters were required in order to obtain the desired result.

The model of the packaging helped Alexandra Ghioc and Dragos Mititelu to validate a series of aspects such as the functioning principles, the ergonomics in handling the container, overall proportion of the product, the transparency effect of the main container in contrast with the opaque funnel and bottle stopper assembly.

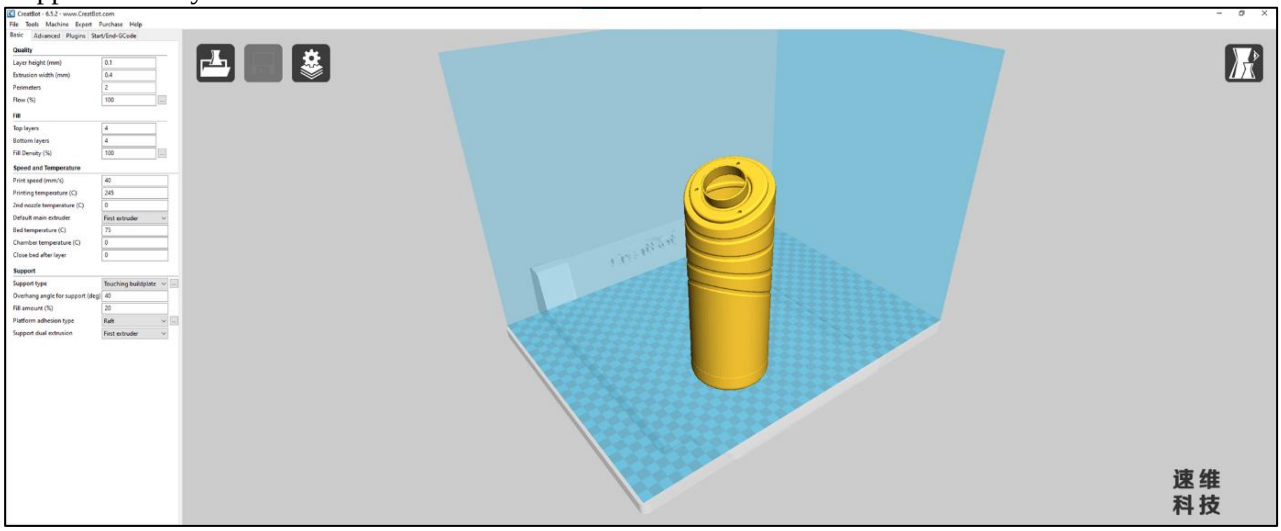

Figure 8. Print screen of the 3dimensional model imported in Slicer software

Figure 9. 3 D printed model of the 1 liter packaging, scale 1:1

Conclusions

Far from being just a financial tool that helps manufacturers to increase their turnover, design has, as its main mission, the conception of innovative goods that improve the quality of life by offering products made from eco-friendly materials, with minimal impact on the environment, both in manufacturing, as well as after the end of the product's life. Designers have the responsibility to conceive sustainable and ethical projects, not only in ecological terms through the materials or processes used, but also in a conceptual manner from the perspective of innovation. Therefore, it is more important than ever that designers are focused more and more on alternative solutions, to develop new methods and approaches to intrigue and change mindsets and behaviours through objects. In the era of overconsumption, design is one of the most important components of the economy and has the mission of generating durable common goods according to the 5 Rs: Refuse, Reduce, Reuse, Repurpose, Recycle.

The designed packaging is fundamentally distinctive from all existing products on the market not only by its particular aesthetics, but especially by the functional innovation that makes the user's life easier and helps to address an improvement from an ecological point of view. Designed with a no leakage geometry, the assembly can be used and refilled an unlimited number of times, making the process of collection of the waste cooking oil easier and more comfortable.

The innovative Oil Packaging concept proposal was awarded at 2 of the most renowned competition in September 2022, namely Red Dot Award (concept category) and Pentawards in London (silver medal). The model is currently exhibited at the Red Dot Design Museum in Singapore and is in the process of being registered as an industrial object at the European Union Intellectual Property Office (EUIPO).

Figure 10. Innovative Oil Packaging awards

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Vibration analysis of shaft-bearing assembly for centrifugal fan

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Abstract. The complete solution of the problem of a free vibration system needs the determination of all the modal frequencies and of correspondent mode of vibration. Many times in practice it is necessary to know only some modal frequencies, sometimes only the fundamental one. The classical method of the vibration problem solution is to write one or more movement equations, using the second Newton's law. For the systems with distributed parameters, the result is a number of differential equations with partial derivatives. The exact solution of the equations is possible only for a relative low number of cases; for the majority of the problems the approximate solving methods must be used. The paper presents comparative studies for the shaft-bearing assembly of the centrifugal fans, regarding the vibration behavior during the service. Two type of modeling has been realized: the first one was an analytical simulation for the ideal shaft, using Mathcad software. The second modeling was a numerical simulation for the real geometrical shaft, taking into account the presence of the bearings, using ANSYS software with all the possibilities of optimization involved. A comparison of the theoretical results between the two modeling has been realized.
Keywords: *fan, frequencies, mathcad, optimization.*

1. Introduction

The complete solution of the problem of a free vibration system needs the determination of all the proper frequencies and of correspondent vibration ways. Many times in practice it is necessary to know only some proper frequencies, sometimes – only one. Usually, the lower frequency is practically the most important. In most cases, the exact knowledge of the vibration way has a minor importance and that allows to elaborate new methods founding the frequencies of a low harmonics number [1], [2], [3].

The classical method of the vibration problem solution is to write one or more movement equations, using the second Newton's law [4]. For the systems with distributed parameters, the result is a number of differential equations with partial derivatives. The exact solution of the equations is possible only for a relative low number of cases; for the majority of the problems the approximate solving methods must be used [5].

Various methods have been used in analyzing the rotary systems, while standard transfer matrix method is given in many handbooks [6], [7]. Analytical results are being generated to demonstrate the need for and the advantage of transfer matrix method in modelling procedures. A quantitative comparison is made between the Finite Elements Method and Transfer Matrix Method, applied to free vibration analysis of rotor systems [8].

A mathematical model governing the transverse vibration of rotor shaft is determined using analytical methods [4]. From the mathematical model, natural frequencies and mode shape of the rotor system is determined. Further, numerical simulation is performed in ANSYS for modal analysis for such system. Unbalance effect is incorporated numerically by performing harmonic analysis of the rotor system in ANSYS [9].

2. Theoretical model

In the theoretical calculus of the proper bending frequencies of the fan shaft it will be used the classical differential equation for the transversal vibrations of the beam [1]:

$$-\frac{\partial^2}{\partial x^2}\left(EI\frac{\partial^2 y}{\partial x^2}\right)=\gamma A(g)^{-1}\frac{\partial^2 y}{\partial t^2} \quad (1)$$

This equation is available with the following hypotheses:

- the material is homogenous, izothrop and perfectly elastic;
- the beam is straight and with the cross section constant for all the length;
- the deformations of the beam are low and its length is much greater, comparative with the dimensions of the cross section.

If the product *EI* is constant, the solution of the equation is:

$$y = X(x)[cos(\omega_n t+\theta)] \quad (2)$$

If $k^4=\omega_n^2\gamma A(EIg)^{-1}$ and dividing equation (1) by $cos(\omega_n t+\theta)$, it obtains:

$$\frac{d^4X}{dx^4}=k^4X \quad (3),$$

where *X* is a function for which the fourth derivative is equal with the constant multiplied by the function itself.

The solution of the equation (3) is given by a sum of linear independent functions as:

$$X = A_1\,sin\,k\,x + A_2\,cos\,k\,x + A_3 sh\;kx + A_4 ch\;kx \quad (4)$$

For the beams having different leaning conditions, the constants A_1, A_2, A_3 and A_4 are established from the limit conditions. It is convenient for founding solutions that the equation (4) must be written like (5), in which two constants are nulls, for each usual limit conditions:

$$X = A(coskx+coshkx)+B(coskx-coshkx)+C(sinkx+sinhkx)+D(sinkx-sinhkx) \quad (5)$$

Applying the limit conditions, the following relations are used:

- the deformation is proportional with *X* and it is null on a stern support;
- the rotation is proportional with *X*' and it is null at a fixed end;
- the bending moment is proportional with *X*'' and it is null at a free or articulated end;
- the cutting force is proportional with *X*''' and it is null at a free end.

For the usual limit conditions, two constants are zero, and it obtains two equations with two constants. Those can be combined and we obtain an equation that contains the frequency as unknown. Using the frequency, one of the constants can be couch – one function other. Thus, a constant remains always undetermined; it can be evaluated only in the case when the vibration amplitude is known.

3. Analytical simulation for the ideal shaft

In the case of the continuous beams on many supports, for founding the modal frequencies, the section between each pair of supports is considered as a separate beam, with the origin in the left section support. The deformation equation is applied for each interval. There is such an equation for each section and the limit conditions are:

- At the ends of the beam we applied the usual limit conditions, function the type of the support.
- On each intermediate support, the deformation is null. Because the beam is continuous, at the left and at the right, in the neighborhood of the support, the rotation and the moment are the same.

A general view of the fan shaft is presented in Fig. 1, while the main components of the shaft bearings are shown in Fig. 2.

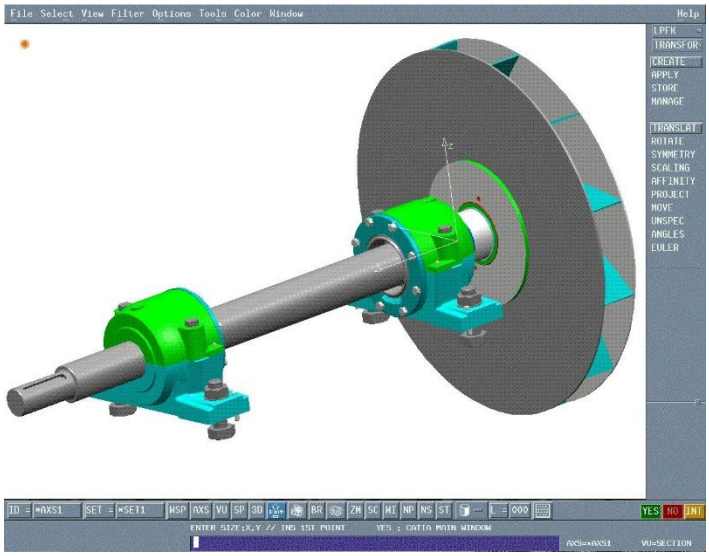


Figure 1. CAD model of the offset rotor shaft of centrifugal fan

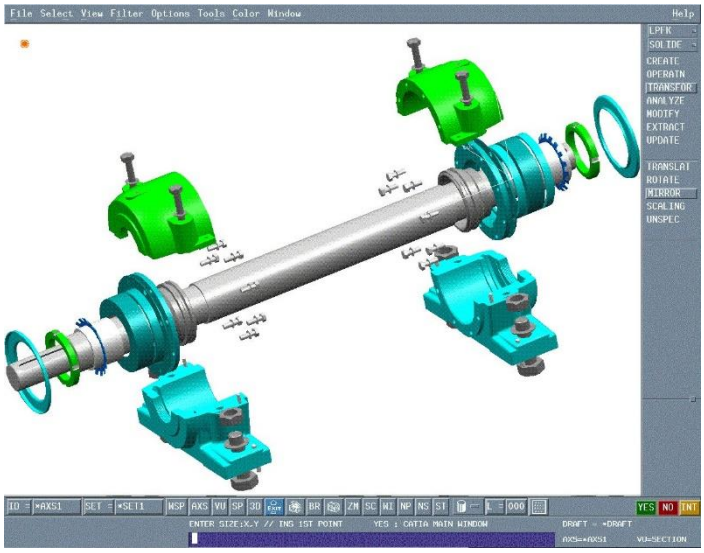


Figure 2. Details of the shaft bearings of centrifugal fan

The main hypotheses for the analytical modeling of the fan shaft are:

- The shaft is modeled like a continuous and homogenous beam, with a constant diameter;
- The equivalent beam is a continuous beam which is staying on two pinned supports (O_2 and O_4) and two free ends (O_1 and O_3) (Fig. 3);
- There are determined only the modal bending frequencies.

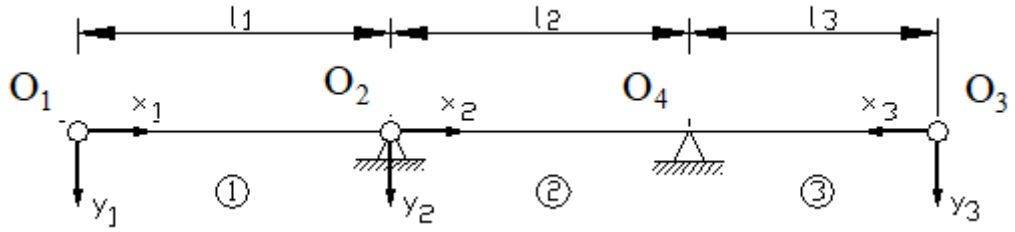


Figure 3. The simplified analytical model of the fan shaft

The geometrical dimensions of the shaft are: the medium diameter - 30 mm; the equivalent lengths: l_1 = 130 mm; l_2 = 200 mm; l_3 = 130 mm. The shaft material is OLC45, with the following mechanical characteristics: the elasticity modulus E = $2.1 \cdot 10^5$ MPa; the density ρ = 7800 kg/m^3. The deformation equations for the three regions are:

Region 1:

$$X_1 = A_1(cos\ \ kx + cosh\ \ kx) + B_1(cos\ \ kx - cosh\ \ kx) + C_1(sin\ \ kx + sinh\ \ kx) + \\ + D_1(sin\ \ kx - sinh\ \ kx) \tag{6}$$

Region 2:

$$X_2 = A_2(cos\ \ kx + cosh\ \ kx) + B_2(cos\ \ kx - cosh\ \ kx) + C_2(sin\ \ kx + sinh\ \ kx) + \\ + D_2(sin\ \ kx - sinh\ \ kx) \tag{7}$$

Region 3:

$$X_3 = A_3(cos\ \ kx + cosh\ \ kx) + B_3(cos\ \ kx - cosh\ \ kx) + C_3(sin\ \ kx + sinh\ \ kx) + \\ + D_3(sin\ \ kx - sinh\ \ kx) \tag{8}$$

The limit conditions imposed are:

At point O_1: $\begin{cases} X_1''(0) = 0 \\ X_1'''(0) = 0 \end{cases}$ At point O_2: $\begin{cases} X_1(l_1) = X_2(0) = 0 \\ X_1'(l_1) = X_2'(0) \\ X_1''(l_1) = X_2''(0) \end{cases}$

At point O_3: $\begin{cases} X_3''(0) = 0 \\ X_3'''(0) = 0 \end{cases}$ At point O_4: $\begin{cases} X_2(l_2) = X_3(-l_3) = 0 \\ X_2'(l_2) = X_3'(-l_3) \\ X_2''(l_2) = X_3''(-l_3) \end{cases}$

The equivalent equations system given by the limit conditions is a homogenous system with 12 equations with 12 unknowns (the coefficients A_1, A_2, …, D_3) like:

$$M \cdot A = O \tag{9},$$

where M is the coefficient matrix, A is the unknowns vector and O is the null vector corresponding to the free term.

The general equation (the case $l_1 \neq l_2 \neq l_3$) for founding the modal frequencies of the shaft is obtained by developing the matrix determinant M, using the symbolic facilities of the Mathcad software. The solution of the equation is obtained only numerical.

For the peculiar case when $l_1 = l_2 = l_3 = l$ (the case is analyzed in ref. [4], but for others supports types: fixed support – pinned support or pinned support – pinned support), the general equation for founding the modal frequencies has a simple form, but also without an analytical solution:

$$3\cosh x \cos^3 x + 8\cos^2 x \sin x \sinh x \cosh^2 x + 2\sinh x \sin x + 6\cos x \cosh x \sin x \sinh x - \\ -3\cos x \cosh^3 x + \cos^2 x - \cosh^2 x = 0 \quad (10),$$

where $x = kl$.

The peculiar solutions of this equation are corresponding to the first five mode of vibrations (Table 1).

Table 1. Peculiar values of the characteristic parameter $x = kl$

Mode of vibration	Parameter $x = kl$
1	1.648
2	4.706
3	6.707
4	7.854
5	9.849

Knowing the constant parameter values $x = kl$, the pulsation and the modal frequencies are obtained using the relations:

$$\omega_n = k_n^2 \left(\frac{EIg}{\gamma A}\right)^{1/2} \quad ; \quad f_n = \omega_n (2\pi)^{-1} \quad (11),$$

where k_n is calculated for each mode of vibration, function of the corresponding parameters x and l.

For the general case of the fan shaft ($l_1 \neq l_2 \neq l_3$), the numerical solution obtained is presented in Table 2.

Table 2. Modal frequencies of the fan shaft (approximate analytical model)

Mode of vibration	Parameter k_n, mm^{-1}	Modal frequency f_n, Hz
1	0.00985	601
2	0.01205	899
3	0.02025	2540
4	0.03068	5828
5	0.03333	6899

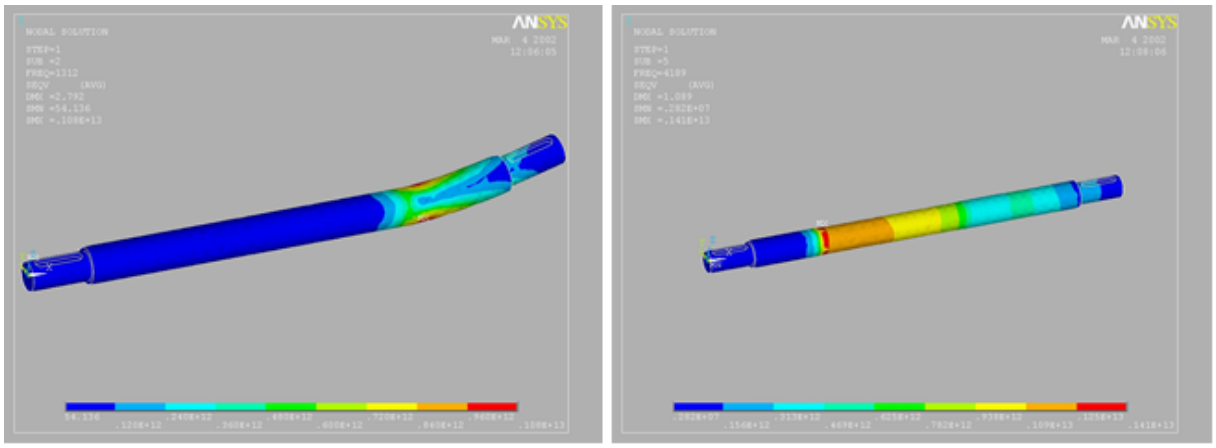
4. Numerical simulation for the real geometrical shaft

The numerical solution obtained with the aid of the finite elements software for the case of the shaft (existent in the shaft – bearings assembly) is presented in Figure 4 a and b.

Also, there are presented the results for the case of whole assembly shaft – rotor in Figure 5 a and b. The numerical values of the modal frequencies for these two real studied cases (shaft – bearing assembly and shaft – rotor assembly) are presented in the Table 3.

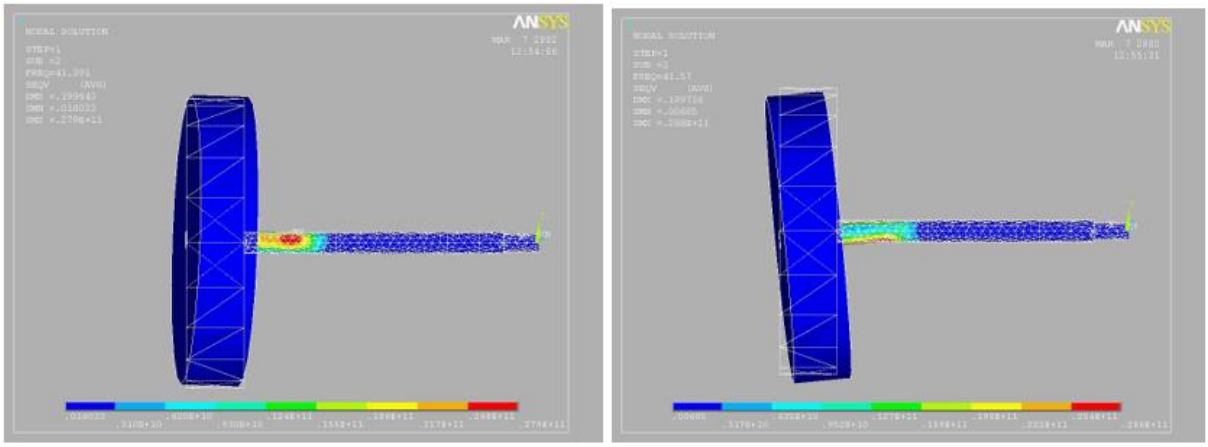
Table 3. Numerical values of the modal frequencies for real cases

Mode of vibration	Modal frequency f_n, Hz (shaft – bearings assembly)	Modal frequency f_n, Hz (shaft – rotor assembly)
1	1311	37
2	1312	41
3	3620	41
4	3667	239
5	4189	240



a. Modal frequency f_n = 1312 Hz b. Modal frequency f_n = 4189 Hz

Figure 4. Mode of vibration for shaft – bearings assembly



a. Modal frequency f_n = 41.39 Hz b. Modal frequency f_n = 41.57 Hz

Figure 5. Mode of vibration for shaft – rotor assembly

5. Conclusions

1. The analytical model proposed permits to establish the general equation, which determine the modal frequencies for a double pinned beam with free ends.
2. The differences existent between the real numerical model and the analytical simplified model for the shaft-bearings assembly are justified by:

- For the analytical case, only the modal bending frequencies are considered; in the numerical case, the modal frequencies result by composing the bending and torsion movement.
- The analytical model corresponds to a constant cross section beam, while the real shaft is characterized by diametrical variation.
- The real shaft is also characterized by the existence of two bearings, which have a significant influence on the results.

3. There are great differences from the point of view of the modal frequencies between the real model of the shaft-bearings assembly and the real model of the entire fan (shaft-rotor assembly). These differences can be explained by the major geometrical and inertial influence of the rotor on the behavior of the entire fan.

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Factors influencing the adoption of solar energy in Harare West: A case of Bloomingdale, Harare.

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Abstract. This study investigated factors influencing adoption of solar energy in Bloomingdale, Harare. The study was prompted by widespread switch from the traditional electricity to solar energy experienced in Zimbabwe. A positivism philosophy, quantitative approach and explanatory survey design were adopted. ZETDC clients were targeted and systematic sampling was used to select a sample of 127 respondents. SPSS version 19 was used to analyse data collected using structured questionnaires. Results showed that as high as 79.2% of the respondents had adopted solar energy as an alternative source of energy. The study revealed that clients are sensitive to the costs of mainstream electricity and find solar energy cheaper to install, maintain and consume. It was also noted that ZETDC is unable to provide adequate electricity with frequent power cuts forcing consumers to adopt solar energy as a backup energy plan. On the other hand, results showed that awareness of the positive social and environmental impacts of solar energy had little influence in the adoption of solar energy in Bloomingdale, Harare. Factor analysis also confirmed that incapability of the existing utility firm to provide adequate electricity and the financial and economic capacity of consumers were key determinants in the adoption of solar energy in Harare.

Keywords: *solar energy; electricity; mainstream electricity, electricity utility firm, environmental impact.*

1. Introduction

Globally, there has been notable increase in the adoption of cleaner and renewable energy (Hulshof and Mulder, 2020). The current global trends in switching from carbon emissions to green revolution and other underlying causes may spell doom to electric utilities companies. Ruggiero and Lehkonen (2017)'s study on renewable energy growth in China showed that electric utilities are pressured to increase clean energy production. The adoption of renewable energy had been found to improve the utilities' environmental performance. Castaneda et al. (2017) evaluated the effect of technology transformation on the Colombian electricity utility industry. It was noted that solar rooftop generation is a major threat for the performance of utilities. Guta (2018) examined determinants of household adoption of solar energy technology in rural areas in Ethiopia and noted that gender, household wealth, education and awareness were key factors.

Changing climatic conditions and global warming has resulted in more droughts negatively affecting electricity generation and transmission in Africa particularly in Central and Southern Africa. It is

estimated that there shall be serious energy shortages in Southern Africa region in the coming 20 years. With water levels at Kariba Dam dwindling due to continued siltation, electricity generation and distribution in Zimbabwe has been constrained over the recent years. Rainfall patterns in the country are likely to remain very unpredictable. However, the demand for solar energy in Zimbabwe has remained strong over the years. A survey conducted by the Zimbabwe Energy Regulatory Authority (ZERA) in 2018 showed that the use of solar energy in Zimbabwe is expected to rise by more than 20% for the 5-year period to 2023. Over the years, the supply of electricity has remained erratic and has also been considered very expensive compared to regional rates. This has triggered a major shift to alternative sources of energy including solar. As at December 2020, about 3% of the Zimbabwe Electricity Transmission and Distribution Company (ZETDC) clients had totally switched from ZETDC energy to solar energy. Over the years, ZETDC has failed to secure enough power imports for winter crop farming forcing most farmers to install solar energy as an alternative. Approximately 70% of ZETDC clients had adopted alternative sources of energy for cooking, charging phones, lighting and refrigeration among many others (ZETDC, 2020). It has been noted that just around 61% of all households in Zimbabwe, both in the rural and urban communities depend on firewood for their cooking and heating requirements (Ministry of Energy and Power Development, 2012). The alternative energy sources are considered to be environmentally friendly and more reliable as compared to fossil or hydro powered energy largely relied upon by ZETDC. The growth in demand for solar energy is therefore a threat to ZETDC as many companies and households have adopted a dual-energy scheme. However, there have been limited studies focusing on the factors influencing the adoption of solar energy in Zimbabwe.

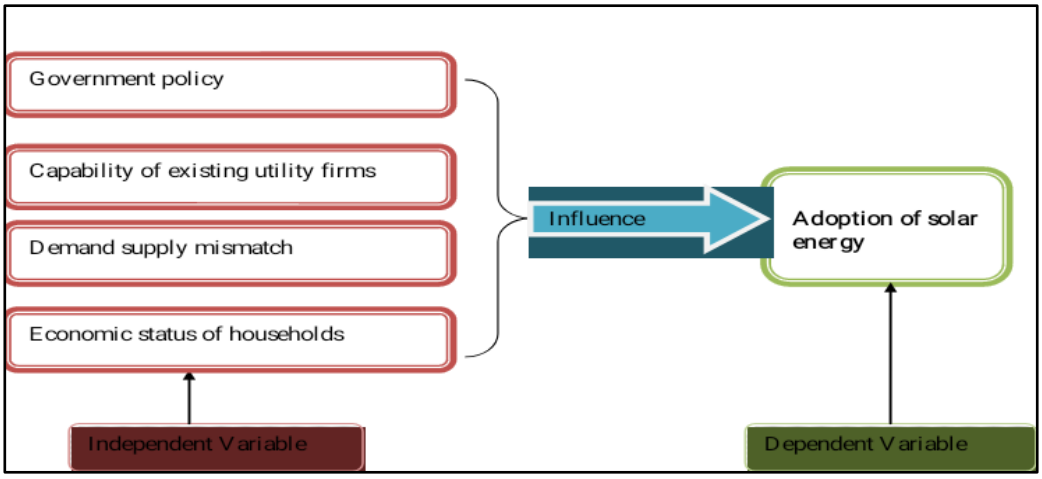
The surge in solar energy adoption in Zimbabwe adversely affects the performance of ZETDC, yet it plays a strategic role in national growth and development. Most of its customers have shifted to alternative sources of energy and little attention has been focused on the reasons in a local context. By December 2020, 3% of ZETDC clients had totally switched to solar energy and as high as 70% had adopted alternative sources of energy (ZETDC, 2020). There is therefore need to analyse factors influencing the adoption of solar energy so that ZEDTC can undertake correctional measures to ensure survival in the long term. This paper therefore examines factors influencing solar energy adoption in Harare West, using the ZETDC as the case study.

2.Literature review

Tornatzky and Fleischer (2018) are of the view that organizations' internal environments, technological developments and environment affect innovation adoption processes. In support of the observations by Rogers (2018), Le et al. (2011) also endorsed key attributes 19 in the acceptance of any innovation. Dedrick and West (2004) went further to highlight the first five attributes mentioned by Rogers as applying in almost all cases of new innovations across industries. Glynn et al. (2019) noted that the same organisational factors also affect adoption. Furthermore, factors such as total ownership cost (Shapiro and Varian, 2008), boundary spanners (Macaulay et al., 2016) and relevance to the organization (Goode and Stevens, 2000) could also fall into this category. There are other intervening factors like government policy on renewable energy, external factors and the utility electricity tariff which can also alter the supply and demand matrix.

Factors influencing adoption of alternative sources of energy

There are a number of factors affecting technology innovations such as solar energy. Tirop and Nganga (2018) are of the view that organizations' internal environments, technological developments and the external environment affect innovation adoption processes. They claim that government policy on renewable energy and the utility electricity tariff system can also alter the supply and demand matrix. Figure 1 below shows the factors influencing the adoption of alternative sources of energy.

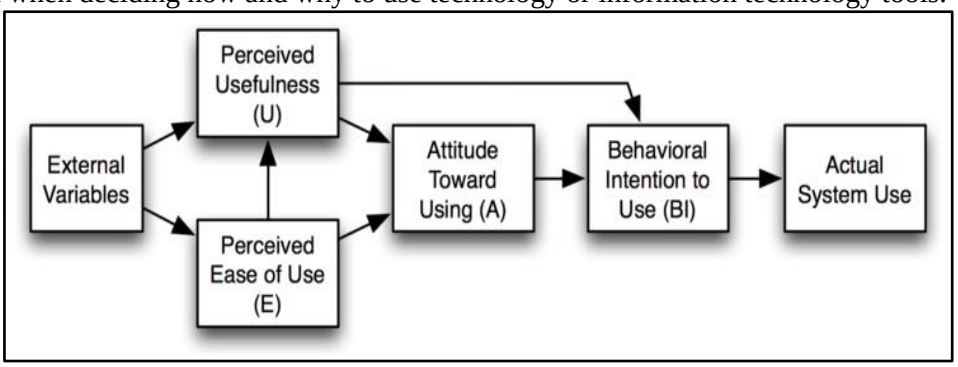


Source: Author (2022)

Figure 1. Drivers of solar energy adoption.

Solar energy is perceived to be cheaper, safer and environmentally friendly when compared to the traditional fossil-powered sources of energy (Maponga, 2018). Neves, Henriques and Vilas (2019) argue that there is an inadequate investment in the electricity grids for most developing countries. Several countries in Africa therefore import electricity to cover up for the shortage in the local production of energy. In Zimbabwe, Maponga (2018) argues that even with the importation, only 21% of the rural people who have access to electricity and 80% of the urban people have access to electricity. The researcher notes that these developments demonstrate that there is a serious problem with the national power utility. This presents to any potential player in the energy sector, a huge opportunity for energy supply in its various forms, especially the need for cleaner energy sources. It should also be noted that just above 5 300 institutions in Zimbabwe are not electrified and these include clinics and schools in the country, especially in the rural areas. This could provide a big opportunity for decentralized mini-grids to address the power needs in each and every community. Overall, there are also over ten thousand other facilities which include pumps which are currently powered, and an equal number of other facilities (such as pumps) are electrified and this is a great opportunity in the sector and presents a challenge to the current market leader, ZETDC (Mzezewa and Murove, 2017). Usually when the leading company in a sector is failing to serve the market adequately, this normally results in the creation of gaps which new competitors may exploit and gain entrance in the market (Kotler and Opresnik, 2019).

In terms of theoretical framework, this study was guided by the Technology Acceptance Model (TAM) indicated in Figure 2. The TAM was initially suggested by Davis (1989) as an analytical tool to characterize, trace and explain the reasons, behaviours, attitudes and opinions among people in an organization when deciding how and why to use technology or information technology tools.



Source: Davis et al. (1989)

Figure 2. Technology acceptance model (Davis, 1989)

The theory explains the adoption of specific new technologies. As shown in Figure 1, the key variables to this equation are Perceived Ease of Use (PEOU) and Perceived Usefulness (PU). Bagozzi, Davis and Warshaw (1992) say that new technologies such as personal computers are complex leading to the existence of uncertainty in the minds of decision makers with respect to their successful adoption. People hence form attitudes and intentions towards trying to learn to use the new technology prior to initiating efforts directed at using it.

As shown above, the attitudes are shaped by PEOU and PU which in turn are shaped by other external variables. The two variables would then lead to the development of a positive attitude towards the innovation or new idea being introduced until there is an intention to use, which is then translated into actual use (Ma and Liu, 2011).

The TAM can therefore be used on any situation where the advancement of technology is made and the area of concern is on acceptability. This study noted that solar energy is a technical product and its adoption falls directly under the technology adoption model. As such, the TAM provides an opportunity for understanding what could have influenced the adoption of solar energy adoption in Harare, Zimbabwe.

Empirical literature review

Mzezewa and Murove (2017) say that a total of 1400 MW are being produced by the various power stations in the country, both thermal and hydro power stations. The nation's current energy requirements are just above 2400 MW and the difference of over 1000 MW is what is being imported and managed through demand side management.

This lack of sufficient energy in the country is the cause for concern and brings about serious threats to ZETDC in the medium to long term future. Existing electricity utilities especially those using fossil-fuel plant are also shifting from their stable and predictable situation to confront challenges emanating from the use of alternative energy services (Frondel et al., 2010). This study notes that to look into the shortages of electricity and consider that as a threat to electricity companies may not be enough without looking into the potential of alternative sources of energy in the form of renewable sources like solar energy.

A study conducted by ZERA (2018) showed that indeed there is potential for new players in the energy sector in Zimbabwe especially with regard to renewable sources. The researcher notes that this presents a serious threat to ZETDC as the viability of these renewable sources of energy could trigger more customers to move away from the national grid or in the most probable cases, reduce their dependence on the ZETDC energy in favor of other alternatives. It is therefore important to understand the factors influencing the adoption of solar energy as an alternative source of energy to enable traditional utility companies to survive.

It is noted that studies on the determinants of solar energy adoption have been carried out mostly in developed countries (Ruggiero and Lehkonen, 2017; Castaneda et al., 2017; Guta, 2018). There is limited literature on developing countries like Zimbabwe with operating environments different from those obtaining in developed countries. There is need to conduct similar studies to establish whether or not the results remain consistent with those obtained in advanced countries. This study therefore uses the ZETDC as the case study.

3.Methodology

The study adopts the positivism philosophy which assumes that reality is fixed and can be objectively measured mathematically or statistically. The positivism philosophy was relevant as it allowed use of existing theory to test data. The researcher was also objective and detached from research processes in this study.

This study adopted a quantitative approach in order to allow the use of scientific techniques. The quantitative approach is objective and makes use of numerical or statistical techniques which aligns with the positivism philosophy. The quantitative approach also facilitated use of descriptive statistics and inferential statistics. The study adopted an explanatory survey design. An explanatory research explains

the cause and effect relationships between variables in a study (Greenfield, 2016). This was appropriate for the current study given the need to explain the factors behind solar energy adoption in Zimbabwe. The survey strategy was meant to ensure that a bigger sample size was adopted cost effectively in a shorter time scale. In this study, the target population was made up of 186 consisting ZETDC clients based in Bloomingdale suburb, Harare, Zimbabwe. Using Yamane (1967)'s sample size calculation formula, the estimated sample size was 127 selected using systematic sampling.

A structured questionnaire was used to gather data and it was prepared using a five point Likert scale with five (5) options namely; strongly agree, agree, uncertain, disagree and strongly disagree was used. The respondents were given five working days to complete the questionnaires at their own time or make any consultations as might be necessary. The rationale for use of questionnaires was that they enabled faster and cost effective collection of data.

The Statistical Package for the Social Sciences (SPSS) version 19 was used to analyse quantitative data collected through closed ended questions. Data were entered into SPPS and cleaned for potential errors. The mean, standard deviation, frequencies and percentages were the main descriptive statistics used. Factor analysis was also used to reduce the data into key factors influencing adoption of solar energy in Harare Zimbabwe. Data were presented using tables, pie charts and graphs generated from SPSS.

Ethical considerations

Informed consent of the respondents was sought so that they voluntarily took part in the study. The researcher did not force the respondents to participate in the study. Anonymity was ensured by not requesting the names or any positive identification of the respondents. Respondents also completed the questionnaires at their own time in the absence of the researcher to enhance privacy. Data collected from the respondents were not shared with third parties to ensure confidentiality.

4. Presentation and discussion of results

A total of 127 questionnaires were distributed to the respondents. Due to persistent follow ups, 109 questionnaires were received. An examination of the questionnaires returned showed that 8 were not fully completed and 101 questionnaires were valid. The valid response rate was therefore 79.5%. This was above the minimum of 70% generally deemed acceptable for generalizing results in quantitative studies (Jackson, 2015). A Cronbach's alpha reliability test was carried out to establish the internal consistency of the 12 five-point Likert scale items operationalizing factors influencing the adoption of solar energy in Bloomingdale, Harare. The reliability values range from 0 to 1 and a minimum value of 0.7 is normally deemed acceptable (Greenfield, 2016). Table 1 shows the results.

Table 1. Reliability Statistics.

Cronbach's Alpha	N of Items
0.788	12

Source: Primary Data

In this study, the reliability value was 0.788 which was above 0.7. As such, the study inferred that the Likert scale items were highly reliable in measuring the determinants of solar energy adoption in Bloomingdale, Harare.

4.1 Demographic information

Table 2 below cross tabulates gender and education levels of the respondents.

Table 2. Demographic characteristics

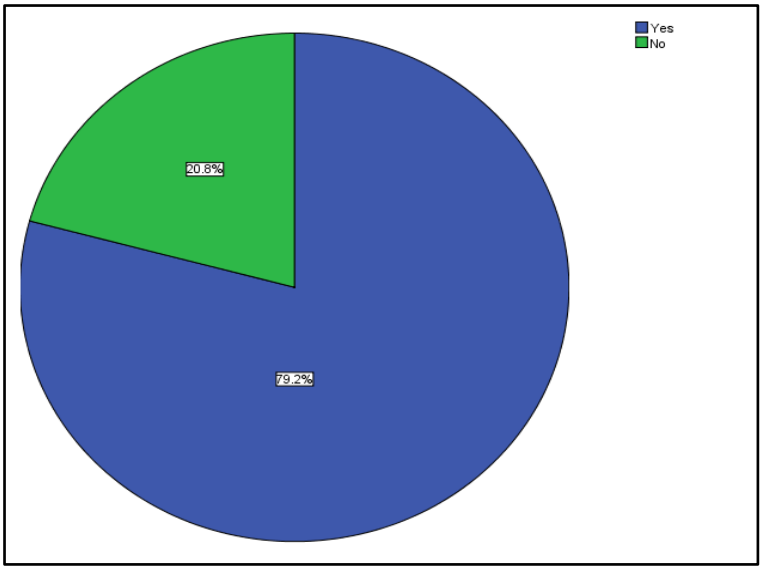
			Highest level of education					
			High school	Certificate/ Diploma	First degree	Post-graduate degree	Other	Total
Gender	Male	Count	11	10	13	10	3	47
		% of Total	10.9%	9.9%	12.9%	9.9%	3.0%	46.5%
	Female	Count	15	13	11	11	4	54
		% of Total	14.9%	12.9%	10.9%	10.9%	4.0%	53.5%
Total		Count	26	23	24	21	7	101
		% of Total	25.7%	22.8%	23.8%	20.8%	6.9%	100.0 %

Source: Primary data

Table 2 shows that out of 101 respondents, 46.5% were males and 53.5% were females. This meant that there was a fair gender parity thus avoiding gender biased responses on the factors influencing the adoption of solar energy. The results also show that 25.7% of the respondents had high school education, 22.8% had certificates or diplomas, 23.8% had first degrees 20.8% had attained post graduate qualifications and the remaining 6.9% cited other qualifications. Since 74.3% of the respondents had some tertiary level education, it was noted that the respondents could appreciate the determinants of solar energy adoption in Bloomingdale, Harare.

4.2 Solar Energy Adoption

The respondents were asked to indicate if they used solar energy within their homes. Figure 3 illustrates the responses received.



Source: Primary data

Figure 3. Solar energy adoption

Figure 3 shows that 79.2% of the respondents had adopted solar energy and 20.8% had not yet used solar energy within their homes. This meant that most (79.2%) of the respondents had used solar energy and could most likely express the reasons behind their decisions. This finding echoed previous surveys

conducted by ZERA (2018) and ZETDC (2020) which showed increased usage of alternative sources of energy in Zimbabwe.

4.3 Factors influencing the adoption of solar energy

In order to establish the factors influencing the adoption of solar energy as an alternative energy source in Harare, respondents were asked to indicate the extent to which they agreed or disagreed with 12 pre-identified factors. A 5-point Likert scale with strongly disagree (=1), disagree (=2), uncertain (=3), agree (=4) and strongly agree (=5) was used. The mean and standard deviation were calculated for each item. In line with the scale adopted, a mean rating above 3.000 indicated general agreement while a mean rating below 3.000 indicated general disagreement. A standard deviation above 1.500 showed that the actual ratings were more dispersed from the mean while a value less than 1.500 showed that the actual ratings were closer to the calculated mean. The results were as shown in Table 3 in descending order of the mean.

Table 3. Descriptive Statistics

	N	Mean	Std. Deviation
I find it expensive to connect electricity in off-grid areas	101	3.92	1.155
I find existing electricity tariffs too expensive	101	3.79	1.177
I find it expensive to maintain existing power infrastructure	101	3.75	1.170
I use solar energy in line with my economic and financial status	101	3.75	1.152
I use solar energy to avoid power cuts on the national grid	101	3.63	1.325
I get inadequate electricity from ZETDC	101	3.55	1.367
I believe ZETDC provides poor service quality	101	3.45	1.338
I use solar energy as backup energy	101	3.37	1.354
I support Government policy on renewable energy	101	2.60	1.364
I am attracted by the advantages of solar energy	101	2.45	1.446
I try new technologies and innovations	101	2.44	1.367
I support the use of green energy	101	2.38	1.272
Valid N (listwise)	101		

Source: Primary Data

The results show that all the standard deviations were less than 1.500. This meant that most of the responses were closer to the calculated means. Table 3 also shows that there was relatively strong agreement on the items that 'I find it expensive to connect electricity in off-grid areas (mean = 3.92), 'I find existing electricity tariffs too expensive' (mean = 3.79), 'I find it expensive to maintain existing power infrastructure (mean = 3.75) and 'I use solar energy in line with my economic and financial status' (mean = 3.75). A key theme from these items is that solar energy is considered cheaper to install, maintain and consume when compared with electricity from utility companies. This supports the assertions made by Maponga (2018) that solar energy is cheaper and safer. The results were also in line with Guta (2018)'s study in Ethiopia which found out that household income influenced adoption of solar energy technology.

The results further show that respondents moderately agreed to the items that 'I use solar energy to avoid power cuts on the national grid' (mean = 3.63), 'I get inadequate electricity from ZETDC' (mean = 3.55), 'I believe ZETDC provides poor service quality' (mean = 3.45) and 'I use solar energy as backup energy' (mean = 3.37). These items collectively suggest that respondents adopted solar energy due to the inability of ZETDC to provide adequate electricity. This finding supports Mzezewa and Murove (2017)'s study which also noted deficits in the supply of electricity in Zimbabwe.

On the other hand, the results show that respondents were in disagreement to the items that 'I support Government policy on renewable energy' (mean = 2.60), 'I am attracted by the advantages of solar energy' (mean = 2.45), 'I try new technologies and innovations' (mean = 2.44) and 'I support the use of green energy' (mean = 2.38). It was noted that consumers' knowledge about alternative sources of energy and the environmental and social impacts did not significantly influence the adoption of solar energy in Harare. This was contrary Ruggiero and Lehkonen (2017)'s study on renewable energy growth in China which showed that consumers pressured utilities firms to increase clean energy production.

4.4 Factor Analysis

In order to statistically confirm the main factors influencing adoption of solar energy suggested by the descriptive statistics, factor analysis was conducted at 5% level of significance. The KMO and Bartlett's Test shown in Table 4 was used to establish if it was suitable to conduct the data reduction exercise. A minimum measure of sampling adequacy of 0.5 is required in order to proceed with factor analysis (Jackson, 2015). Jack

Table 4. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.771
Bartlett's Test of Sphericity	Approx. Chi-Square	1.440E3
	Df	66
	Sig.	.000

Source: Primary Data

In this study, the KMO measure of sampling adequacy was 0.771. This was above 0.5 and thus showed that factor analysis could be done. The principal component analysis extraction method and Varimax rotation were used to extract the key themes or latent factors behind solar adoption as an alternative source of energy. The results were as shown in Table 5.

Table 5. Total Variance Explained

	Initial Eigenvalues			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.37	36.413	36.413	3.549	29.577	29.577
2	4.05	33.748	70.162	3.401	28.340	57.916
3	1.90	15.893	86.055	3.377	28.138	86.055
4	.524	4.370	90.424			
5	.364	3.032	93.456			
6	.239	1.992	95.449			
7	.188	1.569	97.018			
8	.119	.990	98.008			
9	.103	.856	98.863			
10	.060	.504	99.367			
11	.052	.429	99.796			
12	.024	.204	100.000			

Extraction Method: Principal Component Analysis.
Source: Primary Data

Table 5 indicates that three (3) components were extracted with rotated sums of squared loadings of 3.549, 3.401 and 3.377 which accounted for 29.6%, 28.3% and 28.1% of the variation in factors influencing adoption of solar energy respectively. Put together, the three themes explained a cumulative 86.1% of the variation in the factors influencing the adoption of solar energy in Bloomindale, Harare. This suggests that the three components are critical in influencing consumer behaviour towards adoption of solar energy. To identify the components, the rotated component matrix, shown in Table 6, with the factor loadings was used. Factor loadings less than 0.5 were suppressed in order to clearly show component (s) on which the items highly loaded.

Table 6. Rotated Component Matrix

	Component		
	1	2	3
I support Government policy on renewable energy			.873
I find existing electricity tariffs too expensive		.952	
I get inadequate electricity from ZETDC	.959		
I find it expensive to maintain existing power infrastructure		.938	
I use solar energy in line with my economic and financial status		.922	
I use solar energy as backup energy	.898		
I believe ZETDC provides poor service quality	.890		
I use solar energy to avoid continuous power cuts on the national grid	.958		
I support the use of green energy			.912
I try new technologies and innovations			.896
I find it expensive to connect electricity in off-grid areas		.762	
I am attracted by the advantages of solar energy			.892

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Source: Primary data

Table 6 indicates that items which highly loaded on component 1 were 'I get inadequate electricity from ZETDC' (factor loading = 0.959), 'I use solar energy as backup energy' (factor loading = 0.898), 'I believe ZETDC provides poor service quality' (factor loading = 0.890)' and 'I use solar energy to avoid continuous power cuts on the national grid' (factor loading = 0.958). Component 1 was therefore interpreted as incapability of existing utility firms to provide adequate electricity which forces consumers to consider solar energy as an alternative source of energy. This finding was in line with Neves et al. (2019)'s argument that there is inadequate investment in the electricity grids for most developing countries.

Items which loaded highly on component 2 were 'I find existing electricity tariffs too expensive' (factor loading = 0.952), 'I find it expensive to connect electricity in off-grid areas' (factor loading = 0.762), 'I find it expensive to maintain existing power infrastructure' (factor loading = 0.938) and 'I use solar energy in line with my economic and financial status' (factor loading = 0.922). Component 2 was therefore considered as financial and economic capacity of consumers. This confirmed Tornatzky and Fleischer (2018)'s assertions that utility electricity tariff systems can alter the supply and demand matrix.

Table 6 also shows that items which loaded highly on component 3 were 'I support Government policy on renewable energy' (factor loading = 0.873), 'I support the use of green energy' (factor loading = 0.912), 'I try new technologies and innovations' (factor loading = 0.896) and 'I am attracted by the

advantages of solar energy' (factor loading = 0.892). Component 3 was deemed as knowledge of social and environmental benefits of solar energy. However, this component had little impact towards the adoption of solar energy in the context of the study.

5. Conclusion

The study concluded that ZETDC's incapability to provide adequate electricity to its clients as well as the fragile financial and economic capacity of its consumers were the key factors influencing the adoption of solar energy in Bloomingdale, Harare. Persistent power cuts forced consumers to install solar energy as a backup strategy. The clients' high sensitivity to costs associated with mainstream electricity also influenced the adoption of solar energy in Bloomingdale, Harare. The study concluded that, despite usage of solar energy, clients had little awareness of the social and environmental benefits of solar energy adoption.

5.1 Recommendations

The study recommended that ZETDC increase investment into its power generation capacity in order to address the demand and supply mismatch in the provision of electricity in Harare. Reliable electricity could prop of consumer confidence and thus reduce the switch to alternative sources of energy. ZETDC could achieve through mobilizing financial resources from central government as well as regional and international lenders comfortable with the risk profile of parastatals. It was further suggested that ZETDC review its tariffs downwards in line with the financial and economic status of its clients so as induce consumption of the mainstream electricity. Given the growing calls for cleaner and renewable energy, a further study focusing on consumer awareness of the advantages of solar energy was suggested. The study could also examine the capacity of existing electricity utility firms to adopt solar energy into their business models.

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Impacts of using non automated technologies on the Business Performance of Zimbabwean metal recycling industries.

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Abstract. Sustainable technologies play an important role in businesses by reducing negative environmental effects, avoiding depletion of natural resources whilst ensuring productivity. Zimbabwe is importing metal steel products that could be produced locally if local foundries adopt the rightful technologies. Most of Zimbabwean metal recyclers are using manual methods in the recycling process. The study looked at the negative effects of using manual production systems on the business performance of the Zimbabwean metal recycling industries. Qualitative and quantitative data collection techniques were adopted through the use of questionnaires and survey interviews. The researcher collected quantitative data through a questionnaire.77 out of 109 distributed questionnaires were returned and filled correctly by production personnel in the metal recycling industry. This translated to 70% response rate. Semi-structured interviews were conducted for the purposes of gathering qualitative data. Quantitative data revealed that metal recyclers are facing challenges of reduction in processing speeds, reduction in operation profits, poor product quality and high risk of getting injured due to the use of manual production methods. The study revealed that Zimbabwean metal recyclers are facing many challenges which to a greater extent are caused by their operation methods.

Keywords: *Sustainable technologies, Foundry, Scrap metal, Non-automated, Business Performance, Scrap metal.*

1. Introduction

Developing countries such as Zimbabwe deal with challenges in solid waste management such as insufficient waste recycling, hazardous wastes that are not separated for safe disposal, and landfills that are not properly engineered to prevent groundwater pollution (Teta and Hikwa, 2017). Zimbabwe has a lot of scrap metal and this to some extent is due to the fact that the country receives end of life vehicles from Japan, UK and other western countries. The availability of scrap metal in Zimbabwe is an opportunity to improve the country's economic situation. The utilisation of scrap metals using sustainable technologies can improve the profits margins in the local metal recycling industry.

Currently foundries and other informal metal recyclers are using unsustainable manual methods which reduce their competence and operational profits hence they fail to offer good prices for their main raw material (scrap metal). Zimbabwean foundries that are operating are facing a challenge of scrap metal shortage due to continued exports of the scrap metal to countries that pay more for the scrap as they have better technologies and recycling capacity. Zimbabwe could save at least $11 million per month and hundreds of jobs if it stops exporting scrap metal and beneficiate it locally thus according to ZIF (Chingwere, 2018).

Inefficient methods being used result in high usage of fossil fuels for heating, air pollution, hazardous operating method, less valued products and smaller product range of products from the recycled metal waste. The main objective of this research study is to analyse the impact of non-automated production methods used by Zimbabwean metal recyclers.

2. Literature Review

The literature review mainly focused on previous empirical studies on challenges faced by metal recyclers in general. There is a gap in published literature as no paper has been published concerning the impacts of the use of unsustainable manual technologies on the business performance of Zimbabwean metal recycling industries. A significant amount of research has investigated a range of e-waste recycling methods such as pyro-metallurgy, hydrometallurgy and bio-hydrometallurgy (Yken J, 2021).

A thesis for the degree of doctor of philosophy by Magnus Andersson was concerned with increasing the resolution of knowledge around opportunities for, and challenges of, recycling scarce metals and it aimed to identify measures that can raise recycling rates of such metals (Andersson, 2018). The thesis was mainly focusing on challenges of recycling scarce metal from dead motor vehicles e-waste. The conducted research highlights that for individual metals to be recycled, there is need for long-term, high impact and metal specific measures that target build-up of entire value chain (Andersson, 2018).

Mulaudzi et al. (2017) conducted a study on challenges faced by local authorities in solid waste management. The solid waste included scrap metal hence it was also analysed. Mulaudzi concluded that solid waste management in Zimbabwe, particularly Beitbridge is poor and ineffective, due to challenges such as poor community engagement; lack of machinery such as refuse trucks, compactors, there is also poor waste management practices such as burning of municipals and illegal dumping, poor enforcement of the legislations(Kaushik and Walsh, 2019)(Kaushik and Walsh, 2019) (Mulaudzi 2017).

(Adanu, Gbedemah and Attah, 2020) investigated why sustainable technologies are not used to collect, dismantle and sell e-waste given the risk of injury and extensive environmental pollution associated with handling of electronic waste. The research was mainly aimed at assessing the type of technologies that were currently used in managing e-waste. The study also looked at challenges that are faced when adopting sustainable technologies. The use of unsustainable technologies to manage e-waste contributed to physical injuries to workers and pollution of the environment (Adanu, Gbedemah and Attah, 2020). A major challenge limiting the use of sustainable technologies is lack of financial resources to acquire modern equipment despite the laborious nature of the work. The paper concludes that sustainable solutions to electronic waste management requires support from government to subsidize the cost of sustainable technologies in e-waste management.

Secondary data was collected from online newspapers and metal industry inventory data. According to data reported in November 2020, Zimbabwe's scrap metal industry has a monthly scrap metal shortfall of 17 000 tonnes. The scrap metal industry in the country demands a monthly supply of 27 000 tonnes which is currently not being met. At the time of the release of the data in November 2020, the industry could only access 10 000 tonnes of scrap metal having to import the balance of 62%. Scrap metal is a critical input in some domestic manufacturing businesses (Van Beukering and Bouman, 2001) (The Periscope Report Quick Stats, 2020)

The shortage of scrap has further been compounded by continued exports mainly to South Africa despite local foundry men's willingness and capacity to consume all the available scrap metal at competitive prices compared to what is obtaining across the border (Chingwere, 2018).

From the literature gathered the main challenges that are being faced by local recyclers include; quality of steel products produced from the scrap

- Minimizing contamination with other metals.
- Energy sources as they typically rely on coal or electricity for heating
- Lack of efficient refining technologies to recycle future scrap feed.

3. Methodology

The research design adopted was that of a mixed method approach, the researcher used survey questionnaire and interview to collect the data. Some of the sections in the research instrument are shown in Table 1.

One of the objectives of the research study was to examine the current production methods being used in the Zimbabwean recycling industry. Participants were asked to indicate the level of automation in their industry by ticking an appropriate box. The participants were required to indicate the source of energy required in the melting stage.

The research questions used are described in the table 1 below as qualitative or quantitative.

Table 1: Sample research question, type of research and data collection method.

Research Question	Type of research	Data collection method
1. Briefly describe the current metal recycling production methods that your firm uses.	Quantitative	Survey
2. To what extent do you agree or disagree that using unsustainable manual methods causes challenges in process operation.	Quantitative	Survey
3. Are there any strategies that your organization have put in place to address the challenges being faced during your operation process?	Qualitative	Interview
4. How do your products and process compare to those produced by international companies that are highly automated and use sustainable technologies?	Qualitative	Interview
5. In your own opinion why are metal scrap dealers opting to sell scrap metals to companies outside Zimbabwe	Qualitative	Interview
6. What are the main factors that affects the adoption and use of sustainable technologies in the Zimbabwean metal recycling industries?	Quantitative	Survey

Qualitative and quantitative methods was mainly used to collect both primary and secondary data. The survey was done using questionnaires. The quantitative approach used managed to provide information on the main challenges that the Zimbabwean metal recyclers are facing.

The main characteristic of qualitative research is that its outcomes are not measurable and quantifiable, however its basic advantage is that it offers a complete description and analysis of a research subject, without limiting the scope of the research and the nature of participant's responses (Collis & Hussey, 2003). The researcher used interviews which mainly gave a qualitative analysis and survey questionnaires which contributed majorly to the quantitative analysis. The interviews helped the researcher to get to know the challenges that the local recycling industries are facing. The questions in the interview guide were explanatory and descriptive. The researcher also managed to get more information regarding the study as the interview was interactive and, in some organizations, informal giving the respondents freedom to express their views.

3.1 Ethical consideration

The researcher asked for permission first from the recycling companies before getting information from their employees. To gain access to the targeted respondents, the researcher indicated to them about their freedom to respond or not. To ensure confidentiality and credibility all the information that was collected was used for academic purpose only. As a result, no information derived from this research will be passed to a third party without the permission of the researcher.

4. Presentation of Results

The research study focused on ascertaining the challenges or impacts of using manual production methods in the Zimbabwean metal recycling industries.

Participants were first asked to indicate the level of automation and source of heat energy in their industry by ticking an appropriate box. The detailed production methods were explained by respondents who were interviewed and the details are described under the qualitative analysis.

Table 2. Current Metal Recycling Production Methods

Manual (only 1 or no automated stages)	Semi-automated (at least 2 stages are automated)	Fully Automated (all stages are automated)	Source of heat	
			Renewable (solar or biomass briquettes)	Non-Renewable (coke or coal)
69	8	0	0	77

The results indicate that 90% of the respondents have highly manual processing methods, whilst 10% have some stages automated. No respondent indicated that their process is fully automated. All the respondents indicated that they are using non-renewable energy sources

Participants also indicated the extent to which they agree or disagree to challenges that the researcher indicated were caused by using manual production methods. The responses were indicated using a 5-point Likert scale. The results are presented in table 3 below.

Table 3: Challenges of Using Manual Production Methods

Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	**Mean**
Reduction in processing speeds	89.6%	10.4%	0.0%	0.0%	0.0%	**4.90**
Reduction in operation profits	79.2%	13.0%	5.2%	2.6%	0.0%	**4.69**
Reduction on product quality	66.2%	24.7%	6.5%	1.3%	1.3%	**4.53**
Low price offers to scrap metal dealers	39.0%	28.6%	20.8%	6.5%	5.2%	**3.90**
Lack of scrap metals	36.4%	24.7%	26.0%	9.1%	3.9%	**3.81**
High risk of getting injured during operation.	84.4%	13.0%	2.6%	0.0%	0.0%	**4.82**
Product contamination	64.9%	22.1%	10.4%	2.6%	0.0%	**4.49**
Flue gases that affect the operator and environment	71.4%	13.0%	15.6%	0.0%	0.0%	**4.56**

According to table 3, the majority of the respondents strongly agreed that they were facing challenges from using manual processing methods. The major challenges were reduction in operating speeds, profit, product quality and high risk of getting injured during operation. A sizeable number of respondents (39%) did not agree that the challenge of offering low prices to scrap dealers is due to the use of manual production methods. Figure 1 below shows a graphical presentation of the challenges of using manual production processes in recycling industries.

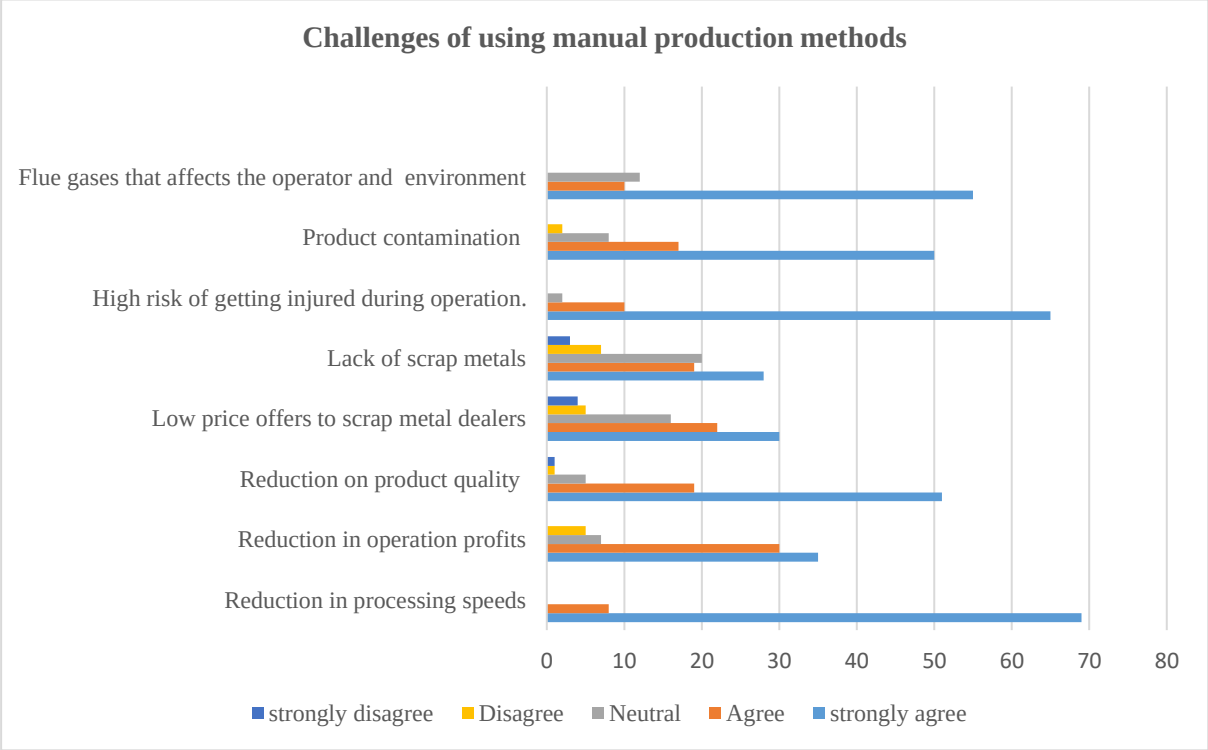

Figure 1. Challenges of Using Manual Production Methods

The graphical presentation clearly indicates that a greater percentage strongly agreed that using manual production processes have negative impacts. The above quantitative findings reveal that there are negative impacts caused by using manual processing methods in Zimbabwean recycling industries. The major challenges are reduction in processing speeds, poor quality products, high injury risks and high production costs. These findings show that manual production methods have a negative impact on the profitability of the industry. The findings are also supported by literature found on news websites and local newspapers.

4.1 Reliability of the Questionnaire

The reliability of the questionnaire was tested using the Cronbach's Alpha to ascertain if the findings obtained are reliable. The reliability test run in the SPSS produced results presented in the table below.

Table 4: Questionnaire reliability

Variable	**Cronbach's Alpha**	**N of Items**
Current Production Methods	0.981	5
Challenges of using manual production methods	0.943	8
Factors affecting adoption of technologies	0.955	7
Overall Cronbach's Alpha	0.979	20

A score of .979 for the 20 items entered in the SPSS software was produced. According to Meyer (2010) an overall Cronbach's Alpha of more above .600 is recommended which shows that the questionnaire was reliable

4.2 Qualitative data analysis

Interviewees were asked to describe their process as either automated, semi-automated or highly manual. The participants were also asked to describe their process operation in terms of sustainability. None of the participants said their process was fully automated and/or sustainable. The majority of the participants said their processes were highly manual with some pointing out that they have make shift locally made crushing machines. One interviewee response is provided below;

Our processes are very simple and not automated. We use jack hammers to crush the scrap metal that we would have selected using the handpicking methods. We remove plastics and some type of metals that will not be fit for that particular feed stream. We use plastics and papers and wood sticks to start the fire which will heat up the coal ashes that will melt our scrap metal. For now, sustainability is not much an issue as we are just looking at providing for the family

The respondent stressed the point that the process is highly manual and for now they just want to have a minimum profit to fend for their family

The study also looked at the safety of the current operating process in most local metal recycling processes. Participants were asked about the injury risks associated with the operation processes. One operator that owned a make shift grinder had this to say;

There are a lot of risks in our industry but due to experience fatalities only happen once in a while. There is a high risk in operating the semi-automatic make shift grinder as it is open on top, any mistake my hand or finger may be grinded. We also have healthy risk of contracting diseases as we do manual separation the clean the scrap metal. There is high risk of being burnt by the fire we make using charcoal, we also inhale a lot of gases from the heating processes that put us at risk of contracting respiratory diseases.

The interviewee basically explained more on the challenges that face especially as small-scale recyclers.

5. Discussion of results

The study established that there are negative impacts that affect the local metal recycling industry. Both qualitative and quantitative data revealed the negative impacts of operating manually. The impacts found were reduction in processing speeds, reduction in operation profits, and reduction on product quality. The other impacts include low price offers to scrap metal dealers, lack of scrap metals, high risk of getting injured during operation, product contamination and flue gases that affects the operator and the environment. Prasanna 2022 indicated the negative effects of manual processes by indicating advantages of automated technologies over manual processes. Unlike non automated recycling systems, automation helps businesses stay profitable by increasing output, reducing errors, and saving time and resources, also in a time of economic crisis, automation is a cost-cutting tool that can also help increase productivity and profit (Prasanna 2022).

The findings revealed that manual processing methods negatively affect operation speeds. The time taken during manual crushing and manual selection processes is long and it has an effect on the overall operation process. This results in less products being produced per day as compared to automated systems. The separation process takes a lot of time and sometimes due to error operators' end up leaving non-metals in the feed stream resulting in poor quality. Manual operation means more human resources which increases the production costs. Negative impacts of manual processing methods were also explained by Granta (2017) who indicated that unlike manual methods, automated machines do not have breaks, sick leave or holidays, and therefore even if they are only running during normal shift hours. This alone can often lead to a production increase of 140%+, automated machinery can also typically run faster and produce more accurately made products with fewer defects (Granta 2017).

The study established that there are a lot of risks in the local metal recycling industry. The risks include being accidentally crushed by hammers. Other risks include healthy risk due to inhaling flue gases from the heating processes. The gases also contribute to climate change as they are greenhouse gases meaning they also affect the environment. There is also high risk of being burnt by the fire the

recyclers make using charcoal. OSHA (2008) also indicated that employees involved in manual metal recycling activities may be exposed to metal fumes, smoke, hot environments, and hot material when working near furnaces, and may come in contact with metals that present hazards through both skin contact and inhalation.

The research findings also revealed that the recyclers are also facing challenges of scrap metal despite the high quantities of scrap metal in the country. The products produced by local recyclers are of poor quality and are sold at low prices. This makes the recyclers offer less price on scrap metals resulting in scrap metal dealers exporting scrap to get more money. Literature revealed that the government has put a ban on metal exports but companies apply for waivers which is sometimes abused. The continued export of scrap metal is resulting in shortages of scrap. Similarly, Chitaka's study (2014) the export of scrap metal was viewed as a great concern to recyclers as it reduces the chances of local beneficiation

6. Conclusion and recommendations

Zimbabwe has a lot of scrap metals which could be locally processed and improve the country's GDP. Most of the local metal recyclers are operating manually and are facing many challenges which contributes to the reduction of profits and high risk of human and environmental health. The major challenges that the study found include reduction in processing speeds, poor quality products, high injury risks and high production costs. These findings show that manual production methods have a negative impact on the profitability of the industry.

Recommendations

The researcher recommends the use of automated technologies in the Zimbabwean metal recycling industry which increases convenience, operation speeds, product quality and profitability. Adoption of technology in the recycling industry has been employed to increase recycling rates, keep up with changing materials and products entering the waste stream and improve profitability for scrap metal recyclers (ScrapWare, 2021). Automated technologies reduce health risks and reduces environmental pollution. New recycling technologies, which arimproving, are one means of addressing current low metal recycling rates (Reck B, 2012). There are many automated technologies available for use by the metal recycling industry.

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Quality Improvement as Major Process of Quality Management in Projects

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Abstract. Quality improvement in projects is the final major process of quality management in projects. Continuous quality improvement in projects, often referred to as continuous improvement process in projects, is a continuous effort to improve project activities with the aim of increasing the quality of products, services or processes resulting from the project. The major quality improvement process will change continuously during the course of the project and the responsibility for updating the quality improvement process lies with the project manager.

Keywords: *quality control, quality management, projects, major process*

Introduction

Quality is considered a complex and fast moving function including a number of technical, economic, aesthetic, ergonomic and reliability/maintainability conditions. Quality management is the set of activities of the general management function of an organisation, which determines, in the field of quality, the objectives and responsibilities it implements within the quality system, through means such as quality planning, quality assurance, quality control and quality improvement. "*Project quality management is the discipline that is applied to ensure that both the project outcomes and the processes by which the outcomes are delivered meet the needs of stakeholders"*, a definition formulated by the Project Management Association of England [3]. In other words, project management is an area of management that plans, directs and controls resources so that the project goal is achieved within the allocated resources (financial resources, time resources, material resources, information).

The project is defined as a "lot of activities" that contribute to a common goal, with its own management and requiring a significant consumption of resources. [1]

The functions of quality management in projects are carried out within the four major processes of quality management in projects: *Quality Planning; Quality Assurance; Quality Control; Quality Improvement*, Figure 1.

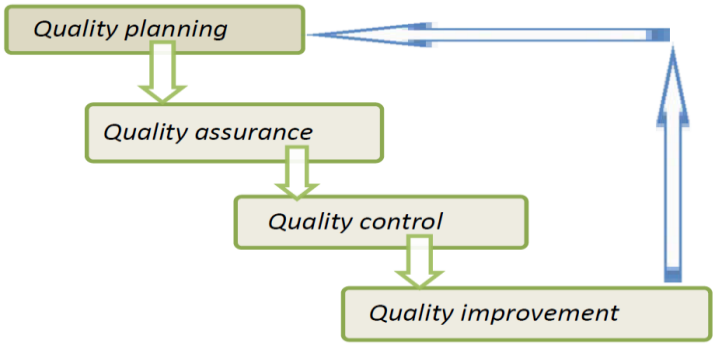

Figure 1. The four major processes of quality management in projects.

Quality improvement in projects is the final major process of quality management in projects. For the project manager, but also for the project implementation team, it will be an objective to be achieved on a continuous (permanent) basis. The *"Project Quality Improvement"* process is an overlapping process on top of all other major processes of project quality management. Quality improvement will be done continuously in all phases of the project management.

Contents

In the late 1990s, the ISO 9001:2000 standard - which covered quality management systems and principles - was debated by those involved in its application regarding the use of the word "continuous" [9]. Representatives from the regulatory authorities decided that the use of the word "continuous" was not applicable because it meant that an organization had to improve minute by minute, whereas continuous improvement meant incremental improvement or improvement by segments" [7]. The concept of "continuous improvement" is essential to the British Standards Institute Publication 2019: BS 8624 Guide to continuous improvement: methods for quantification [11]. BS 8624 describes the requirements for "Continuous improvement" and provides methods and examples of recognised techniques.

Continuous quality improvement in projects, often referred to as continuous improvement process in projects, is a continuous effort to improve project activities with the aim of increasing the quality of products, services or processes resulting from the project. These efforts take the form of incremental "improvement over time" or "breakthrough" improvement at a time [2]. The final project product (deliverable) is evaluated by customers and is constantly meeting their requirements. This allows evaluation and improvement based on collected data, efficiency, effectiveness and even flexibility of processes within a project.

Often, continuous performance improvement is sought. It is believed that better performance leads to better customer satisfaction. Largely true, but this implies additional costs and therefore a higher cost of the product resulting from the project, all to the detriment of the beneficiary. This principle does apply however, and is to involve all staff at all levels and in all entities in activities to improve the distinctive capabilities of the project.

In Japan a new strategy of "continuous improvement", called **KAIZEN** (KAI = change, ZEN = better) in Japanese, was invented and applied by Masaaki Imai (1986) (6). "KAIZEN" means "continuous improvement involving everyone from managers to workers". KAIZEN means a systematic approach to closing the gap between customer expectations and process output characteristics.

Walter Deming devised a continuous improvement process called the **"P-D-C-A cycle"**, which he introduced in Japan in 1950 and which is also called the *Deming cycle*. The four phases of this cycle are: (P) - Planning improvement of the plan activities, (D) - Execution of the improvement plan, (C) - Verification of the work performed, (A) - Action to correct the process. W. Edwards Deming, a pioneer in the field, saw the quality improvement process as part of the "system" by which the feedback from the process and the customer was evaluated against organizational goals. Although

it is called a management process it does not mean that it must be executed by the project ”PM”, but rather only that decisions will be made about project implementation.

Measurement and analysis of project data allow the project manager to draw correct conclusions about errors, deviations, mistakes or changes that influence the project objectives and to decide the necessary actions to achieve the project targets according to the planned budget, allocated time or other resources established in the planning process [7]. Quality improvement will be done continuously in all phases of project management. Measuring and analysing the results of each project activity allows the implementation team, but mainly the project manager, to draw correct conclusions on mistakes, deviations and errors that influence the quality objectives and thus to make decisions to apply corrective or preventive actions in all phases of project implementation.

Quality improvement in projects can be seen as a process superimposed on quality control and will be a permanent objective of the PM and the implementation team. Measuring, analysing and diagnosing project data informs the project manager to draw conclusions on the implementation of project and non-project activities (errors, deviations, mistakes or changes) that influence the project objectives and to decide on the necessary actions to achieve the new project goals according to the planned budget, allocated time or other resources established in the planning process.

If a quality improvement programme is to be implemented within a project, and the project results are to be optimised, a methodology can be applied that includes the following steps E1-E7:

E1. Current status assessment of the project;
E2. Diagnosis based on inputs in the project processes;
E3. Defining new stage for the project and finding differences from the current implementation;
E4. Setting new project targets / adding on existing ones;
E5. Identify new activities and resources, reorganise existing ones;
E6. Planning and implementing new project activities;
E7. Ongoing improvement of the project.

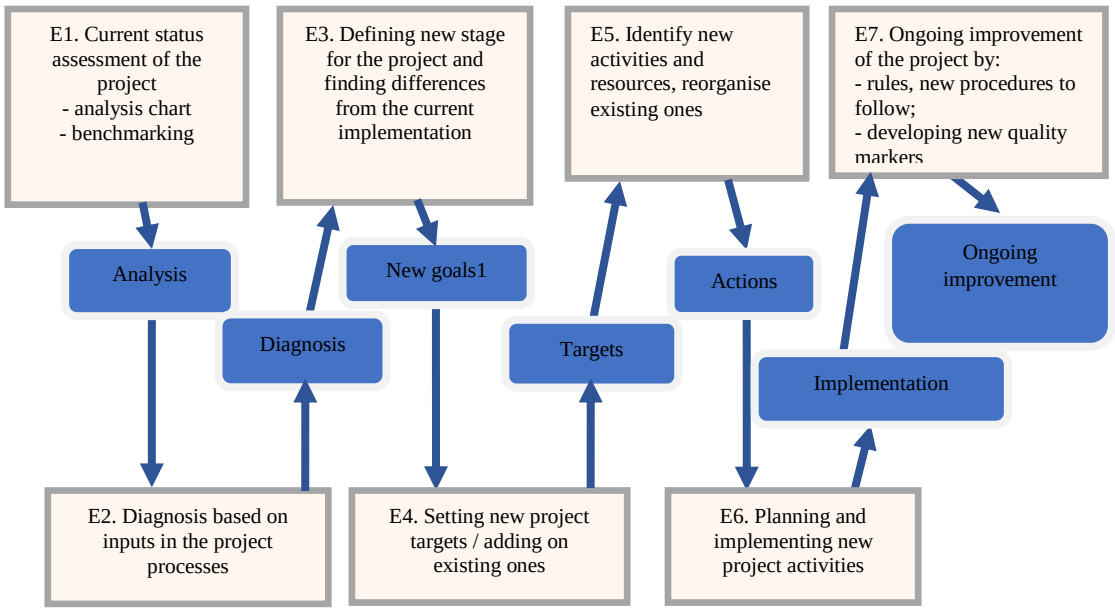

Figure 2. Methodology for continuous quality improvement of projects

The concept of continuous improvement can also be used in projects implemented by organisations with environmental management systems (ISO 14000). The term ”continuous improvement” is used in ISO 14000, and is understood to refer to a continuous series of activities for the purpose of increasing quality, each of which is carried out in a discrete,that means a ”step-by-step” manner. There are several differences between the concept of continuous improvement as

applied to quality management in projects and quality management in environmental projects. Continuous improvement in environmental projects aims to improve the natural impacts of the products and activities resulting from the project. There is also no customer orientation in environmental projects. It can be considered on the basis of the project quality methodology, shown in the figure above, that the continuous improvement process in projects is in fact a meta-process for most project quality management systems. One can thus consider quality management in business, management, social projects etc.

Conclusions

- The major process of quality improvement in projects changes continuously and in real time according to new project quality objectives, which are a moving target. It has been found in practice that no project has evolved according to the initial planning, with the first management plan applied, rules and new procedures to be followed have already been identified;
- The result of current status assessment of the project of the overall quality objective and the lower level objectives in the projects are input data, thus the outcome of the major quality improvement process will change continuously during the course of the project and the responsibility for updating the quality improvement process lies with the project manager.
- Improving quality in projects as a process the major process of quality assurance in projects requires that the project implementation team includes people who have a thorough knowledge of quality and mathematical statistics (graphs, charts, statistical interpretation etc.), which leads to statistical quality improvement in large projects through the application of statistical control while for small projects internal or external quality audits are used.

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Enabling entrepreneurial ecosystem framework as a panacea to formalisation of manufacturing MSEs in Harare, Zimbabwe.

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Abstract: The aim of this study was to develop an enabling entrepreneurial ecosystem framework for the formalisation of manufacturing Micro and Small Enterprises (MSEs) in Harare, Zimbabwe. This study adopted a pragmatism research philosophy that adopts a mixed methods research design. The population for the quantitative research consisted of around 2 000 metal fabricators and furniture manufacturers operating at Mbare-Magaba Siyaso and Glenview Area 8 Home Industry Complex clusters and the sample was made up of 300 respondents. Quantitative data was collected using structured closed-ended questionnaires and analysed using the Statistical Package for Social Sciences (SPSS). Qualitative data was collected through in-depth semi-structured face to face interviews and the population consisted of five directors at the Ministry of Women Affairs, Community, Small and Medium Enterprise Development. However the sample for qualitative data was made up of two directors. The findings from this study show that informal manufacturing MSEs in Harare face several barriers to formalising their businesses and the key entrepreneurial ecosystem factors are not currently available in the environment where they operate. Furthermore, access to financial support, physical infrastructure, support systems, domestic and export markets as well as favourable legal and regulatory framework were considered as key to formalisation of the informal manufacturing MSEs. The findings from the interviews show that the current Zimbabwe Micro, Small and Medium Enterprises Policy has failed to ensure regularisation of the informal sector.

Keywords: *Entrepreneurial ecosystem, formalisation, manufacturing, informal, MSEs, pragmatism, Zimbabwe*

1. Introduction and background

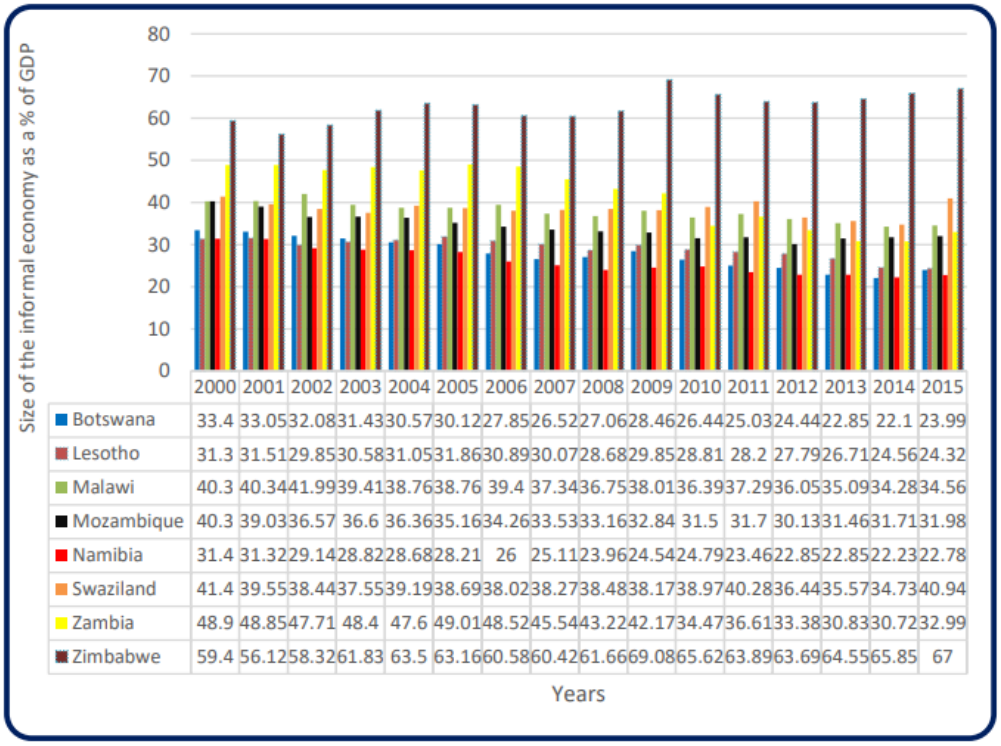
The entrepreneurial ecosystems concept, referred to EE henceforth, has rapidly gained impetus within entrepreneurship domain and research circles. Several countries the world over are making strategic decisions to regularise the shadow economy (Koos & Kok, 2014). From a global perspective, around two billion workers, which represent 61.2% of the world's working population are engaged in informal economy employment (ILO, 2018). Informal employment is characterised by unsafe, harmful working conditions, low skills levels, undefined workspaces, low incomes, lack of access to markets, finance, information, training, technology and there are long working hours (Ibid). The informal enterprises are not registered and the workers are not regulated by the labour laws as they do not have formal contracts. Similarly, Loayza (2018) states that workers in the informal sector have less social safety nets compared to their counterparts in the formal sector. Chodorow-Reich et al. (2020) highlighted that the workers operate in crowded places and they

use cash and carry that increases chances of spreading diseases. The best way to address challenges outlined above is through the transition to formality.

Considering the African continent, ILO STAT (2020) reported that the Sub-Saharan African (SSA) region, compared to other regions in the world, has the highest number of labour force that are engaged in the informal economy. In terms of figures, when the agriculture sector is excluded, the informal economy in SSA region represents 76.8% of total employment and 89.2% if the agricultural employment is included (ILO, 2018) and informal output was estimated at 62% of official GDP (Ibid). From the statistics given above, the SSA region has a long way to go in reducing the size of the informal economy which has negative characteristics. Equally, Jayaram et al., (2020) states that the African continent has over 300 million people who operate in the second economy and some choose to remain informal even the formal institutions become more business friendly (Williams et al., 2016).

High levels of informality are prevalent in the developing nations and ILO (2020) estimated more than 2 billion people which represent 60% of employees and 80% of enterprises. In North Africa and the Middle East, the informal enterprises were found to account for at least 70% of employment and over 80% in SSA and South Asia (ILO, 2019).

The World Bank (2020) report states that in Zimbabwe, the informal economy on average contributes 61% to the nation's GDP. On the other hand, the same report highlighted that in Zambia the GDP was standing at 33%, 53.3% in the DRC, 34% in Tanzania, 34.3 in Kenya, 39.1% in Ethiopia and 35% in Malawi. The statistics show that Zimbabwe has the highest level of informality in the SADC region and SSA in particular. Also, Medina et al., (2018) states that the Southern African region has GDP contribution ranging between 40-50 percent and Zimbabwe has a 50% rate. The SSA's informal sector accounted for 80% of total employment and if the countries can account for production that take place, it has the potential to contribute 55% of GDP (Ibid). The figures indicate that the sector is important to any nation. According to the Figure 1.1 below, Zimbabwe, Zambia, Swaziland, Mozambique and Malawi had high informality levels between the years 2000 to 2015.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Botswana	33.4	33.05	32.08	31.43	30.57	30.12	27.85	26.52	27.06	28.46	26.44	25.03	24.44	22.85	22.1	23.99
Lesotho	31.3	31.51	29.85	30.58	31.05	31.86	30.89	30.07	28.68	29.85	28.81	28.2	27.79	26.71	24.56	24.32
Malawi	40.3	40.34	41.99	39.41	38.76	38.76	39.4	37.34	36.75	38.01	36.39	37.29	36.05	35.09	34.28	34.56
Mozambique	40.3	39.03	36.57	36.6	36.36	35.16	34.26	33.53	33.16	32.84	31.5	31.7	30.13	31.46	31.71	31.98
Namibia	31.4	31.32	29.14	28.82	28.68	28.21	26	25.11	23.96	24.54	24.79	23.46	22.85	22.85	22.23	22.78
Swaziland	41.4	39.55	38.44	37.55	39.19	38.69	38.02	38.27	38.48	38.17	38.97	40.28	36.44	35.57	34.73	40.94
Zambia	48.9	48.85	47.71	48.4	47.6	49.01	48.52	45.54	43.22	42.17	34.47	36.61	33.38	30.83	30.72	32.99
Zimbabwe	59.4	56.12	58.32	61.83	63.5	63.16	60.58	60.42	61.66	69.08	65.62	63.89	63.69	64.55	65.85	67

Source: Medina and Schneider (2018)

Figure 1.1. Informal Economy Size in Southern African Countries from 2000 to 2015.

From the Figure 1 above, we can see that informality in Southern Africa is high and the majority of the countries in the study reported percentages of over 30%. On average, Zimbabwe is the highest with above 60%, Swaziland second at 39%, Mozambique and Malawi following with above 30% respectively. Southern African governments have a lot of work to reduce the barriers to formalisation. The enterprises that switch from informality to formality attains greater profit as well as value-added as equated to the ones that remains unregistered (Boly, 2017).

This study seeks to identify the challenges of informality and to determine the barriers to formalisation among the manufacturing MSEs. Furthermore, it seeks to identify the availability/status of the EE factors for the informal manufacturing MSEs and determine the importance of EE factors to formalisation of manufacturing MSEs. Lastly, the research determines the impact of formalisation on the business performance of manufacturing MSEs and assesses the Zimbabwe MSMEs Policy in driving formalisation of manufacturing MSEs.

2. Literature Review

2.1 What is an Entrepreneurial Ecosystem?

According to Mason & Brown (2014), an entrepreneurial ecosystem is "a set of interconnected entrepreneurial actors (both potential and existing), entrepreneurial organizations (e.g. firms, venture capitalists, business angels, banks), institutions (universities, public sector agencies, financial bodies) and entrepreneurial processes (e.g. the business birth rate, numbers of high growth firms, levels of 'blockbuster entrepreneurship', number of serial entrepreneurs, degree of sellout mentality within firms and levels of entrepreneurial ambition) which formally and informally coalesce to connect, mediate and govern the performance within the local entrepreneurial environment." "It is a set of interdependent actors and factors coordinated in such a way that they enable productive entrepreneurship" (Stam, 2015). However, Stam's definition is extensively used in academic research as it broadly covers the EE concept.

2.2 Entrepreneurial Ecosystems Theories

2.2.1 Network Theory

Purbasari *et al.*, (2019) defined network theory as "the mechanism and process of interaction in network structures to get results for individuals and groups." In a network,there are actors that create bonding that help to unite them. They type of connections are correlated to achieve a common goal. The actors are either connected directly or indirectly. Boggati & Halgin (2011) highlight that network theory considers the structure of the network, location of actors and identify ways they can produce outputs. Network theory has been considered to be relevant in the EE domain because it comprises of factors and actors that cooperate in a productive manner. The concept of ecosystem was developed from the network theory (Letaifa *et al.*, 2016). The theory can better be explained by looking at the interaction among organisations with matching characteristics. The network theory has become very significant in entrepreneurial literature and research circles. Purbasari *et al.*, (2019) state that using the network approach helps to identify and discover associations among actors so that value can be created.

2.2.2 Institutional Theory

The presence of institutions has actually enhanced the advancement of the society. In the academic literature, the institutional theory has helped to advance entrepreneurial research. Mason & Brown (2014) and Stam (2015) highlighted that any ecosystem is composed of formal and informal institutions. Isenberg (2010, 2011) has the same view and state the different types institutions that exist in entrepreneurial ecosystems and these are shown in the Figure 2.1 below.

Institutional theory	Bahrami and Evans (1995)	Neck et al. (2004)	Isenberg (2010, 2011)
Formal Institutions	Leader users	Incubators	Innovative products
	Universities and research institutions	Formal networks	Facilitating policies
	Private financing market	Spin-offs	Financing
	Support infrastructure	Physical infrastructure	Support infrastructure and institutions
Informal Institutions	A talent base	Informal networks	Human resources
	Entrepreneurial spirit	Culture	Culture

Figure 2.1: Institutional Theory and EE elements. ***Source:*** Fuentelsaz *et al.,* (2017)

Equally, formal and informal institutions are vital for the growth of a successful EE that fosters the formalisation of informal MSEs. Governments should put in place conducive formal institutions in the form of rules, regulations and other policies so that productive entrepreneurship takes place.

2.3 Definition of Informal Economy

According to IMF (2017), the informal economy, "comprises economic activities that circumvent costs and are excluded from the benefits and rights incorporated in laws and administrative rules covering property relationships, commercial licensing, labour contracts, torts, financial credit, and social systems". A study by ILO (2017) recognised the informal economy as "consisting of unregulated small-scale firms that include carpenters, shop owners, restaurant owners, and grocers, employing ten or less low-skilled employees, who works in dangerous conditions without social protection or health and safety measures at the workplace." Another definition by ILO (2016) states that "the informal economy are all economic activities, excluding illegal activities, by workers and economic units that are in law or in practice either not covered or insufficiently covered by formal arrangements".

2.4 Definition of Informal Entrepreneurship

Autio & Fu (2015) defined informal entrepreneurship as "active engagement and managing a new venture that produces or sells legitimate goods and services and is not registered with official authority." Likewise, Williams & Nadin (2013) defined informal entrepreneurship as "the process of engaging in paid production and selling of goods and services that are legitimate in all respects, but not declared to the state fortax and/or benefit purposes."

2.5 Definition of Micro and Small Enterprises

ILO (2017) took the perspective of number of employees to define MSEs as "firms with less than 10 or 50 workers and medium-sized enterprises as those with less than 100 or 250 workers." Using the World Bank Enterprise Survey, Williams & Kedir (2017) defined micro enterprises as "businesses with less than five workers." The European Union has defined micro and small business as "enterprises that employ at most 250 workers" (Stokes & Wilson, 2010). The description is based on headcounts, value of assets and revenue as guiding standards. The Zimbabwe Small Enterprises Development Corporation Amendment of 2011 defines micro enterprises to include entrepreneurs with without any employees or enterprises with a maximum of 5 employees, small enterprises with 6 to 30 or 40 employees subject to the sector and medium sized enterprises with 31 to 75 employees.

2.6 Informality and MSEs Vulnerability

Feige (2016) states that at company level, informality comprises entirely the enterprises and entrepreneurs that manufacture lawful goods and services which are however not compliant with the country's administrative laws and protocols, employment and fiscal regulations. The United National Industrial Development Organisation and Unite Nations Office of Drugs and Crime (2012) highlight that SMEs are more likely to suffer from bureaucratic bribery compared to the well- established ones. They lack of financial capacity to exercise influence over the relatedgovernment institutions and officials that control their activities. In addition, they are also susceptible to corruption at the hands of the state officials due to limited negotiating power to deny requests for illicit payments. Inadequate legal support is another challenge. The International Labour Organization (2018) cited risky and vulnerable work conditions as coupled with ill-paid wages as other challenges faced by the informal entrepreneurs. In terms of employment vulnerability rate, the SSA was projected at 72% in 2017 with 36% extreme working poverty in the whole African country (ILO, 2018). In most SSA countries, women are at the receiving end from the negative consequences of informality and there is a gender gap of above 70%. The majority of the vulnerable groups are in the informal sector and with the consequences of Covid 19 pandemic, Africa's total informal employment and GDP has risen (ILO, 2020).

2.7 Informal Economy Theories

The *modernist perspective* according to Packard (2007) states that the presence of the informal economy gestured "backwardness" and "underdevelopment" whereas formal entrepreneurship indicated "progression," "growth" and "improvement". It assumes that the IE will eventually be engrossed into the formal economy with the passing of time. The *structuralist perspective* regards the IE as a sector of the economy that relies on the regulated economy. The assumption is lack of a clear separation between the mainstream economy and the second economy. The *neo-liberal perspective* is premised upon the assumption that high business registration costs and high bureaucracy are the key reasons for operating in the hidden economy. They prefer conduct their business informally so that they circumvent registration costs (Biles, 2009). The *post-structuralist perspective* theorists who include Roland Barthes and Michael Foucault state that the hidden economic activities occur in pursuing a broad social band that is external to the economic activities. The financial profit is not more important to the players than other social reasons.

3. Materials and Methods

This study adopted a pragmatism research philosophy which takes a mixed methods research design. The total population for the quantitative study was 2000 informal enterprises. There is no clear sampling frame for the informal enterprises operating at the two clusters and the researchers used the population used by previous researchers at the two clusters. A self-administered closed ended questionnaire survey was used to collect data from a sample of 300 participants operating at Mbare-Magaba Siyaso and Glenview Area 8 Home Industry Complex clusters. This study considered a value of at least 0.6 plus Cronbanch's alpha coefficient as the reliable values for positive internal consistency of the questionnaire. The researcher used SPSS to calculate the coefficient (α) and this was done for each section of the questionnaire to demonstrate the internal consistency of each subcategory. The availability of survey was communicated through a pilot study of the questionnaires. Correlation tests were also conducted in this research. A stratified random sampling method was used to select the sample in the quantitative research. Data was analysed using the Statistical Package for Social Sciences (SPSS) Version 22 software. The researcher summarised details about the participants for this study using descriptive statistics in the form of pie charts, histograms and tables. For the qualitative research, the population was made up of five directors within the Ministry of Women Affairs, Community, Small and Medium Enterprises Development and a sample of 2 directors was used for the study. Purposive sampling was used to select the interviewees for the qualitative study. Qualitative data was analysed using content analysis. The validity of qualitative study was ensured through voluntary participation of interviewees and the researcher requested to record the interview session so as not to lose the data. The

participants were not given incentives to participate in the study. The researchers observed ethical principles during data collection phase and the principle include anonymity and confidentially, voluntary participation and informed consent.

4. Results and Discussions

4.1. Response Rate

The researcher distributed 300 total questionnaires at the two clusters that were under the focus of this study. Out of the 300 distributed questionnaires, 183 questionnaires were returned and used in data analysis and presentation, therefore 117 questionnaires were not returned. In terms of percentage, the overall response is 61% which is a good response rate for the research findings to be generalised. The researcher attributes the positive response rate to self-administration of the questionnaire and frequent visiting of the clusters for data collection.

4.2.Reliability of the research instrument/Questionnaire

The Cronbanch's Alpha was used to test the reliability of the questionnaire used in this survey. The Figure 4.1 below shows a good internal consistence among the variables in the questionnaire.

Table 4.1. Cronbanch's Alpha Reliability Test Results

Variable	Cronbanch's Alpha	N of Items
Challenges of informality	0.933	7
Barriers to formalisation	0.782	9
Availability of Entrepreneurial Ecosystem Factors	0.613	10
Importance of Entrepreneurial Ecosystem Factors	0.774	10
Impact of Formalisation on Business Performance	0.876	7
Overall Cronbanch's Alpha	0.733	43

4.3 Respondents' Demographic Characteristics for Quantitative Research

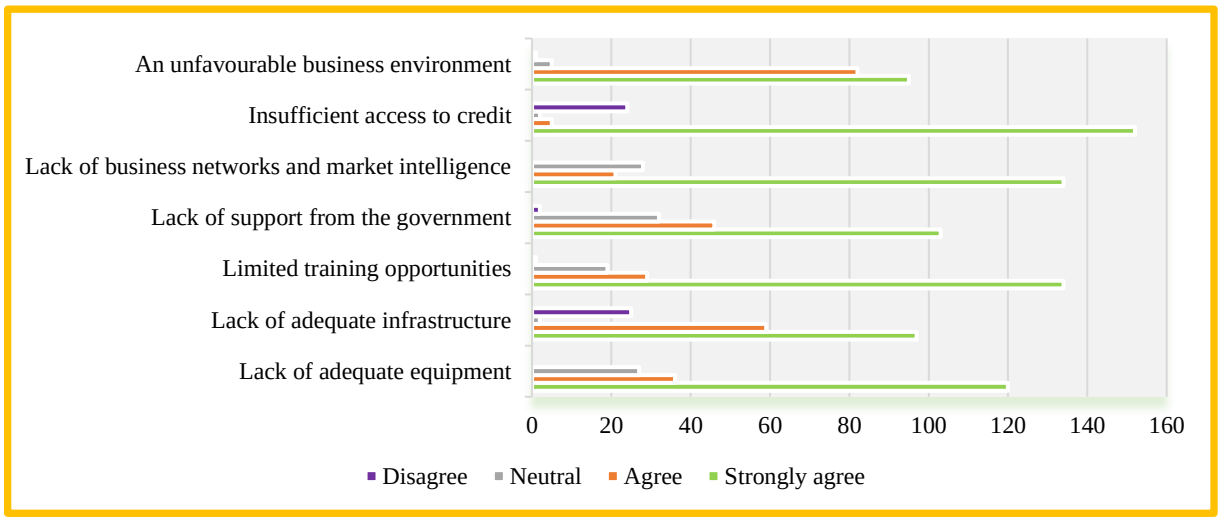
Table 4.2. Demographic Characteristics

Demographic characteristic	Items	Frequencies
Sex	Male	143
	Female	40
Age Ranges	Below 20	3
	21-30 years	45
	31-40 years	73
	41-50	43
	51 and above	19
Highest Level of Education	Primary	15
	Secondary	92
	Certificate	43
	Diploma	19
	Degree	14
Respondents' Position in the Business	Owner	44
	Owner and Manager	40
	Manager	42

Demographic characteristic	Items	Frequencies
	Employee	57

The Table 4.2 above shows the demographic characteristics of the study participants. The results revealed that males dominate the informal manufacturing business activities. This can be attributed to hard work involved in manufacturing which most females find it difficult to execute. In addition,the findings also revealed that the majority of the participants were aged between 31- 40. This shows that the young generation is more involved in informal manufacturing businesses. The secondary educationdominated the highest level of education. In addition, most respondents indicated that they are employees with a frequency of 57, followed by owners with frequency of 44, managers with frequency of 42 and owner and manager with frequency of 40.

4.4 Challenges of Informality



Source: Research data (2022)

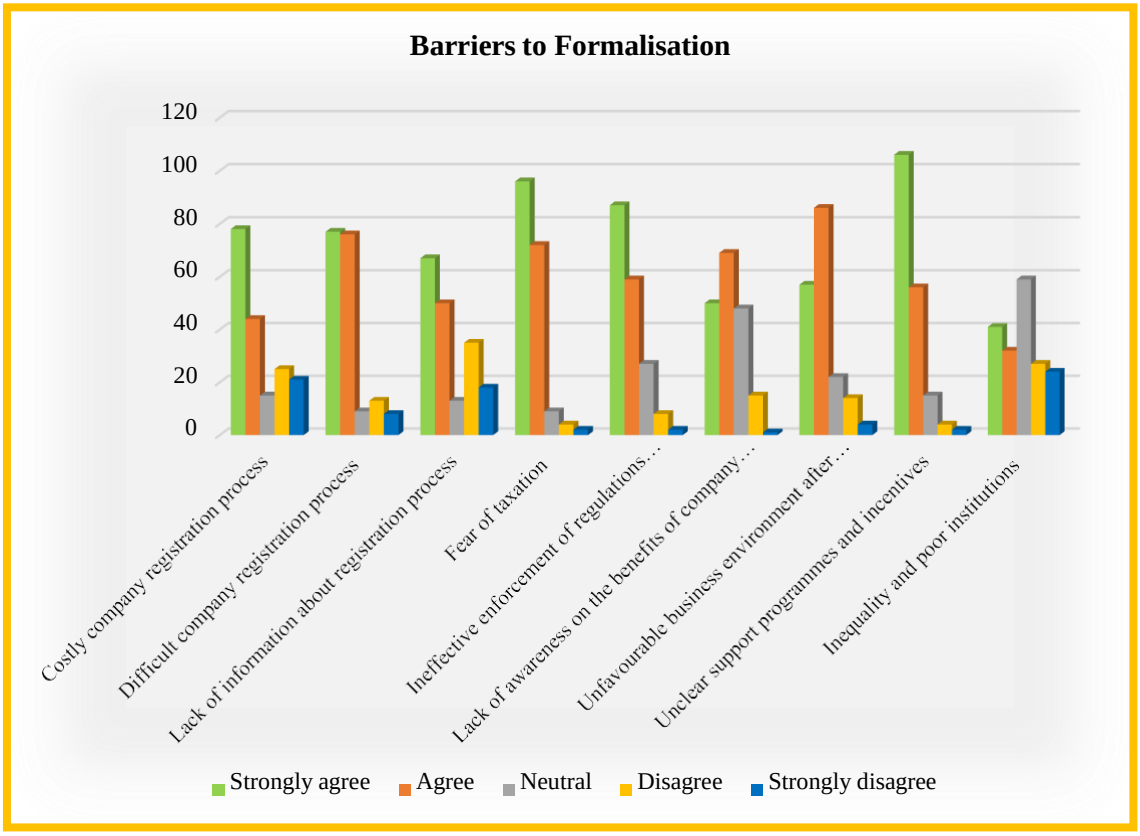
Figure 4.1. Challenges of Informality

The Figure 4.1 above shows that the majority of the respondents strongly agree that they are facing challenges pertaining to the business environment they are working within, access to finance, business networks and market, government support, inability to access training opportunities, lackof infrastructure and equipment. The challenges identified play a significant role in inhibiting the transition to formality.

4.5. Barriers to Formalisation

4.5.1 Analysis of responses on aspect of the barriers to formalisation.

This study collected data on the barriers to formalisation by the manufacturing MSEs in Harare that are located in Mbare-Magaba Siyaso and Glenview home industry complex. Figure 4.2 below shows the results on from the questionnaire survey.



Source: Research data (2022)

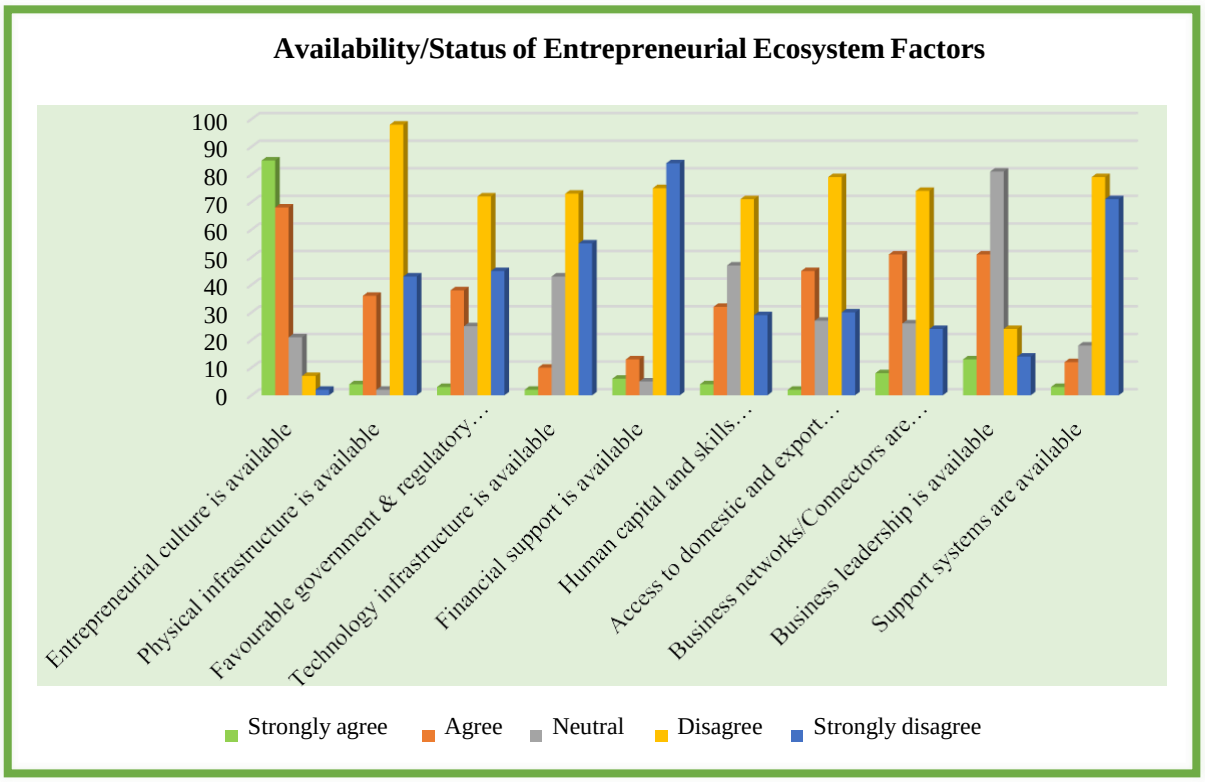
Figure 4.2: Barriers to Formalisation

With regard to costly company registration process, the majority of respondents strongly agree that it as expensive for them to register the company. In terms of difficult company registration process, most respondents agree that it is a key factor contributing much for not registering their business. A few of them disagree and strongly disagree that difficult company registration process is key barrier.

Furthermore, the majority of the informal manufacturers indicated that lack of information about registration has been a barriers to business registration. Fear of taxation has been considered as the major hindrance to formalisation by the study participants. They fear paying government tax if they register their businesses.

Additionally, the majority of the respondents strongly agree that unclear support programmes and incentives is a deterrent to business registration. Moreover, ineffective enforcement of regulations concerning enterprise registration, lack of awareness on the benefits of company registration and unfavourable business environment after registration were all considered as barriers to business registration. Interesting to note is the fact that on the influence of inequality and poor institutions to business registration, the majority were neutral.

4.6 Availability/Status of Entrepreneurial Ecosystem Factors



Source: Research data (2022)

Figure 4.3. Status of Entrepreneurial Ecosystem Factors

With regards to the availability of favourable government and regulatory framework, the results show that the majority either disagree or strongly disagree on that aspect. Furthermore, participants were asked to indicate the extent to which they agree about theavailability of finance in their business. The results are very clear that access to finance a big challenge to the informal manufacturers. Most of the respondents are of the view that human capital and skills development is lacking within their business ecosystem. Although they are making their products, they need continuous skills-set upgrade to meet changing current needs. In addition, the majority of respondents either strongly disagree or disagree about the availability of access to market. The domestic and export market access is a big challenge to the them. In terms of access to business networks or connectors, the majority disagree that they have excellent connections. Most of the respondents were neutral to the availability of business leadership within their business. However, more strongly agree and agree to the presence of business leadership compared to those who disagree and strongly disagree. Support systems were said to be unavailable to the informal metal fabricators and furniture manufacturers.

4.7 The Importance of Entrepreneurial Ecosystems Factors to Formalisation

This study sought to determine and rank the importance ten entrepreneurial ecosystem factors to formalisation of the manufacturing MSEs. On a 5 point Likert scale, the respondents were asked to rate each factor in terms of whether they think it is extremely important, important, neutral, unimportant and extremely unimportant to their decision to register the business.

The Figure 4.4 below shows the results on importance of the 10 EE factors to business registration. The results on the chart below shows that access to financial support, physical infrastructure, access to domestic and export markets and support systems respectively and in that order, are the most rated EE factors in formalising their businesses.

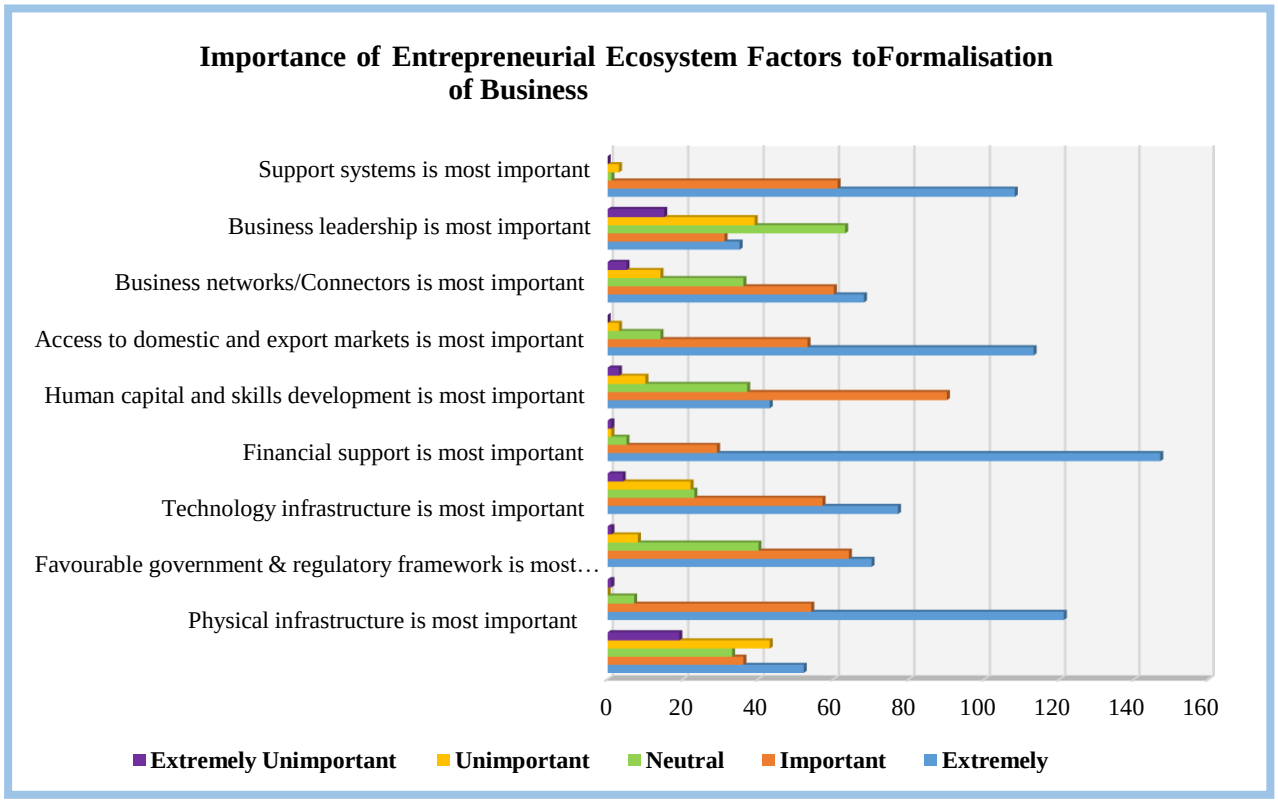
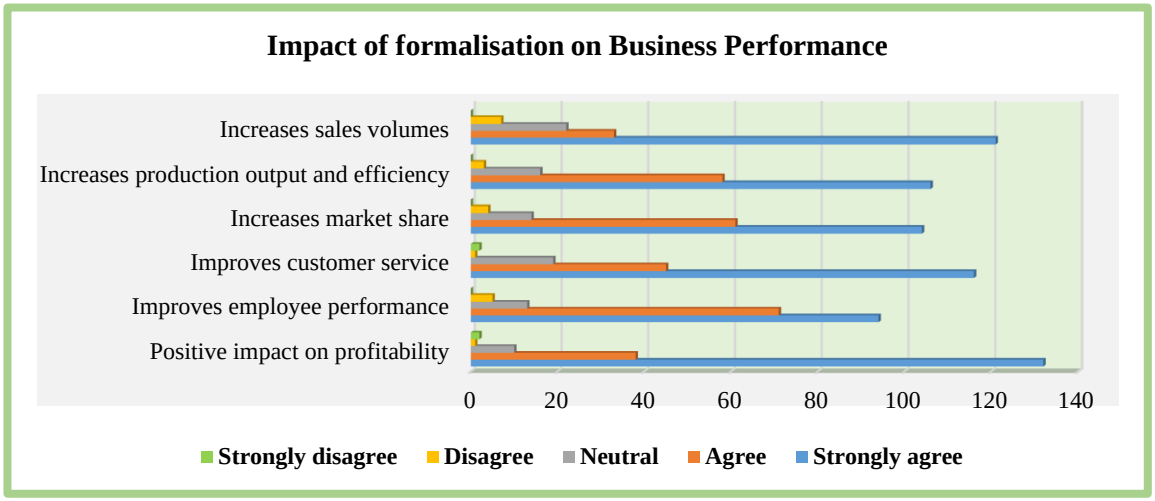


Figure 4.4: Importance of Entrepreneurial Ecosystem Factors **Source:** Research data (2022)

4.8 Analysis of responses on the impact of formalisation on business performance.
This study also sought to find out from the viewpoint of the informal business enterprises if registering their businesses has any influence on the performance of their businesses. On a 5-point Likert scale, the respondents provided their perspective on seven measures of business performance. The results are presented in the Figure 4.5 below.



Source*:* Research data

Figure 4.5. Impact of formalisation on business performance

The results on Figure 4.5 above shows that the majority of the participants strongly agree and agree respectively with the positive impact of the measures of business performance after registering their companies. An incredibly low percentage of the respondents either disagree or strongly disagree that their business performance will improve after formalisation of the business.

4.8 Content Analysis of Qualitative Data

The researcher used content analysis to analyse qualitative data collected through interviews. This was done by using a descriptive manner in contextualising the research findings. Word for word quotes from the directors interviewed were regarded as very important in this study. The interview questions were designed from the current Zimbabwe Micro, Small and Medium Enterprises (MSMEs) policy framework. The following section shows the findings from the interviews conducted at the Ministry.

4.8.1 The simplification of tax laws and administration to ensure compliancy and formalisation by MSMEs.

The study sought to find out the efforts made by the government through the MSMEs policy in simplifying tax laws and their administration so as to drive formalisation. The interviewees' responses on this enabling regulatory and legal framework are provided below. R1 means respondent number 1 and R2 means Respondent number 2.

R1: *"The Ministry of Women Affairs, Community, Small and Medium Enterprises Development (MWCSMEsD) does not administer the Finance Act, but it developed by the Ministry of Finance. The administration part is done by ZIMRA. However, the Ministry of Women Affairs, Community, Small and Medium Enterprises Development is doing the lobbying for simplification of the tax systems."*

The interviewee stressed the point that the policy framework is a government policy not developed by the Ministry. The Ministry is currently engaging other government authorities like ZIMRA to simplify the taxes and their administration.

R1: *"The Ministry of Women Affairs, Community, Small and Medium Enterprises Development does not end in lobbying, but it also conducts education programmes in collaboration with ZIMRA. ZIMRA explains the tax laws and obligations that are expected of MSMEs in paying taxes. The ministry and ZIMRA are there together in spreading the gospel of tax simplification."*

The interviewee highlighted that some training programmes have been conducted in trying to educate the small businesses on tax issues. However, the majority of the informal business may not be aware of these programmes and there is need for improving publicity in this regard.

R2: *"The government has introduced presumptive taxes for MSMEs through the Ministry of Finance. There is no need to keep books of accounts and these allows the MSMEs to pay taxes amount say per quarter depending on the sector of the industry. The amounts are fixed despite revenue generated during that period. The presumptive taxes are however favourable to a few MSMEs who generate high revenue but most of the informal businesses find it difficult to pay the taxes due to low revenue."*

The government has made positive move towards simplification of the tax system as stated by the interviewee above. However, for most MSMEs, the presumptive taxes have not been received with joy as they do not earn much revenue. The disadvantage is that whether they generate more or little revenue, they are required to pay a fixed tax amount which becomes a burden to them. Furthermore, the MWCSMEsD needs to create awareness to the MSMEs on the presence of presumptive taxes as most of them are not aware. The advantages and disadvantages of such taxes need to be explained clearly.

R2: *"The ZIMRA annual reports for 2019 states that compliance is still very low despite the introduction of the presumptive taxes. MSMEs that have filed compliance was about 50% but payment compliant was around 30%. The challenges include ignorance and outright disobedience and low revenue."*

The low percentage of paying compliant clearly shows that it is because of fearing loss of income. In terms of ignorance, the government through the MWCSMEsD should explain the advantage of complying with tax laws compared to disobeying the laws.

4.8.2 Collaboration between local authorities and MSMEs in reviewing by-laws that affect the operations of MSEs.

The study also sought to discover the extent to which the local authorities have collaborated with the MSMEs in reviewing some of the by-laws that affect business activities of MSEs. Information obtained during the interviews include the following:

R1: *"The government through the MWCSMEsD is working with local authorities in trying to bring the MSMEs complying with the by-laws. From time to time, the local authorities are invited to ministry programmes to explain the key by laws and also quite a number of meetings are held with the local authorities to come up with a harmonised model by law that promote uniformity among the local authorities with little variations."*

Noteworthy is the fact that no specific by-laws that promote the formalisation of informal MSMEs are in the public domain. There is need to invest in publicity and make it clear on the ways in which the small businesses operations are enhanced. The MSMEs need to be aware of the by-laws that have been reviewed in creating harmonised by-laws and the impact made to the registration process of MSMEs.

R2: "*The challenge with most local authorities is lack of commitment to implement things that would have been agreed. This can be attributed to polarisation of local authorities in terms of political circles. It is difficult to separate politics and economic development and the polarisation is a setback in achieving the policy goals."*

From the respondent above, it can be discovered that there are some divergent views between the government policy and the local authorities. There seems to be lack of unity in driving the common cause and issues of politics are not being separated from economic development matters.

4.8.3 Measures that have been taken to enhance the capacity of financial institutions critical to the development of MSMEs.

This study also sought to find out the measures that have been taken to ensure access to finance for MSMEs. The interviewees provided the following responses:

R2: *"The government is in a process of capacitating institutions like the Small and Medium Enterprises Development Corporations (SMEDCO), Zimbabwe Women Microfinance Bank and Empower Bank. These are the institutions getting capitalisation from the treasury. Every year these institutions get an allocation from the treasury through the Ministry."*

From the responses given by the interviewee above, it can be derived that the government is making some efforts to capacitate the government institutions responsible for financing MSMEs. It however seems as if the funds are not adequate enough as the data from quantitative research showed that most informal manufacturing businesses are lacking financial support in their businesses.

R1: *"The institutions got ZWL 500 million stimulus package for on lending to MSMEs and some have received the funds although is not enough to fund all small businesses."*

Regarding the stimulus package, the government has made efforts in trying to fund some SMEs although the money is not given for free. It is for on lending as stated by the interviewee R1 above. The findings from the quantitative data analysis showed that financial support is not currently available in their businesses. The information about the stimulus package for MSMEs is not known by most informal enterprises and it is usually accessed by the registered SMEs. There are some challenges being faced in trying to provide financial support to the informal businesses as highlighted below.

R1: "*Biggest challenges are that most SMEs are not bankable, they do not keep records and they have a culture of misuse of funds. In addition, they have a culture of not paying funds. What then happens is that financial institutions then end up asking for collateral security, which the small businesses do not have."*

The conditions highlighted above makes it hard for the informal businesses to access funding from the government. Government can assist these unregistered businesses by acting as the guarantee of the debt finance they access because they lack the collateral security. The culture of misuse of funds and not paying back money should be addressed by the informal businesses themselves.

R2: *"Stimulus package for MSMEs provided to institutions like SMEDCO are revolving funds. The MSMEs are supposed to pay back the money in order for the recapitalisation of the institutions. Government used to give them money, but they could not pay back."*
The unregistered MSMEs should have register their businesses in order to access the money. The lack of awareness about the availability of the funds is hindering the access to financial support as they could not register their business in anticipation of accessing the funds.

4.8.4 Assistance to informal MSMEs for accessing local and export markets for their products.
The researcher also sought to find out the kind of assistance given to the MSMEs to ensure that they access local and export markets. The following were the responses obtained during the interview sessions.
R2: *"The small businesses have been provided with an opportunity to exhibit at Expos like the Zimbabwe International Trade Fair and the Harare Agricultural Show. Around 20 enterprises are given the opportunity to market their products at the mentioned expos. There is also the SMEs Expo usually held in October every year."*
R1: *"Opportunities are also available for regional and international exhibitions. Examples of these exhibitions include the Lusaka Agricultural Show, the Consumer Fair in Botswana and the Global Expo. However, there is lack of resources to make sure that a good number of the SMEs attend the regional and international Expos."*
The responses above show that from the government perspective, some efforts are being done to try to create market spaces for small businesses. However, it was not made clear on what criteria is being used to choose the participants at the expos. A few informal MSMEs are participating at the different expos.

4.8.5 Attraction of private investors to develop workspace and infrastructure for MSMEs under different arrangements.
The study also sought to obtain information about whether the government and the Ministry have attracted private investment to help expand and build workspace and other infrastructure. The Zimbabwe MSMEs policy framework indicated that this goal would be achieved through different arrangement with the private sector.
R1: *"The development of workspace for the MSMEs is a very big challenge that requires a lot of investment. There has been little infrastructure development over the past 20 years. However, the government through the MWCSMEsD is engaging the private sector like Old Mutual for the construction of workspace."*
R2: *"Property owners are being encouraged to plan with the SMEs in mind and some are constructing factory shells industrial clusters like Magaba-Mbare Siyaso industrial area."*
The interviewees indicated that provision of adequate infrastructure is still a difficult task for the government and the Ministry. A kind plea has been made for the private property owners to build with a long-term mindset of accommodating the SMEs who lacks enough workspace and infrastructure.

4.8.6 Appropriate training programmes developed for MSMEs in collaboration with institutions of higher learning, technical colleges and vocational training.
The researcher also sought to get information from the MWCSMEs development about any customised training programmes designed in partnership with the institutions of higher education and the impact made so far in that regard. Below are the responses from the interviewees:
R2:*"The Ministry is conducting some training programmes in collaboration with the private sector and public institutions. For examples Chinhoyi University of Technology (CUT) has collaborated with the Ministry to train SMEs. However, the challenge is lack finance to fund the trainings."*
R1: *"There is lack of regular evaluation and documentation on the trainings conducted for the MSMEs. In addition to that, there is lack of finance to spearhead the training programmes and this has resulted in less impact noticed on the ground as we speak."*

Training programmes are said to be conducted in collaboration with some private sector and public sector organisations. However, there is lack of specifics on the key trainings conducted so far except that Chinhoyi University of Technology has been training some SMEs in Mashonaland West Province. One other challenge identified is the lack of documentation and evaluation of the impact made by the training initiatives.

4.8.7 Policy initiatives being undertaken to support and strengthen the capacity of MSMEs to carry out Research and Development (R&D)

The study also sought to find out information about some initiatives that the Ministry is undertaking or has undertaken to support MSMEs research and development.

R2: "*The Ministry is promoting R&D through awareness programmes and through collaboration with the Research Council of Zimbabwe. However, economic challenges act as barriers to witnessing meaningful R&D results."*

R1: *"There is a general perception that the MSMEs do not take R&D seriously as they have other pressing challenges and one other thing is that there is lack of documentation on the R&D efforts."*

The responses obtained above point to the fact that economic challenges are inhibiting the R&D support initiatives. The small enterprises themselves are said to be not taking their research and development efforts seriously.

4.8.8 Appropriate technological facilities such as technology parks, innovation hubs and technology service centres established in selected provinces.

The study also sought to find out on the suitable technology facilities, if any, established in selected provinces for access by the MSMEs. The interviewees of this qualitative research revealed the following information.

R1: *"Through the development of clusters, the Ministry is trying to ensure the access of ICTs facilities. However, the access to ICTs pillar has been affected by the reconfiguration of the Ministry where the technical services is now under the Ministry of Higher and Tertiary Education, Science and Technology Development."*

R2: *"The Ministry is also taking some SMEs to exhibitions and business match making programmes."*

The data obtained above identified the development of industrial clusters as one way in which the Ministry is trying to promote access to production technologies. The reconfiguration of the technical services from the MWCSMEsD to the Ministry of Higher and Tertiary Education, Science and Technology Development has been considered as one thing that has affected the drive to achieve goals for this policy strategic pillar.

5. Discussions

The study has shown that the informal manufacturing MSEs in Zimbabwe are facing many challenges as a results of being informal. These enterprises also encounter a lot of barriers in a bid to register their business and these include difficult and costly registration process, unclear support programmes and incentives, high taxation after registration and unfavourable regulatory framework among other.

In terms of the availability of entrepreneurial ecosystem factors, the results have shown that most of the factors are unavailable except for entrepreneurial culture.

The ranking of the entrepreneurial ecosystem factors for the registration of the business has shown that the top key factors are: access to financial support, access to physical infrastructure, access to support systems, access to domestic and export markets and access to favourable legal and regulatory framework. Government need to ensure the availability of the most important factors in order to witness transitioning to formality.

Mahembe (2011) carried out a study on the barriers to formalisation by small enterprises and found that there are very few businesses in the informal economy that are aware of the registration process and government support programmes. Lack of information has been attributed to the vast number of informal enterprises that still remain in the informal sector.

In another study by Ntema & Marais (2012) high informalisation in most African countries was argued to be as a result of inadequate business skills and lack of education. The lack of unclear support programmes by the government has also been identified as the key barrier to business registration (Ibid).

A study by Chavis *et al.,* (2010) that used the World Bank Enterprise Survey (2006 -2009) for 123 nations revealed that around 31% of the small firms they studied considered access to finance as a key constraint. The results are in line with the findings by Mupambireyi *et al.,* (2014) that found that the entrepreneurs in the informal sector operates in dilapidated infrastructure. They lack roof quality and adequate workspaces. Lack of education and training was cited in a study carried in South Africa by Ngek & van Aardt Smit (2013) as one of the main reason for SME failures.

A study by Stam (2015) used the factor analysis which showed that the framework conditions have a major impact on the success of an EE compared to the systematic conditions.

The researcher has proposed a home grown entrepreneurial ecosystem framework for spearheading the formalisation process.

The framework is very appropriate in providing an enabling entrepreneurial ecosystem that will result in the voluntary and gradual formalisation of informal manufacturing MSEs. It looks at the key factors or pillars of an entrepreneurial ecosystem and links each to actor(s). It was developed considering the rankings on the important entrepreneurial ecosystem factors for the registration of businesses.

5.1 Uniqueness of the Proposed EE Framework from other existing EE frameworks

The existing frameworks are just universal and they do not speak to a particular entrepreneurial. There is need to develop different sets of EE frameworks for entrepreneurs operating in diverse industries. The existing frameworks also did not show clear roles and interactions among the actors. Developing home grown or localised entrepreneurial ecosystems that addresses the drawbacks of existing universal model helps to advance literature.

The world cannot adopt have an EE framework that has been developed for other context (Isenberg, 2011). Formalisation is affected by various factors for in different African countries hence the need for customised frameworks. It has actors like technology community and local authorities that are not found in other frameworks. An improved environment for the voluntary and gradual formalisation of manufacturing MSEs is created.

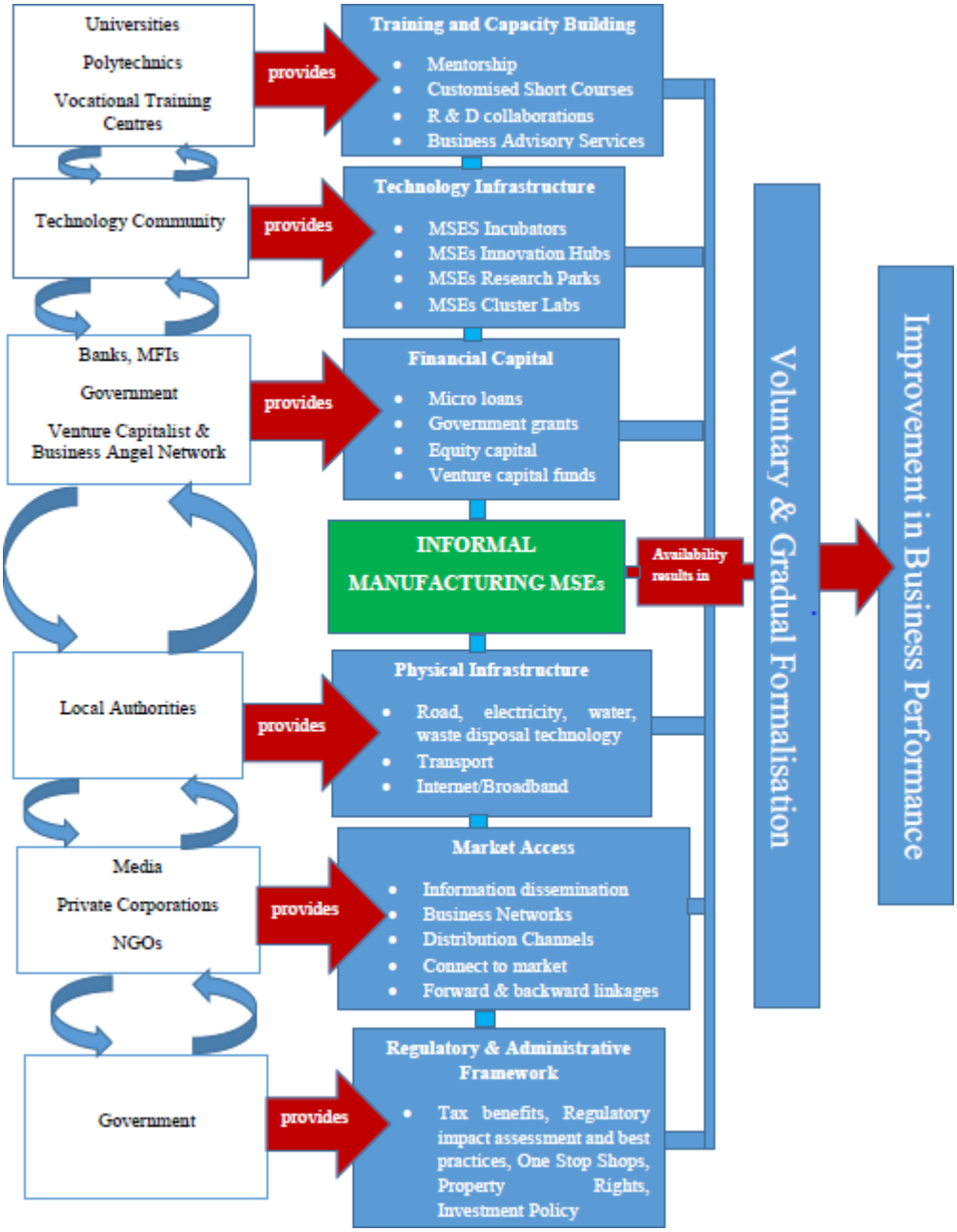


Figure 5.1. Proposed EE Framework **Source:** Researcher's Own Compilation (2022).

The framework consist of actors and factor that interact together in driving formalisation. The informal enterprise is at the centre of the framework as indicated by the EE literature. New actors not common in previous EE frameworks are the technology community and local authorities. The framework is tailor-made to suit the Zimbabwean context as it is not a universal framework.

The presence of the EE factors as provided by the different actors will result in formalisation. Informal manufacturing MSEs can witness improvement in business performance after formalisation. Below is a table that shows each actor's roles and justification for the roles.

Table 5. 1. Actors' roles and justification

Actor	Role(s)	Justification (s) for the actor(s) and their roles in the proposed framework
Universities, Polytechnics and Vocational Training Centres	Provision of training and capacity building to informal manufacturing MSEs. The tertiary institutions provide: • Tailor-made short courses • Mentorship • Research and development collaborations • Business advisory services and • Micro and Small Enterprises Conferences • Business advisory services	The informal manufacturing MSEs are lacking key skills in their businesses. The skills include business management, marketing, accounting, finance, change management and business planning. It is the role of institutions of higher learning to provide training to the informal businesses so that they improve business performance. Access to these key services will drive voluntary and gradual formalisation.
Technology Community	Responsible for providing access to technology infrastructure for MSEs. Some of the proposed infrastructure include: • MSEs incubators • MSEs innovation hubs • MSEs research parks and technology packs • MSEs cluster labs	The concept of technology community has not been well embraced in academic research circles and in entrepreneurial ecosystem literature. The government of Zimbabwe and the private institutions have not constructed technology infrastructure in the form of MSEs incubators, innovation hubs, research parks, technology parks, cluster labs and techno centres accessible particularly by informal manufacturing MSEs. Evidence from the primary data collected during the quantitative research revealed that the informal manufacturing sector faces challenges in accessing technology infrastructure.
Banks **Microfinance Institutions** **Government** **Business Angel Network** **Venture Capitalist Network**	These are responsible for providing financial capital/support to the informal manufacturing MSEs in Harare. The capital is the form of equity and debt. It includes: • Micro loans • Government grants • Equity capital • Venture capital • Crowd funding • Seed capital	Despite the government effort to provide access to finance, the huge informal sector still has problems in accessing financial capital. The outcomes from the quantitative survey revealed that the majority regards financial support as not available and it was ranked first in driving business registration if made available.
Local Authorities	In the proposed EE framework, local authorities have a role to play in helping formalisation by the informal manufacturers. They are responsible for providing infrastructure in the form of: • Quality roads • Water • Electricity • Waste disposal technology • Transport facilities • Internet access at clusters	The role played by local authorities in the development of an enabling entrepreneurial ecosystem for the formalisation of informal manufacturing MSEs cannot be undermined. The findings from the research revealed that quality infrastructure is currently not available.

Actor	Role(s)	Justification (s) for the actor(s) and their roles in the proposed framework
Media **Private corporation** **Non-Government Organisations (NGOs)**	These organisations are responsible for: • Disseminating information about the business activities of informal manufacturers • Providing business networks • Act as distribution channels • Connecting informal enterprises to the market • Providing forward and backward value chain linkages	This study included the media in the proposed strategy as they play a key role in information dissemination. Private corporations have established business networks that informal business can benefit from. NGOs can link the informal businesses to local and export markets.
Government	The government is responsible for providing a favourable regulatory and administrative framework through: • Offering tax benefits for formalisation • Regulatory impact assessment • Regulatory best practices • One Stop Shops • Property rights • Investment Policy Framework	The findings from the quantitative research found that there is a lack of a favourable regulatory and administrative framework for the informal sector. A favourable regulatory and legal framework was ranked fifth in terms of driving business registration if made available. Government plays the role of developing the regulations.

The successful implementation of the EE framework on Figure 5.1 is expected to result in the formalisation and improvement in performance of the informal manufacturing MSEs in Harare.

5. Recommendations and conclusion

The government should embark on creating awareness on the advantages of operating a formally registered business compared to an unregistered business. Furthermore, some incentives should be provided to the informal enterprises that voluntarily transition to formality. The incentives shouldinclude tax holiday, availing of credit facilities at favourable rates, among others. Attention shouldbe put on removing disincentives but rather make sure that incentive through access to different services is guaranteed. The Zimbabwean government should reduce administrative barriers during the registration process. The government should introduce One Stop Shops (OSSs) for informal business where they access key government services. This will have a significant contribution in driving voluntary andgradual formalisation if services are easily accessible and process made easier. Registration fees for informal MSEs should also be minimised.

Tax laws should be simplified in order to ensure a business-friendly environment for the registered businesses. Retrospective taxes should be avoided for voluntarily formalised MSEs. The government and local authorities should minimises excessive licensing and statutory requirementfor the informal businesses. During policy formulation on formalisation, the government should engage all key stakeholders including the informal MSEs themselves for their input. Moreover, 'one-size-fit-all' kind of policies should be avoided. Entrepreneurs in eachsector of the economy have their special needs that should be distinguished from the needs of operators in other sectors. Therefore, monolithic policy framework is not likely to serve the needsof diverse groups of entrepreneurs. Policy measures should be tailor made to suit different groups of informal entrepreneurs. Hence, appropriate policies should be designed for different types of operators rather than adopting a 'one-size-fits-all' approach. A monolithic policy cannot be adequate in addressing of different informal sectors and entrepreneurs.

Local Authority Service Centres (LASCs) should be established so that the informal MSEs will access key services offered by the city councils. The councils have a big role in the business activities by the unregistered enterprises as they enact important by-laws. The role played by local authorities in

the formalisation process cannot be undermined. Finally, Business Forums and Industry Association Programmes for MSEs should be developed so that there is regular contact and interaction between the informal MSEs and policy makers andother stakeholders. Through these platforms, ideas and obstacles to formalisation are shared in order to develop lasting solutions to challenges.

The conclusion that can be made is that the Zimbabwe informal manufacturing MSEs can take a long time to join the mainstream economy if no immediate solutions are provided through government policy. Policies should target reducing the challenges faced by being informal and also eliminate the barriers to business registration. Most of the identified challenges and barriers can be attributed to a lack of support structures within the ecosystem.

The government of Zimbabwe need to open OSSs for informal MSEs where they can access key services and this has a potential of speeding up the registration process. The legal and regulatory frameworks should favour the informal MSEs. To sum it up, formalisation has a positive impact to business success and the barriers and challenges negatively affect the performance of the businesses in the informal sector.

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Sustainable transportation planning in the context of a socioeconomically disadvantaged urban community

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Abstract. The San Jose neighbourhood of Albuquerque, New Mexico, U.S.A., is one of the most socioeconomically disadvantaged neighbourhoods in the nation. As is typical of such areas, it is subjected to a disproportionate share of the costs of the city's transportation system, while receiving very few of the system's benefits. This paper examines the major obstacles to the development of an environmentally and socioeconomically sustainable transportation plan for the neighbourhood. It then outlines a planning process that can assist the community to overcome these obstacles.

Keywords: *Sustainable transportation, transportation planning, land use planning, environmental justice*.

1. Introduction

A key component in the pursuit of sustainability is sustainable transportation. Globally, the transportation sector directly accounts for a significant share of carbon emissions: 7,7 Gt of a total of 36,3 Gt CO_2 (21.2%) of energy-related emissions. [1] In addition, transportation contributes a significant proportion of air and water pollutants, and transportation infrastructure causes major disruptions to natural and built environments. [2] In the U.S.A., adverse environmental, social, and economic impacts from transportation projects have historically fallen disproportionately on socioeconomically disadvantaged communities, especially those of racial and ethnic minority status. [3][4][5][6] The fundamental tenets of sustainability require that transportation planning take into account both environmental and socioeconomic impacts and strive for an equitable distribution of positive as well as negative outcomes. [7]

Recognizing the need to pursue equity in the outcomes of governmental planning processes, environmental justice (EJ) was formalized as an important policy objective by Executive Order 12898, which was issued by the Office of the President of the United States of America on February 16, 1994. This policy was incorporated in the guidance for transportation project planning by the U.S. Department of Transportation (DOT):

DOT incorporates EJ and equity principles into all transportation planning and decision-making processes and project-specific environmental reviews.

The Department's guiding EJ principles are briefly summarized as follows:

- To ensure the full and fair participation by all potentially affected communities in the transportation decision-making process;

- To avoid, minimize, or mitigate disproportionately high and adverse human health and environmental effects, including social and economic effects, on minority or low-income populations; and
- To prevent the denial of, reduction in, or significant delay in the receipt of benefits by minority or low-income populations. [8]

However, even though environmental justice has been a broad policy objective of the U.S. government and a specific objective of the Department of Transportation for close to thirty years, ensuring EJ compliance has been challenging. [9]

This paper discusses the transportation challenges faced by an urban, socioeconomically disadvantaged community

2. Characteristics of the San Jose neighbourhood in Albuquerque, New Mexico

The San Jose neighbourhood is located in Albuquerque's southeast quadrant. Its boundaries are defined by major transportation corridors: it is bounded to the east by Interstate 25, to the west by the tracks of the Burlington Northern and Santa Fe (FNSF) railroad tracks, to the south by Rio Bravo Boulevard, and to the north by Gibson and Broadway Boulevards and Kathryn Avenue (Figure 1). The northern half of the neighbourhood is primarily residential, while the southern portion features largely industrial uses (the areas adjacent to the residential areas are zoned for heavy industry).

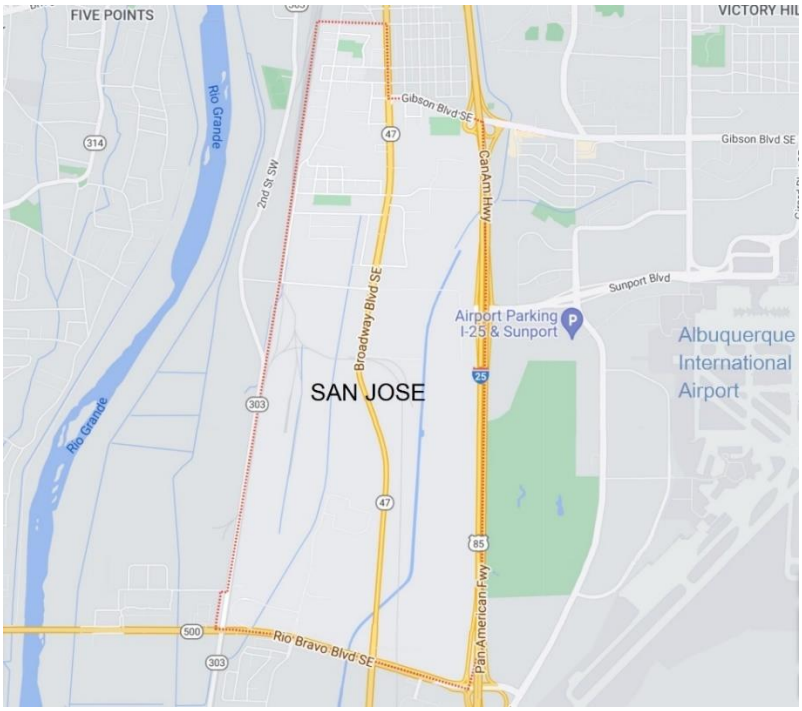

Figure 1. San Jose neighbourhood, Albuquerque, New Mexico

San Jose was settled in the late 1830s or early 1840s by Hispanic farmers and existed as a self-governing village through World War II, after which it was absorbed by the city of Albuquerque. After the railroad reached Albuquerque in 1880, an increasing number of its residents were employed by the Santa Fe Railway, primarily at the shops which were located just north of the community. [10] The decline of the railroad industry in the 1950s and 1960s caused job losses and population loss. Since then, San Jose has continued to be populated predominantly by minority residents with low incomes, leading to a marginalized population without a voice to oppose the heavy industry encroaching onto its borders. The heavy industry and close proximity to the interstate contribute to high levels of heavy vehicle traffic and visual blight, resulting in many sources of air, water and noise pollution. [11]

2.1 Socioeconomic characteristics

According to the 2020 census, the San Jose neighbourhood has a population of 2.843. A significant proportion of the residents (21,8%) are immigrants, primarily from Mexico. The neighbourhood's median income of $28.912 is well below that of the State of New Mexico ($51.243), and of the U.S.A. as a whole ($67.521). In fact, San Jose is one of the lowest income areas in the U.S.A., ranking below 90,3% of the nation's neighbourhoods. With 46,4% of children living below the federal poverty line, San Jose has a childhood poverty rate that is worse than 91,9% of U.S. neighbourhoods. [12]

Most of the residents are employed is lower wage occupations. Almost 45% of the working population is employed in retail sales and the service sector. About 22% are in manufacturing and manual labour, and 16,5% are in clerical and technical support occupations. [12] The unemployment rate is close to 8%, which is significantly worse than the New Mexico (4,4%) and national (3,7%) rates. [13]

The U.S. Census Bureau maintains a web-based mapping and reporting application known as OnTheMap, which uses the Bureau's Longitudinal Employer-Household Dynamics data to show where employers work and live. This tool shows that almost 98% of employed residents work outside their neighbourhood. In fact, over 10% of employed residents work more than 10 miles away. Over 90% of employed residents report that owning a car is essential for getting to work and, therefore, for remaining employed. [14]

2.2 Challenges posed by the transportation infrastructure

The railroad that marks the west boundary of San Jose attracts a high concentration of heavy industrial activity. Rail car movements at the freight rail yard towards the south edge of the neighbourhood at the at-grade road crossing often blocks traffic on Woodward Road for up to 20 minutes according to residents. Both trains and semi-trucks idle for extended periods of time at the rail yard and elsewhere in the neighbourhood, subjecting residents to unpleasant noise and harmful exhaust fumes.

Although the railroad tracks running along the west side of the neighbourhood serve the Rail Runner (heavy rail) commuter line, the line has only one stop, at the southwestern limit of the neighbourhood (Figure 2) . This stop, on Rio Bravo Boulevard, serves only commercial and industrial properties, as it is quite far from the neighbourhood's residential areas (which are concentrated on its northern part).

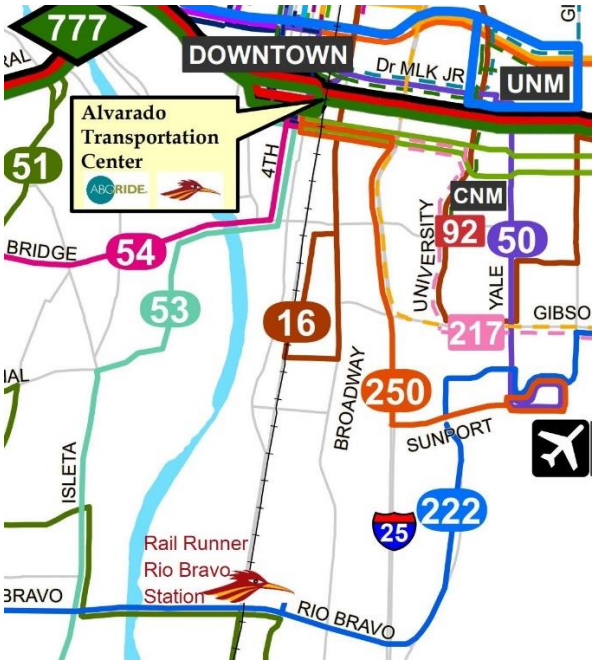

Figure 2. Public transit system in the vicinity of San Jose neighbourhood

In addition, only a single bus route, No. 16 (see Figure 2) is adjacent to the neighbourhood. This route has a few stops on the streets that form San Jose's northern boundary: Broadway Boulevard and Kathryn Avenue. These stops are too far from most of the neighbourhood's residential properties to be accessible by foot, though they may be accessible by bicycle. Albuquerque's bus rapid transit system runs east-to-west along Central Avenue and, at its closest, is 3 km away so it also is of no benefit to the residents of San Jose.

Albuquerque Sunport (Albuquerque's International Airport) is essentially adjacent to San Jose, as it is directly east of Interstate 24 where that freeway forms the neighbourhood's eastern boundary. However, there are not public transportation means for San Jose residents to access either the airport or the freeway. The airport, and Kirtland Airforce Base, which is essentially an eastward continuation of the airport, have had very large negative impacts on the community, primarily through fuel storage facilities that serve them. Leakages from these facilities that went on for decades, have contaminated the area's groundwater. Clean-up and remediation of this contamination has been very difficult. Remediation activities have been going on for more than 30 years and have been funded largely through the U.S. federal government's Superfund law. [15] The airport and freeway are also major sources of noise, air, and surface water and soil pollution (through surface runoff).

To compound these existing problems, Bernalillo County is planning a roadway and intersection modification to extend Sunport Boulevard, which currently terminates at Interstate 25, to connect to the eastern end of Woodward Road. To relieve congestion at two interstate freeway off-ramps, Bernalillo County officials are in the process of extending Sunport Boulevard through the San Jose Neighbourhood. The extension would also provide additional means of accessing the Albuquerque International Airport (Sunport) for those living on the southwest side of town. The neighbourhood residents are concerned about the impact of increased traffic through their residential area, which is expected to climb from 6.000 vehicles per day to over 21.000.

The proponents of the extension project claim that connecting Sunport Boulevard to Broadway Boulevard facilitates access to the airport from the West Side of Albuquerque and eases traffic for the Gibson Boulevard and Sunport Boulevard interchanges at I-25. They consider the extension as a necessary response to Albuquerque's growing population. The community, however, has many concerns about this project. Some critics worry that it will adversely impact existing toxic waste clean-up sites and air quality in the area. The project is scheduled to disrupt six wells that are being used for clean-up and monitoring activities relating to the toxic contaminants of the aquifer on which many of the residents rely for drinking water supply. This may cause significant delays in the clean-up process. [15] In addition, neighbourhood residents who live on Williams Street are worried that their street will become a cut-through for truck traffic when trains block the at-grade rail crossing.

3. Alternative transportation strategies and policies

3.1 Walking and bicycling

Research on transportation alternatives to single-occupancy vehicle travel has documented the benefits of walking and bicycling both on human health and on the environment. The U.S. Federal Highway Administration (FHWA) recognizes the following as primary measurements quantifying the benefits of bicycling and walking:

- Reduced fossil fuel use
- Lower emissions of carbon dioxide (CO2), carbon monoxide(CO), nitrogen oxides (NOx), and volatile organic compounds (VOCs)
- Lightened roadway congestion at peak travel times
- Fewer VMT (vehicle miles traveled)
- Lower body mass index and increased physical activity

Encouraging bicycling and walking requires ensuring that adequate walking and bicycle facilities exist. For walking, this includes sidewalks, public spaces, street lighting and safe street crossings. For bicycling, this includes relatively wide curb lanes, on-street bike lanes or off-street bike paths, bicycle parking and traffic calming. Factors such as an area's socioeconomics, the character of the built environment, and personal preferences and attitudes can affect the amount of bicycling and walking in a community.

Analysis of bicycling facilities shows those cities with a greater supply of bike paths and lanes have higher bike commute levels. Furthermore, research on environmental factors associated with walking shows the aesthetic nature of the local environment, the convenience of facilities for walking (footpaths, trails), accessibility of places to walk to (shops and recreation and employment centres), and traffic volume on roads have all been found to be associated with walking for particular purposes.

Implementation would require not only significant funding but also considerable coordination with other aspects of comprehensive planning such as land use, public transit, and policy. Land use strategies would define access needs for an area—as an example, a grocery store or retail establishment would require pedestrian access. Similarly public transit strategies would define the bus routes which may in turn influence designing the walking and bicycling networks.

3.2 Public transit

Buses are the most widely used form of mass transit in America due mainly to their cost effectiveness compared to that of other forms of public transportation such as light rail, commuter rail, and heavy rail systems. [16] Bus systems move people effectively while addressing issues of congestion and air quality due to high volumes of auto and truck traffic. Public transit can be more economical than vehicle ownership and less stressful than driving. It reduces the demand for parking and increasing roadway capacity and provides access and mobility to individuals who do not have access to a car. [17][18]

Light rail is a mode of urban transport using fixed guide ways often but not always in dedicated right of ways separated from other transportation. Unlike freight rail, light rail is designed to handle passengers rather than freight, and as a result can deliver high mobility to its users. The rail system can provide point-specific development options given the dedicated access for retail, residential, and business commuters. Light rail benefits from locating transit stops at high-density points that concentrate travel destinations such as downtown centres or business centres within residential communities.

Commuter and heavy rail differ from light rail in that these rail systems are high-capacity, high-speed systems. Both commuter and heavy rail systems use the same gauge of tracks due to the availability of equipment for construction and maintenance of the infrastructure, and the flexibility of using the same rail infrastructure for both passengers and freight. Trains vary in size from three to twelve cars dependent upon route length, frequency and volume. Commuter rail best serves regional systems, which connect multiple municipalities

Bus Rapid Transit (BRT) emulates the look and feel of light rail while maintaining the flexibility and lower cost of operating on any paved road. Most BRT systems provide dedicated lanes for buses to avoid conflict and delays associated with sharing right of way with other vehicles. Buses are often larger, articulated buses, which stop less frequently than local bus lines and run more frequently. Other features associated with BRT include improved stations, off-vehicle fare collection, near-level boarding (which facilitates the boarding of persons with disabilities), peak headways of 15 minutes or less, and unique branding. [19]

3.3 Policy options

In economic theory and analysis, traffic congestion is the result of a market failure. Driving on a congested roadway generates costs to the driver, as well as to the environment, the road infrastructure, and other drivers. However, these costs are diluted among all roadway users. The marginal cost to a single driver is minimal compared to the perceived benefits of using even a congested roadway.

Neoclassical economic theory posits that congestion pricing policies would monetize the cost of driving and, consequently, internalize that cost to each individual driver. Properly calculated congestion

pricing would increase the overall efficiency of the transportation system. This would be achieved by charging car drivers as many as possible of the negative externalities that result directly from that person's vehicle use, including air pollution, water polluted by road runoff, degradation of soil, and adverse health impacts resulting from vehicle emissions. Placing a direct cost on the full spectrum of costs from driving not only dissuades drivers from taking nonessential trips during peak hours, it also generates revenue that can be used fund key transportation improvement projects such as remediating environmental impacts or improving alternative transportation infrastructure. [20]

The Complete Streets initiative incorporates these economic proposals in ways that are designed to accommodate all users, including bicyclists, pedestrians, public transit users, and private car users. By adopting a Complete Streets policy communities direct their transportation planners and engineers to routinely design and operate the entire right of way to enable safe access for all users, regardless of age, ability, or mode of transportation. This means that every transportation project should make the street network better and safer for drivers, transit users, pedestrians, and bicyclists, improving safety and quality of life. An ideal Complete Streets policy:

- Includes a vision for how and why the community wants to complete its streets.
- Specifies that 'all users' includes pedestrians, bicyclists and transit passengers of all ages and abilities, as well as trucks, buses and automobiles.
- Applies to both new and retrofit projects, including design, planning, maintenance, and operations, for the entire right of way.
- Makes any exceptions specific and sets a clear procedure that requires high level approval of exceptions. [21]

4. Implementation

4.1 Creation of a community planning and action group

San Jose is among the oldest and most culturally diverse but also most socioeconomically disadvantaged neighbourhoods of Albuquerque. Because almost all of its housing is surrounded by major transportation infrastructure and mostly light but also some heavy industry, its residents have been subject to serious adverse environmental impacts. The neighbourhood is a prime example of environmental injustice. Both general federal government and specific U.S. Department of Transportation policies to promote environmental justice should be applied to this community.

An important requirement of these policies is engaging the community in all transportation project planning and implementation processes. [8] To promote effective community engagement, a committee comprised of residents and property owners should be established to identify the community's transportation and land use planning issues, to represent the community to the city and county, and to engage with local, state, and federal planning agencies. The committee should serve several functions, among them:

- Create and promote a "Neighbourhood Vision for Sustainable Transportation."
- Collect community concerns and ideas in land use and transportation.
- Collaborate with the city, county, and MPO in planning workshops, outreach efforts, and public hearings.
- Provide feedback to the community, and education, on public planning processes, available options, timelines, and related trade-offs.

4.2 Establish truck routes and weight restrictions

With the exception of the Big Bear Petroleum-Honstein Oil activity on Commercial Street, heavy trucks have no need to enter or travel through the San Jose neighbourhood. If the community employs a weight restriction on the residential streets, it would effectively limit heavy vehicles to clearly established truck routes outside the perimeter of the neighbourhood. The truck routes would circumnavigate the community on Bridge Boulevard-Avenida Cesar Chavez, Broadway Boulevard, Woodward Road, and

2nd Street. Trucks would be explicitly prohibited from Williams Street and all other cross-streets from Stadium Boulevard to Bethel Avenue.

In order to guarantee truck compliance and restrict cut-through, Williams Street and all residential/community roads connecting to Broadway should be clearly marked with "no trucks" and/or "weight restriction" signage (recommend 5-ton limit) and the installation of engineering controls (physical barriers to trucks) such as traffic circles, at all neighbourhood entrances. As traffic circles are often perceived as inconvenient to motorists, the community planning committee must educate residents on the needs and benefits of the circles to garner support.

4.3 Engage in comprehensive land use planning and zoning efforts

The extension of Sunport Boulevard into the community will create pressure for development of vacant land in the area where the ramp from the bridge over I-25 will bring the extension to ground level. This will be close to the geographic centre of the community and, therefore close to the residential areas. In order to protect the residents from additional adverse impacts from vehicle traffic, it should be emphasised in planning processes that the San Jose neighbourhood has greater potential than simple industrial expansion. Development of vacant land should not result in increased heavy truck traffic and industrial growth so close to residential areas should be prohibited. The Sunport Extension should be used as a foundation for a new land use vision for the neighbourhood. Zoning policies should be utilized to guide this change. Rather than continued industrial development, vacant land should be rezoned for hotels, restaurants, light commercial, and other uses that will support both the airport and the community.

Zoning efforts can be used to establish light commercial buffer zones between residential and industrial areas. Community involvement in local zoning should focus on efforts that encourage the types of enterprises and economic activities in which residents are currently employed. The location of retail sale establishments, restaurants, hotels, etc. starting in the parts of the neighbourhood that will become directly connected to the airport and the freeway will make it possible for community residents to work much closer to home. This will reduce their need to use private automobile transportation and will shorten or eliminate their commutes, resulting in a much more sustainable transportation system for the neighbourhood. In addition, such development will form a buffer area and prevent encroachment by industry. Zoning should focus on selectively promoting optimal (given local conditions) mixed-use solutions that incorporate residential, commercial, and other uses where compatible. It has been shown that mixed land use with deliberate design and planning has been effective at encouraging walking, cycling and transit ridership, while at the same time reducing dependency on the personal automobile. [22][23]

4.4 Clean air initiatives

Clean Air initiatives and anti-idling legislation combined with effective enforcement are successful at reducing diesel particulate matter (DPM) and improving local air quality. Parked trucks, those waiting at intersections, idling locomotives, and old outdated diesel engines all contribute significantly to poor air quality. Any measure to reduce or eliminate these pollution sources will improve air quality (and reduce noise and vibration) in the San Jose community. Several courses of action are available, and all will require extensive effort and coordination.

The long term solution to idling and clean air issues is to engage state legislators in the issue and highlight the merits of a statewide Clean Air Campaign as a proactive measure to prevent New Mexico from incurring EPA's Air Quality nonattainment status. The use of alternative fuels (natural gas, bio-fuels, etc) and hybrid technologies have shown progress in controlling emissions and improving air quality. The identification of major equipment operators in the area, and their fleet conversion to cleaner technologies could have measurable results to local air quality. Again, incentives and legislative mandates serve as encouragement for companies to make the necessary investments in equipment renewal.

5. Conclusions

5.1 Summary of findings

Albuquerque's San Jose neighbourhood faces many social, economic, and environmental challenges. The neighbourhood already suffers from the impacts of heavy industry and a transportation system that meets very few of the community's needs. The Sunport Boulevard extension project has the potential to add to and intensify the existing transportation-related problems. The purpose of this paper is to address the most critical of these problems and provide the community with recommendations for planning processes that can lead to an environmentally and socially sustainable transportation system for San Jose.

The creation of a community planning and action group is an essential step for the residents to claim agency and be able to control the process of transportation planning for their community. The existence of such a group also has the potential to improve communication between community members and the city, as it is a setting within which information, ideas, and concerns of both sides can be presented and discussed. A good relationship between stakeholders allows honest and direct conversation, enabling solutions that benefit both sides. Community input can, for example, steer development from the Sunport Boulevard extension project in a direction that will benefit community residents as well as the city's economy.

5.2 Limitations and recommendations for future research

The purpose of this research is to identify the main obstacles to a sustainable transportation system for the San Jose neighbourhood of Albuquerque, New Mexico, and to offer the outlines of a planning process that is capable of overcoming these obstacles. It is not possible for us to develop any specific recommendations regarding transportation planning, such as bus routes, bicycle and pedestrian pathways, or roadway improvements. We also cannot offer specific recommendations regarding land development, such as what types of zoning would be most appropriate for specific locations or on what land parcels specific types of businesses, such as hotels, restaurants, or retail are most appropriately placed.

Such specific recommendations would require quantitative assessments such as models of travel demand, traffic congestion, air pollutant emission and dispersion, economic impacts of development projects, etc. These assessments would produce data that would be utilized by the transportation planning process which would be set up to address the community's multiple problems.

As the Sunport Boulevard extension project is about to begin, the San Jose neighbourhood is at the threshold of a major change in its transportation system. This is a significant challenge but also an important opportunity. We hope that this research will motivate the multiple and varied quantitative assessments that are needed in order to determine the costs and benefits of different transportation and land use options and set the stage for the development of a sustainable transportation system for San Jose.

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Uses of biodegradable lubricants, a challenge of today's societies

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Abstract. In this paper, aspects regarding lubricants, their classification, their influence on the environment and their areas of use are presented. Lubrication represents an important process for various equipment and machines with moving parts. The correct choice of lubricant can lead to increased energy efficiency and at the same time decrease the rate of wear of various moving elements. We must take into account the fact that the choice of the lubricant requires special attention because at the moment a large part of the lubricants used are those based on mineral oils, which leads to damage to the environment, human health and high costs. According to the above, we can turn our interest to biodegradable lubricants (based on vegetable oils and animal fats), because they represent renewable and easily biodegradable resources.

Keywords: *biodegradable, lubricants, properties, viscosity.*

1. Introduction

According to the Standard ASTM Designation G40-95 [1], the lubricant is represented by any substance interposed between two surfaces in order to reduce friction and/or wear between them. Some authors [2], [3] state that the lubricant represents the third body interposed between the surfaces of the friction coupling. This may be naturally present or may be intentionally introduced to reduce friction and wear and/or to dissipate heat generated by friction. Although the term lubricant often suggests oils or thick greases, these being the most used lubrication materials, the notion of lubricant is much broader, being represented by a wide variety of substances in all states of aggregation [2]. Figure 1 shows the schematic representation of the interaction between two surfaces in relative motion.

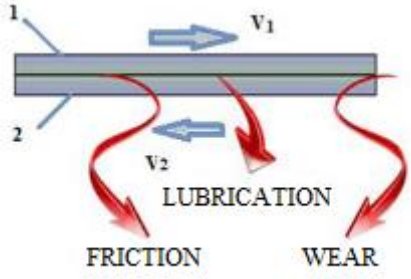

Figure 1. Schematic representation of the interaction between two surfaces in relative motion with the highlighting of the three basic phenomena specific to tribology [3].

There is a growing interest in research studies on the use of oils from renewable resources as substitutes for mineral oils, but these are not on a large economic scale and the processing technology to the lubricant is not yet very cost-effective. Hence the interest of researchers to study their rheological and tribological behavior. Human activity since the beginning of society has required technologies and materials to reduce friction to transport materials in construction, agriculture, but also in other fields of activity [2]. Figure 2 shows the classification of lubricants.

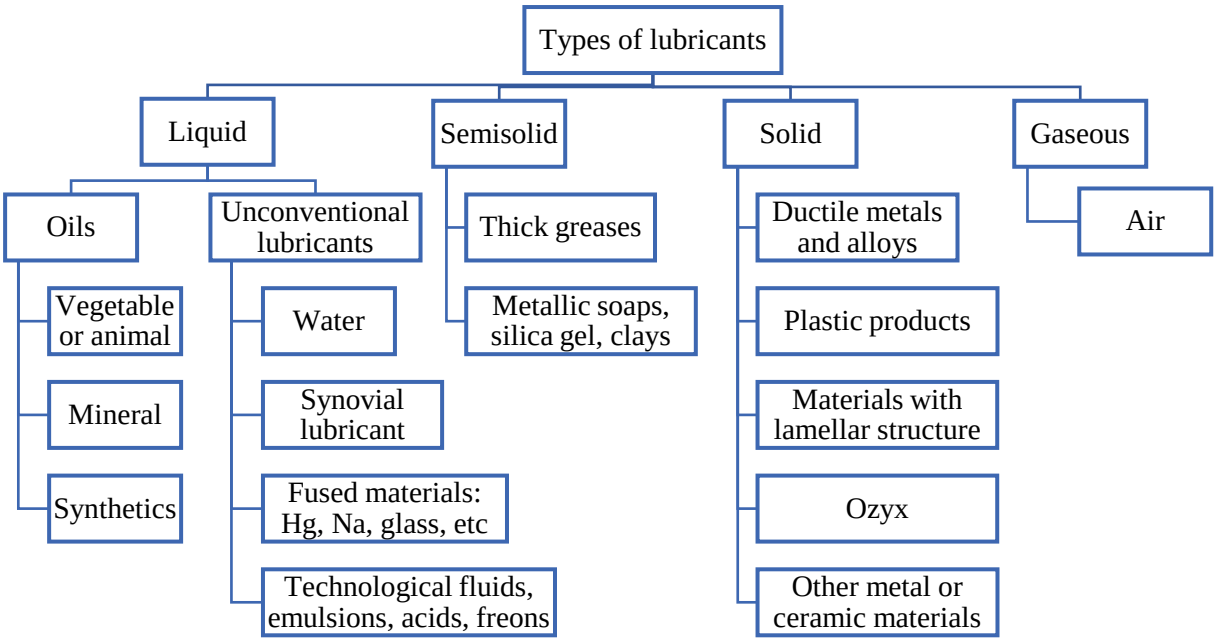

Figure 2. Classification of lubricants [2].

2. Biodegradability of lubricants

Biodegradable lubricants have a long history. Specifically, natural oils and fats, being made up of unsaturated triglycerides, such as castor oil, palm oil, soybean oil, tallow, lard are historically well documented for their lubricating properties. However, their range of use is generally limited by lower stability against thermal and hydrolytic oxidative stress and partially inferior cold flow properties. These limits can be improved in several ways, for example by chemical or genetic modification or by additive [4].

The often-used prefix "bio" refers to an association with a renewable resource of biological origin, such resources generally excluding fossil fuels. Biodegradation is the decomposition or chemical transformation of a substance caused by organisms or their enzymes.

Biodegradability is not just a "property" or characteristic of a substance, but is also a system concept, i.e., a system with conditions that can determine whether a substance in it is biodegradable.

For the most part, when the term "biodegradable" is used to describe a lubricant product, it means that the product is more biodegradable than petroleum-based stocks or formulations [4].

The key to recipes for biodegradable lubricants is closely related to two aspects: the selection of the base oil and the selection of the additive package, which establishes an acceptable compromise in terms of biodegradability, performance and price. The main groups of base fluids that would meet the above requirements, which also have practical applicability, are synthetic esters, natural esters and polyglycols (these are also part of the classification of biodegradable lubricants) [2], followed by fatty oils, mineral base fluids, synthetic base fluids and complex esters:

- natural esters (vegetable oils) - such as those obtained from rapeseed, sunflower or soybean seeds);

- synthetic esters (esters of dicarboxylic acids or polyolesters) from mineral or vegetable base oils;
- polyglycols (especially polyethylene glycols) from mineral base oils.

2.1 Properties of biodegradable lubricants

The evaluation characteristics of lubricants are included in two main groups: physico-chemical characteristics and performance characteristics. The physico-chemical characteristics can be divided into two categories: recognition (commercial) and rheological. When designing, approving, manufacturing, choosing and recommending lubricants, these characteristics must be examined as a whole. From the product catalogs, norms and quality standards, information is obtained especially regarding the (commercial) recognition characteristics, this of course being subjected to quality guarantees. From the point of view of the manufacturer and the user, it is important to know more about the respective lubricants, namely, other characteristics related to their operating behavior [2].

Tabel 1 shows physico-chemical properties of vegetable oils.

Table 1. Physico-chemical properties of vegetable oils [5]–[9].

Oil type	Property								
	Density [kg/m³]	Viscosity index	Kinematic viscosity at 40°C [mm²/s]	Kinematic viscosity at 100°C [mm²/s]	Saponification index [mg KOH/g]	Acid value [mg KOH/g]	Pour point [°C]	Flash point [°C]	Iodine value [mg I_2 g^{-1}]
Rubber tree seed oil	0.922	182	32.80	-	206	13	-9	295	135
Coconut oil	0.925	159	29.00	-	265	0.4	22	320	9
Sunflower oil	0.934	176	40.05	8.65	186	4	-18	332	127
Soybean oil	-	219	32.93	8.08	189	0.16	-9	240	144
Rapeseed oil	-	216	45.60	10.07	180	1.40	-12	240	104
Jojoba oil	-	233	24.90	6.43	94.69	1.10	9	-	98

Vegetable or natural oils are triglycerides of natural fatty acids, for example palmitic acid, stearic acid, oleic acid, vegetable oils, linolenic acid, etc. Due to the relatively high content of unsaturated fatty acids, natural oils tend to have low oxidation stability. A high unsaturated acid content is characterized by a lower iodine number which in turn tends to result in higher solidification temperatures. This means poorer cold flow behavior. Rapeseed oils present a fairly good compromise between low temperature behavior and oxidation stability [10]. Low temperature flow properties and oxidative stability and especially the relationship between the two are related to the fatty acid profile of the oil [11].

3. Impact of lubricants on the environment

Biodegradable lubricant formulation is a reversal from the current mineral oil dominated lubricant market. It is accepted that over 90% of all lubricants could be rapidly biodegradable. Currently, some countries in Western Europe and Scandinavia are the largest consumers of biodegradable lubricants. In 2005, in Germany, 5% of lubricating base oils were rapidly biodegradable esters (natural and synthetic). Over the years, the focus on lubricants has shifted from biodegradability to regenerability.

This influences the design of such products. Descriptors such as green or compatible lubricants suggest that there is no interaction with the environment. Since any oily substance stains the soil, it has been suggested that the term "environmentally friendly lubricants" expresses minimal damage and danger to nature [12], [13].

3.1 Driving forces for reducing environmental impact

Ways and measures to reduce environmental damage that mean overcoming or at least reducing the problems caused by the contact of lubricants with the environment in general are initiated or intensified by the following driving forces [11]:

- Environmental facts;
- Public awareness;
- Government directives and regulations;
- Globalization of markets;
- Economic incentives.

Bartz [11] pointed out that no lubricant can be truly environmentally friendly (i.e. not harming the environment); at best, a lubricant can remain environmentally neutral (i.e. harmless). The best that can be hoped for is that the lubricant affects the environment to an acceptable degree (minimum impact).

Consideration of the environmental aspects of lubricants should cover the entire life cycle from production to disposal. In particular, the production and use of lubricants should not cause resource depletion, disposal problems, waste formation or emissions, should have low energy consumption, should not present health hazards, should be ecotoxicologically acceptable and rapidly biodegradable.

The terminology used in relation to "environmental compatibility" is both subjective (unmeasurable) and objective (measurable). The subjective criteria are ecological and compatible with the environment. The objective criteria for "bio lubricants" are biodegradability of at least 60% according to OECD 301 (aerobic biodegradation test) or 80% according to CEC L-33-A-93 (test method for biodegradability) [4].

4. Fields of use of biodegradable lubricants

Lubricants are used in various industrial applications. The most important categories in which lubricants are used are [14]:

- Oils used in industrial applications such as machine oils, compressor oils, metalworking fluids and hydraulic oils, etc.;
- Automotive oils used in the automotive and transportation industry, such as engine oils, gears, transmission fluids, gear oils, brake and hydraulic fluids, etc.;
- Special oils such as process oils, white oils, tool oils, etc.

Biodegradable lubricants offer significant advantages as an alternative lubricant for industrial and maintenance applications due to their inherent superior qualities. Due to the environmental benefits of biodegradable lubricants, they allow their use in sensitive environments and ensure pollution prevention. Biodegradable lubricants have the ability to be used in various industrial and maintenance applications [15].

4.1 Experimental studies of biodegradable lubricants for different applications

Ibrahim et al. [16] carried out a study in which they experimentally analyze the performance of sunflower oil and soybean oil as lubricants for helical gears. The machine used for the experimental testing was a gear test rig. Oil input data for the tests were taken periodically from the gear test facility over 80 consecutive hours. Oil performance properties such as kinematic viscosity were measured immediately after oil sampling using Brookfield LVDV-II with PRO digital programmable viscometer. The kinematic viscosity parameter was measured in cSt units at temperatures of 40ºC and 100ºC using the ASTM D445-06 method [17]. All measured data were subsequently compared with the SAE 75W synthetic gear lubricant brand Renolin B10 [16]. Following experimental results show that sunflower oil, soybean oil and Renolin B10 have similar viscosity properties at high temperatures, but soybean oil has poor properties at low temperatures compared to sunflower oil. At low temperatures, soybean oil is less viscous, which can affect the contact surface between the two gears. The oil will allow the surface to contact each other and cause friction to increase and damage to the gear surface will occur. This can lead to reduced gear life in low temperature applications [18].

According to the above, we can say that sunflower oil is suitable as a lubricant for bevel gears compared to soybean oil which is in the SAE 75W classification. By comparison, sunflower and soybean oils have poor low temperature properties and have a wide range of viscosity over a temperature range that indicates the oil will not perform well throughout. However, both sunflower and soybean oils can perform well at higher temperatures [16].

In 2011, Majdan et al. [19] carried out an experimental study in which they present a comparison of the quality of two fluids. The first was the UTTO type mineral oil that is commonly used in the transmission and hydraulic systems of agricultural tractors. The second fluid tested was a biodegradable hydraulic fluid of the ERTTO type that could replace toxic mineral oil. Both fluids were tested under the same test conditions using a special test device according to STN 11 9287 (1983). Selected hydrostatic pump parameters were evaluated. The tests were evaluated according to the parameters that describe the technical condition of the hydrostatic pump as follows: the flow efficiency, the decrease in the flow efficiency and the level of cleanliness of the tested fluid. Based on the results obtained, we can state that the biodegradable hydraulic fluid does not exert any harmful influence on the technical condition of the hydrostatic pump. Therefore, the tested biodegradable fluid can be used for agricultural tractors. The selected parameters have been shown to be suitable for evaluating the hydraulic fluid during its working performance.

Permsuwan et al. [20] conducted tests to determine the effect of vegetable oils on piston deposits and cylinder bore deposit formation, engine oil consumption and viscosity stability when used in a gasoline engine on a period, representing the normal oil change period (i.e., 7 hours with a low tank refill compared to 250 hours of full tank operation). The method used to evaluate the degree of varnish deposition was Demerit Rating (DR), which is a standard method of the Petroleum Institute [21].

Several vegetable oils have been tested with this technique and satisfactory results have been obtained. The vegetable oils selected for testing were: R30 castor oil (which is a high-performance castor base oil), crude castor oil (which is unprocessed and toxic), and pure coconut oil. The tests were carried out on a Villiers C-30 industrial gasoline engine. The motor load was supplied by a coupled generator having an adjustable electrical resistance. The duration of the test for each oil was 7 hours [20]. The viscosity of the tested vegetable oils was raised using this type of test, namely, R30 castor oil (which is a commercial high-performance race car oil), its viscosity increased by 37% during the 7-hour test period and coconut and castor oil could be used as engine lubricants in the test engine. During testing, the engine ran with these oils without any problems or breakdowns. The results show that all vegetable oils protect the piston jacket from lacquer deposition. Crude castor oil gave the best result as there was no deposit on any area of the piston except the crown. Coconut oil also gave a good result with little deposit in the first ring groove. Coconut oil crown deposition was the lowest [20].

Lovell et al. [22] conducted an experimental study in which they introduced and analysed a new environmentally friendly lubricant to determine its potential use in sheet metal stamping processes. This lubricant is based on a combination of boric acid and rapeseed oil, both of which are natural, environmentally friendly and have independently demonstrated good lubrication potential. To evaluate the frictional characteristics of rapeseed oil and boric acid lubricant in a forming operation, a strip stretch friction simulator was used. Using the test apparatus, the coefficient of friction between the mold and a steel sheet was measured for four different lubrication conditions: unlubricated, canola oil, transmission fluid, and a combination of boric acid and canola oil. The author demonstrated that this apparatus effectively models the deformation behavior encountered in a deep drawing process and accurately reproduces the frictional effects experienced during sheet bending. Based on the experimental results, the boric acid and canola oil lubricant significantly outperformed the other lubrication conditions in terms of measured friction coefficient, final sheet surface properties, and overall sheet formability. These results indicate that boric acid and canola oil lubricant has substantial potential to provide the manufacturing community with a commercially reliable and environmentally friendly alternative that will enable the forming of complex parts.

In their paper, A.V. Radulescu et al. [23] determined the main rheological properties of pork fat, which is one of the most important sources of animal fat waste in the food industry. From this point of

view, two kinds of pork fat were tested: pork fat from the back of the neck and from the breast. The measuring equipment for the tests was a Brookfield Cap 2000+ rotary cone and plate viscometer. The viscometer uses CAPCALC32 software for complete control and data analysis. The viscometer is suitable for digital data acquisition and provides the ability to determine the variation of viscosity as a function of temperature. All measurements can normally be made in a temperature range between 5 and 75°C [24], [25]. Three types of tests were performed for these greases: shear tests, time influence on viscosity and temperature performance.

Following the experimental results, the conclusions are as follows [23]:

- The rheological properties of pork fat depend on the portion of the pork body from which they were collected;
- Pork fat has an important thixotropic behavior, due to the breaking of the structure when shearing at a given rate;
- The transition area, between semi-plastic and fluid behavior, is accentuated for a range of temperatures between 25°C and 35°C;
- The appearance of pork fat, in a fluid state, depends on the portion of the pork body from which it was collected.

The paper of I. Radulescu [26] is focused on the rheological study of biodegradable fats based on rapeseed oil and beeswax, added with graphene or graphite nanoparticles. For this study, 4 types of grease samples were prepared, namely: pure grease, additive grease, with antioxidant (1%) and antiwear additives (2%), graphene grease, with antioxidant (1%), antiwear (2 %) and graphene powder (0.5%), graphite grease, with antioxidant (1%), antiwear (2%) and thermally expanded graphite (0.5%). Each of them was thermally analyzed in the temperature range of 20°C…50°C. Rheological tests were performed using a Brookfield CAP 2000+ viscometer with cone and plate geometry. The experimental test consists of a loading from 10 s^{-1} to 2000 s^{-1} shear rate gradient, followed by an unloading to highlight the thixotropy of the lubricant - "shear memory". The experimental results show that the addition of nanoparticles increases the homogeneity of the grease and increases the range of use of biodegradable lubricants up to the melting point of beeswax. The highest values of the yield point and viscosity are obtained for the grease added with graphite nanoparticles, compared to the one added with graphene nanoparticles. From the adhesion point of view, graphite nanoparticle grease is more suitable than graphite nanoparticle grease.

5. Viscosity index

5.1 Variation of viscosity with temperature for vegetable oils

The viscosity index (VI) is an arbitrary measure of the change in viscosity of a fluid in relation to a change in temperature. It is also defined as the dimensionless number that indicates how changing temperature can affect the viscosity of an oil (engine oil and automatic transmission oils and power steering fluids). The higher the VI, the smaller the change in fluid viscosity for a given change in temperature, and vice versa. Thus, a fluid with a low viscosity index will experience a relatively large change in viscosity as the temperature changes. Liquids with high VI, on the other hand, are less affected by temperature changes [27].

The ASTM D2270 standard calculates the viscosity index by measuring the kinetic viscosity of oils at 40°C and 100°C [27] using the relationship below:

$$VI = \frac{L - U}{L - H} \times 100, \tag{1}$$

where [28]:

- VI = viscosity index;
- L = kinematic viscosity at 40°C of an oil of 0 viscosity index, having the same kinematic viscosity at 100 °C as the oil whose viscosity index is to be calculated, mm^2/s;

- H = kinematic viscosity at 40°C of an oil of 100 viscosity index, having the same kinematic viscosity at 100 °C as the oil whose viscosity index is to be calculated, mm^2/s;
- U = kinematic viscosity at 40°C of the oil whose viscosity index is to be calculated, mm^2/s.

Another indication of the change in kinematics viscosity with temperature, which is less arbitrary than the viscosity index, is the viscosity-temperature coefficient (VTC) defined by the relationship [29]:

$$VTC = \frac{A - B}{A}, \quad (2)$$

where:

- A = viscosity (mm^2/s) at 40°C;
- B = viscosity (mm^2/s) at 100°C.

Table 2. Experimental results of biodegradable oils regarding viscosity index and temperature-viscosity coefficient

Oil	Kinematic viscosity at 40 °C (mm^2/s)	Kinematic viscosity at 100 °C (mm^2/s)	Viscosity index (VI)	Viscosity temperature coefficient (VTC)
Rubber seed oil	32.80	7.02	184	0.7860
Coconut oil	29.00	6.02	161	0.7924
Sunflower oil	40.05	8.65	203	0.7840
Soybean oil	32.93	8.08	234	0.7546
Rapeseed oil	45.60	10.07	216	0.7792
Jojoba oil	24.90	6.43	231	0.7418

Table 2 shows experimental results regarding the characteristics of biodegradable oils (rubber seed oil, coconut oil, sunflower oil, soybean oil, rapeseed oil, jojoba oil) together with the kinematic viscosity at temperatures of 40°C and 100°C corresponding to each oil, with which the viscosity index could be determined using relation (1) and the temperature-viscosity coefficient using relation (3).

From Table 2 it can be seen that the values for VTC are much lower than those of VI, so we can see that the highest value for VTC is represented by coconut oil, and the lowest by jojoba oil. From the point of view of VI, coconut oil has the lowest VI, and the highest is represented by soybean oil.

The viscosity index could also be determined using the ASTM D 134 chart, as can be seen in Figure .

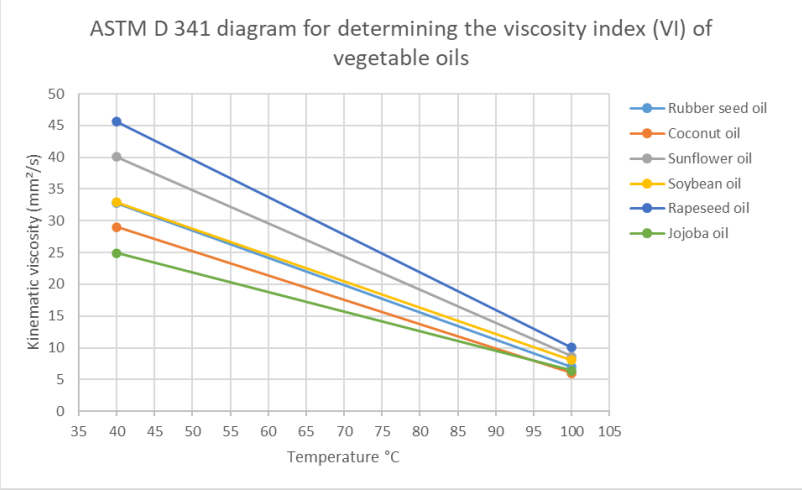

Figure 3. ASTM D 341 diagram for determining the VI viscosity index of vegetable oils

Kinematic viscosities for temperatures of 40°C and 100°C were plotted in Figure 4 for the six oils. These points were joined by lines for each component separately. The lower the viscosity index, the less dependent the viscosity is on temperature variation.

From Figure 4 it can be seen that jojoba oil has the smallest slope, which means that the viscosity variation with temperature is smaller.

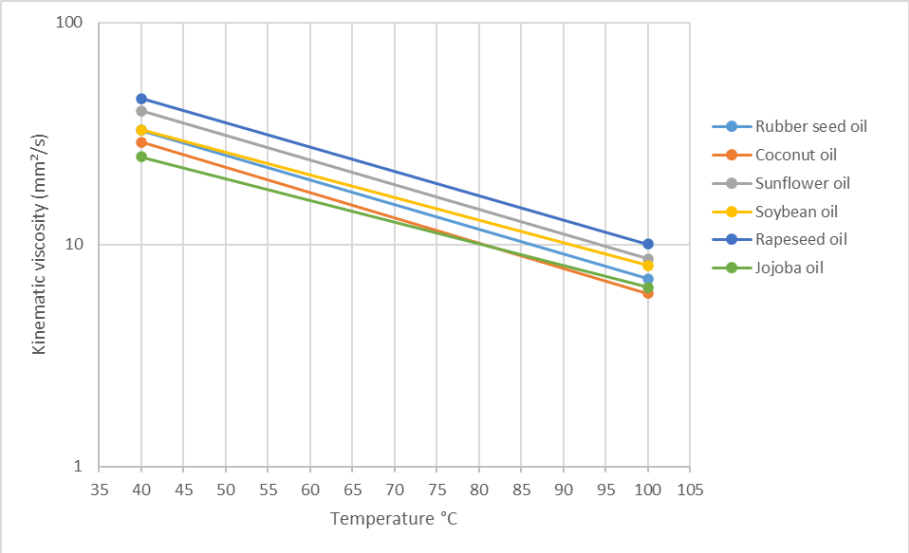

Figure 4. ASTM D341 chart for determining the viscosity index (VI) of vegetable oils with logarithmic kinematic viscosity

6. Conclusions

Following the theoretical research carried out in this first report, it was found that biodegradable lubricants are of great interest both from the point of view of the environment and for their use in agricultural, food, hydraulic machinery, etc., but also their testing to identify properties and influencing factors. For these biodegradable lubricants, vegetable oils, polyglycols and synthetic ester oils can be used as base oils. Replacing petroleum-based lubricants (which are an exhaustible resource and at the same time polluting the environment) with vegetable oils will represent a renewable resource over time.

The viscosity of biodegradable oils varies with their temperature, as the viscosity decreases, the temperature increases because the molecules vibrate more and interact less [29].

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Profitability analysis of the establishment of currant and gooseberry plantations for obtaining and processing the fruits in pasteurized juice

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Abstract. Currants and gooseberries are part of the category of consumer goods, being appreciated both for their special taste and for their healing properties, being very rich in antioxidants and bringing health benefits, and for this reason they are used in food and pharmaceutical industry. The paper presents: the description of the area chosen for the establishment of the plantation, the currant and gooseberry varieties, diseases and pests, the planting technology, maintenance and harvesting of the fruits and the economic analysis of the business.

Keywords: *Currants, gooseberries, juice, pests, technology, economic analysis.*

Introduction

Blackcurrant and gooseberry are specific with early fruiting, from the fourth year after planting, with growing productions up to the 6th year. The fruits are rich in vitamin C, organic acids and mineral salts with a role in strengthening the human body and improving health.

In addition to the fruits, consumed in processed, frozen or dehydrated form (teas), the leaves and especially the buds, which are rich in essential volatile oils with antibacterial and cicatrizing properties, can also be used.

The main blackcurrant varieties grown in our country are: Tsema, Deea, Abanos, Amurg, Perla negrag, Record 35, the redcurrants: Early Red, Jonkheer van Tets, Abundent, Houghton Castle, and the whitecurrants: Pearl, Blank and Smoleaninovskaya.

Gooseberry varieties are divided into two groups, namely varieties with thorns (Ruschii and Invicta) and varieties without thorns (Verda). The fruits have various colors from pale green, yellowish green to greenish yellow and from pink to dark red or violet.

The most common diseases and pests of currant and gooseberry are: Pseudopeziza ribes, Sphaerotheca mors-uvae., Cronartium ribicola, Botrytis cinerea, Abraxas grossulariata, Synanthedon tipuliformis, Quadraspidiotus perniciosus and Cryptomyzus ribis.

The technology of establishment and maintenance of currant and gooseberry culture

a) Technology of establishment until entering the fruit

Land preparation. It consists in removing the plant residues of the preceding crop at least two months before planting, followed by the leveling of the land and the execution of a deep plowing of 35-50 cm.
Lands sheltered from winds and cold air currents are chosen.
Density. Planting density is chosen depending on soil maintenance work and fruit harvesting technology 1.5 m is chosen between the rows, and 0.8 m is chosen between the cuttings on the same row.
Support system. The support system is made of concrete trellises with three or four wires and a distance between them of 8 m.
Irrigation system. Two irrigation systems can be used, namely sprinkler irrigation or drip irrigation.
Planting period. Planting of cuttings is carried out in autumn at the end of October. The cuttings are planted so that the entire root and 3-4 cm of the stem enter the planting hole. The soil is compacted very well around the plant and 5 - 6 liters of water are added.
Ground maintenance. Between the rows and in each row, the land is kept clean by performing weeding and weeding works. Spacing between lines is not recommended.

b) Technologies applied after entering the fruit

Irrigation. During dry periods, sprinkler or drip irrigation is done 5 - 7 times per season depending on the rainfall during the growing season.
Fruiting cuttings. It is carried out starting from the 6th year when the crown of the bush is fully formed, the broken, diseased, dry branches and those that fill the bush are removed. The lateral branches are shortened to a length of 20-25 cm.
Ground maintenance. It is kept free of weeds along the row by hoeing or mulching.
Fertilization. NPK doses of 15:15:15 are applied in fruit plantations.
Fruit harvesting and storage. Fruit harvesting is chosen according to the method of utilization. For industrial processing, picking begins in May, when the fruits are still green. For fresh consumption, the fruits are harvested at full maturity, when the skin is transparent, and the pulp is soft. Fruits are stored in cool rooms for 5-6 days or in cold stores at a temperature of -0.5-1.0 0C for 7-8 weeks. Harvesting is done manually or mechanized.

Presentation of the planting plan and the technological stages

I) Planting plan

It is proposed to establish a plantation of fruit bushes of the currant and gooseberry species in Bâlteni commune (Gorj County) on an area of 2 ha, of which 1.5 ha of black currant and 0.5 ha of gooseberry. After analyzing the characteristics of the currant and gooseberry varieties, presented in the specialized literature, it was decided to cultivate blackcurrant of the *Tsema* variety, and for gooseberries, the *Verda* variety.
The proposed plantation plan for the project implementation period is presented in table 1.

Table 1. Plantation plan

Current Number	Plantation Name	Planting Area [ha]
1	Currant	1.5
2	Goosberry	0.5
Total		2

A modern, intensive system of establishment and exploitation of the mixed currant/gooseberry culture will be adopted within the fruit bushes plantation, characterized by the application of efficient work methods that require minimal labor consumption and low operating costs. The realization of the project will mean the capitalization of a whole series of economic opportunities (free land, access to the road,

free water) and social (creation of new jobs), with favorable effects in the development of the local economy (local input suppliers will be stimulated). services, etc.), as well as in increasing local budget revenues.

II) Calculation of the material requirements for the establishment of the plantation
Calculation of the nutrition area for the currant plantation in an intensive system

$$N_s = R_d \cdot P_s$$
$$= 4 \cdot 0.5$$
$$= 2\ m^2$$

Where:
Ns – nutrition space;
Rd – distance between rows (4 m);
Ps – the space between plants in a row (0.5 m).

Calculation of the number of cuttings for the cultivated area of 1.5 ha

$$C_r = \frac{P_a}{N_s} + p$$
$$= \frac{15{,}000}{2} + 10\%$$
$$= 7{,}500 + 750$$
$$= 8{,}250\ currant\ cuttings$$

Where:
Cr – the number of cuttings required;
Pa – the area that is desired to be planted (Pa = 15,000 m2);
Ns – nutrition space (2 m2);
p – required filler cuttings (10% of Cr).

Calculation of the nutrition area for gooseberry plantation in intensive system

$$N_s = R_d \times P_s$$
$$= 1.5 \times 0.8$$
$$= 1.2\ m^2$$

Where:
Ns – nutrition space;
Rd – distance between rows (1.5 m);
Ps – the space between plants in a row (0.8 m).

Calculation of the number of cuttings for the crop area of 0.5 ha

$$C_r = \frac{P_a}{N_s} + p$$
$$= \frac{5{,}000}{1.2} + 10\%$$
$$= 4{,}166 + 416$$
$$= 4{,}582\ goosberry\ cuttings$$

Where:

Cr – the number of cuttings required;
Pa – the area that is desired to be planted (Pa = 5,000 m2);
Ns – nutrition space (1.2 m2);
p – required filler cuttings (10% of Cr).

III) Calculation of water requirements
The water requirement for the 1.5 ha of blackcurrants

$$Q_{H_2O} = N_u \cdot Nr_w$$
$$= 280 \cdot 10$$
$$= 2{,}800\ (m^3/ha)\ \cdot 1.5$$
$$= 4{,}200\ m^3$$

Where:
Q_{H_2O} *- the water requirement for irrigation of the plantation during the growing season.*
No – watering norm (280 m3/ha).
Nrw– the number of waterings (10 waterings).

The water requirement for the 0.5 ha of yellow gooseberry

$$Q_{H_2O} = N_u \cdot Nr_w$$
$$= 320 \cdot 5$$
$$= 1{,}600\ (m^3/ha)\ \cdot 0.5$$
$$= 800\ m^3$$

Where:
Q_{H_2O} *- the water requirement for irrigation of the plantation during the growing season.*
No – watering norm (320 m3/ha).
Nrw– the number of waterings (5 waterings).

Description of the technological flow for obtaining currant and gooseberry juice
The technology of obtaining juice, the production of currants and gooseberries goes through the following stages:
Qualitative and quantitative reception. The qualitative reception consists of:
- the external examination of the batch;
- the organoleptic examination (taste, smell, aroma);
- physical-chemical analyzes (consistency, pH, acidity, soluble dry matter).

Temporary storaging. Only if the flow of raw material exceeds the processing capacity, temporary storaging carried out.
Sorting. The sorting of the fruits will be done on each batch separately. On this occasion leaves, unripe fruits, rotten fruits, crushed fruits or other impurities will be removed.
Washing. The washing operation must be carried out in order to completely remove any mineral impurities (traces of earth), but especially to remove any traces of the chemical substances used in the treatments against pests.
Cleaning. The rachis and peduncle of the fruits are removed.
Crushing. A good crusher must cut a homogeneous, fine-grained pulp, without large pieces, but without a pasty consistency.
Pasteurization - cooling. The operation of heating the crushed currants/gooseberries is particularly important because the anthocyanin substances are mainly located in the skin, being difficult to extract by pressing.

Enzymatic maceration. It is the operation through which the fruits are thermally treated to facilitate the extraction of coloring substances from the skin.
Pressing. It is the most used method for obtaining juices.
Enzymatic clarification. It is recommended for treating juices rich in pectic substances and for obtaining concentrated juices, in order to reduce viscosity and avoid the phenomenon of gelation.
Filtering. This operation is necessary to ensure the transparency and stability of the product.
Preparation of sugar syrup. To prepare the sugar syrup, calculate and weigh the amount of sugar required for production depending on the variety of currants/gooseberries and the size of the mixture, then calculate the volume of water required.
Coupling. Assembling the ingredients to obtain the blend is based on two processes:
• a physical process, of dissolving the ingredients;
• a mechanical, mixing and homogenizing process.

The principle underlying the preparation of the blend is "what dissolves in what".
Packaging. The packaging of the products must process from fruits and vegetables must exclude any possibility of their contamination involving two distinct technological operations: dosing the product and closing the container.
Pasteurization. Pasteurization aims to destroy the remaining microorganisms in the juice to prevent it from spoiling during the warranty period.
Storing. The purpose of storage is to preserve the integrity and quality of the finished product.
Table 2 shows the material balance centralizer.

Table 2. Material balance for obtaining currant and gooseberry juice

Operation	The amount of incoming materials, kg/day	The amount of materials released, kg/day	Loss
1.Qualitative and quantitative reception	500	500	0%
2.Temporary storaging	500	490	1%
3.Sorting	490	475.3	3%
4. Washing	475.3	467.87	1.5%
5. Cleaning	467.87	463.2	1%
6. Crushing	463.2	460.9	0.5%
7. Pasteurization	460.9	459.75	0.25%
8.Cooling	459.75	458.6	0.25%
9.Enzymatic maceration	458.6	456.346	0%
10. Pressing	456.346	296.692	1%
11.Enzymatic clarification	296.692	296.707	0%
12. Filtering	296.707	293.729	1%
13.Coupling	1650.559	1642	0.5%
14. Packaging	1642	1,633.79	0.5%
15. Pasteurization	1633.79	1,633.79	0%
16. Storaging	1633.79	1,633.79	0%

Table 3 shows the indicators of the economic efficiency of establishing a currant and gooseberry plantation for the successful transformation of production.

Table 3. Calculation of economic efficiency indicators

Current Number	Indicator	Value
1	Turnover-T	1.237.721,70
2	Annual profit-A_p	189.254,084
3	Profit Rate-$P_r = T/A_p$	0.152
4	Payback period-$P_r = I/A_p$	6.5 years
5	The investment efficiency coefficient-$E_i = I/P_r$	190,418

Where: P- production = 163,379.00 liters of juice/season; I – investment = 1,237,721.70 Lei.

Conclusions

For currant culture, the most favorable soils are fertile, rich in organic matter, light, well-drained: alluvial, clay-sandy, clay-loamy and even clayey if they have good water drainage.

Gooseberry prefers deep, well-drained, loamy-sandy, sandy-loamy soils with a high humus content, with a pH of 5.5-7.5.

The main diseases and pests of currants and gooseberries are the followings: anthracnose, powdery mildew, rust, gray rot, leaf spot, stem borer, San Jose aphid and yellow aphid.

Currants and gooseberries are marketed in two quality classes: quality I and quality II - a.

Since currants and gooseberries are very perishable, a technological line for obtaining currant and gooseberry juice will be created with a processing amount of 500 kg/8 hours of operation. From the production of currants and gooseberries that will be produced starting from the fourth year of the plantation, 10% of the production will be sold fresh and 90% will be processed in the form of juice. The calculations resulted in a production cost of 5.79 lei/liter of juice and a minimum delivery/sale price of 7.57 lei/liter. The recovery period of the investment that will be made for the establishment of the plantation and the realization of the processing line is 6.5 years.

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Titanium joining - a brief review of the processes used on this material

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Abstract. In a few decades, titanium has gone from being used almost exclusively in top-secret aerospace projects to being used in the construction of custom car parts. Thanks to its incredibly high strength-to-weight ratio and excellent corrosion resistance, titanium will be used even more extensively in the future. There are various ways of joining titanium, one of the most used being welding. Titanium generally has good weldability, but welding it poses problems in terms of the danger of atmospheric contamination of the joint, as titanium, along with zirconium, beryllium, hafnium, and several other metals, has a high affinity for atmospheric gases. In this paper, the characteristics of titanium and its alloys will be presented, as well as the main processes for joining them by welding and a brief review of some examples.

Keywords: *welding, production, titanium, construction of custom car parts*

Introduction

Titanium represents about 0.6% of the Earth's surface, making it the fourth most abundant element after iron, aluminium, and magnesium. It is estimated that there is more titanium in the earth's crust than the sum of chromium, copper, nickel, zinc, and lead.

Although titanium is abundant in the earth's crust, its use only began around the 1950's due to the difficulties of mining, processing, and refining.

However, its unique properties have made it a key player in the aerospace, aeronautics, nuclear, chemical, and medical (implants) industries.

Depending on how it is processed, titanium is used in two ways:

- technical titanium, which contains about 0.5% impurities (about 0.3% nitrogen, 0.15% oxygen, 0.15% iron, 0.1% magnesium, 0.05% silicon).
- pure titanium, containing a maximum of 0.04% impurities.

Titanium has two allotropic forms: up to 882°C titanium α with a hexagonal lattice, and at temperatures above 882°C titanium β with a cubic lattice with centred volume. Because of the value of the hexagonal cell c/a ratio (c/a = 1.587) titanium exhibits sufficient slip systems so that it is a ductile metal and without ductile-fragile transition point. As the density is relatively low (ρ= 4540 kg/m3) the mechanical strength/density ratio is superior to all other metals. Therefore, at the same level of stress the titanium/titanium alloy part is lighter [1-5].

The corrosion resistance of titanium is excellent and superior to stainless steels. Titanium is resistant to dilute sulphuric and hydrochloric acids, chlorine gas, chlorine-based solutions, and most organic acids, but is soluble in strong acids. The very good resistance in chlorine-containing environments is due to a thin (approx. 100 nm) protective film of titanium dioxide that forms on the surface of the metal. Titanium burns in air at around 1200°C and in pure oxygen at 600°C or more, forming titanium dioxide. The melting temperature of titanium is about 1725°C. Therefore, the metal cannot be melted in open air because it burns before it reaches the melting point; for this reason, the melting process can only be carried out in an inert gas atmosphere or vacuum. Titanium is, also, one of the few elements that burns in pure nitrogen gas (above 800°C and forms titanium nitride, which causes loss of ductility).

Titanium is a paramagnetic metal and has relatively low electrical and thermal conductivity.

The metal retains its toughness at very low temperatures (-196°C) and has good fatigue strength. Titanium alloys exhibit good mechanical strength at high temperatures.

Titanium is sensitive to impurities such as nitrogen, carbon, oxygen, and hydrogen. It forms with them the solid α-insert solution, as well as a series of intermetallic compounds (hydrides, carbides, nitrides) which lead to reduced ductility, workability, and weldability.

The automotive applications using titanium follow logically from high strength, low density, and low modulus, and they have excellent resistance to corrosion and oxidation. Titanium is primarily used in internal combustion engine components, such as valves, valve springs, retainers, and connecting rods.

In the last few years, titanium has been adopted to fracture-split connecting rods, fuel tanks, and fuel cell separators of mass produced vehicles because of not only the development of titanium alloys in which low-cost alloying elements are added and low-cost processing methods are carried out by material producers, but also the cooperative development of material producers, part makers, and car manufacturers.

2. Welding behaviour of titanium and its alloys

The welding behaviour of technical titanium is mainly determined by:

- its particular chemical affinity to oxygen, nitrogen and hydrogen, both in liquid and solid state at temperatures above 650°C;
- its tendency towards overheating and growth of β-phase grains.
- formation of brittle α' phase on cooling.

The influence of hydrogen on the properties of the base metal and welded joints is mainly manifested by a decrease in resilience at both normal and negative temperatures. It has been experimentally shown that by increasing the hydrogen content in the technical titanium from 0.01% to 0.05%, the Charpy V strength at +20°C decreases from 6 daN·m/cm^2 to 1.5 daN·m/cm^2, practically without any change in the tensile strength and elongation. In addition, hydrogen is the main source of pore formation in titanium welding.

The nitrogen, oxygen, and carbon content acts primarily to decrease the plasticity of welded joints. Experimental researches have shown that increasing the oxygen content of technical titanium from 0.15% to 0.38% (at 0.02% nitrogen content) decreases the bending angle of specimens taken from 1.5 mm thick sheet metal welded joints from 180° to 100°. The same phenomenon occurs when the carbon content increases from 0.05% to 0.28% [6-11].

The alloying elements of titanium, which greatly decrease the plasticity of the joint (in order of effectiveness: Cr, Fe, Mn, W, Mo and V) result in the formation of the α' phase in the seam and in the thermally influenced zone, with disordered orientation and particular brittleness.

Like technical titanium, titanium alloys containing nitrogen, oxygen, hydrogen, and carbon in small amounts have good welding behaviour. Depending on the alloying elements contained in the alloys, the influence of these damaging factors is felt. For example, in titanium alloys containing aluminium, tin, copper or manganese up to 5%, the presence of 0.05% hydrogen in the seam practically does not change the strength value; at the same time, titanium alloys with

a similar molybdenum or iron content, with the same amount of hydrogen, show a marked increase in seam strength.

Preparation for welding surfaces

Regardless of the welding process applied, measures must be taken to prepare the surface of the joining sheets before welding.

In general, the surfaces of the sheets are covered with complex particles consisting of oxides resulting from the rolling process at relatively high temperatures and in an open atmosphere, grease, moisture, and dust, deposited or absorbed subsequently.

Removal of all impurities to achieve a welded joint free of pores and other defects can be done:

- mechanically by cleaning with a stainless-steel brush.
- chemically by pickling with a solution of 4% hydrofluoric acid, 40% nitric acid, 56% distilled water for 1...15 min.

If, however, the titanium sheets have been produced in a protective atmosphere, it is sufficient to clean the surface with a solvent such as methanol, ethanol, acetone, or any other substance that evaporates without leaving residues.

The surface of the sheet must be prepared to 25...30 mm from the edges that meet.

Both conventional and unconventional processes are used for welding titanium and its alloys. Conventional welding processes include WIG welding with or without filler material and MIG welding. The remainder are laser welding, plasma welding, electron beam welding and friction stir welding (FSW).

3. Welding processes used in titanium joining

3.1. WIG welding with or without filler material

WIG welding of titanium and its alloys is recommended for sheet thicknesses from 0.5 to 12...13 mm. Pure argon is used as a shielding gas, which is sometimes mixed with helium (maximum 25% He) for automatic welding. Pure argon means argon of at least 99.95% purity.

Welding in direct current, direct polarity, the arc is more stable than in reverse polarity welding; also, the electrode life and melting rate are longer.

WIG welding without filler material is used for joining 0.5...3 mm thick sheets. The joint is made in a single pass, without the need for edge machining and with zero joint width.

When access from both sides is possible, sheets up to 6 mm thick can be welded in this way.

Manual WIG welding with filler metal is used to join titanium sheets with a thickness of 0.8...6 mm.

Robotic or half-machined welding using the WIG process with filler metal is used to join 3...10 mm thick sheets with machined joints. Joining of sheets up to 6 mm thickness is carried out in one pass, and for greater thicknesses in 2...4 passes.

As filler materials for WIG welding of titanium and its alloys, rods with a chemical composition like that of the base metal are used.

According to ASTM, there are 31 classes of titanium with different plasticity, corrosion resistance and weldability. Therefore, special attention should be paid to the choice of filler material if it is to be used.

Before welding, both the wolfram electrode and the filler material must be cleaned to remove oxides, dust, moisture, and grease from their surfaces. This can be done with acetone or methyl ethyl ketone.

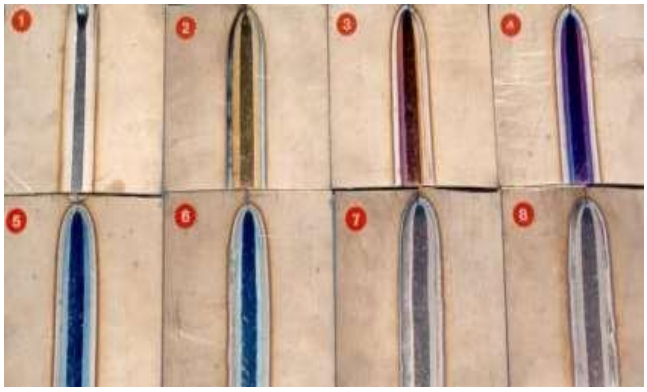

Figure 1. WIG welds in titanium sheet made successively by progressive contamination of shielding gas with air

Also, to prevent contamination of the weld joint, the end of the welding rod is cut off before welding.

Table 1. *Correlation between current intensity and wolfram electrode diameter*

Welding current	Diameter of Wolfram Electrode
< 125 A	≤ 1,6 mm
125 – 200 A	1,6...2,4 mm
> 200 A	2,4 mm; 3,2 mm

A particular case is the welding of pipes and tubes made from titanium or other reactive metals such as stainless steel and zirconium.

To prevent corrosion and blockage, pipes must be joined by good quality welds, which is not easy to achieve with conventional devices.

It is often not cost-effective to fill whole pipes with inert gas before welding and to maintain the gas supply both during and after the process. Also, in many of today's industries the welding area must be purged of oxygen down to 100 ppm (mg/l) or even less in the case of the food industry.

To overcome these challenges, Huntingdon Fusion Techniques (HFT) has introduced PurgElite, a range of affordable, inflatable tube and pipe purging systems ("purge dams") designed to drastically reduce the purge area, thereby reducing inert gas costs and welding time.

Each purge system features an IntaCal purge gas supply and a RootGlo positioning indicator light that allows the operator to ensure the system is accurately positioned, centrally within the tube or pipe.

HFT's innovative PurgeGate valve is available as an accessory and is suitable for all types of inflatable purge systems. The PurgeGate is a one-way valve designed to regulate gas flow and pressure during purging to prevent overfilling and bursting of purge dams.

Quick connect/disconnect fittings and o-rings to seal against gas leaks, fitted with an anti-release ring, are fitted to all systems to prevent accidental separation of component parts within the welded pipes.

Temperature resistant caps up to 300ºC are available as accessories to protect the inflatable 'booms'.

Interpretation of the colouring of a WIG weld in titanium

The following figure shows eight welds made in pure titanium by the WIG process, each with a different colour, and *Table 2* shows how to interpret the colour of each of these welds. It should be noted that the welds were made successively by progressively contaminating the shielding gas with air [8-13].

Table 2. *Colour interpretation of a WIG weld in titanium*

Nr. crt.	Colour	Interpretation
1	silver	Adequate, satisfactory protection
2	straw-yellow	Slight but acceptable contamination
3	open	Slight but acceptable contamination
4	dark straw-yellow	More pronounced contamination, but can be
5	dark blue	acceptable depending on application
6	light blue	Severe contamination unlikely to
7	blue grey	be accepted
8	grey	Very severe contamination, not acceptable

Some of the causes that lead to the colour change of a WIG weld in titanium are the following: - Insufficient gas protection at the root of the weld; - use of a filler material that does not contain titanium; - use of a gas nozzle of too small a size; - not using a weld shield.

3.2. MIG titanium welding

The MIG process for titanium is used to weld titanium and titanium alloy sheets with a thickness of 3...20 mm.

Helium (80%) mixed with argon (20%) is used as a shielding gas to increase the arc voltage and productivity of the process.

Helium has a higher ionisation potential than argon (24.5 V compared to 15.7 V) and therefore its introduction as a shielding gas lead to an increase in the calorific value of the arc and therefore to increased melting of the filler metal and base material.

The quality of the joint depends on the transfer of molten metal through the arc gap. Higher quality joints can be obtained by performing a very small droplet transfer of the type "spray droplets. For this reason, welding with thin wires (1.2...2 mm diameter) at high welding currents (160...220 A) is recommended.

MIG welding is carried out in direct current, both with direct and reverse polarity.

Welding of 8...10 mm thick sheets can be carried out in a single pass. Sheets thicker than 10 mm should be welded in several layers. For butt joining of 3...6 mm thick sheets it is recommended to use a V-shaped joint.

Table 3. *MIG welding parameters for different titanium thicknesses*

Thicknesses [mm]	I [A]	U [V]	Vs [m/h]	Gas flow (burner) [l/min]
3	200-220	20-25	22	35-40
6	300-330	22-27	20	35-40
16	400-420	25-30	25	40-45

3.3. Joining of titanium alloys by Friction Stir Welding technology

Although most common titanium alloys are generally weldable by conventional methods, problems can occur with distortion of the workpiece and poor weld quality. In addition, some of the more advanced titanium alloys (such as Ti-6246 and Ti-17) can be difficult to weld using fusion processes. The development of FSW offers the possibility of a new, cost-effective method of welding in high quality, low-deformation sheet and plate.

The first studies on FSW in Ti were carried out as early as 1995 as part of TWI's in-house research programme.

These initial welds were carried out in pure commercial titanium (grade 2) and demonstrated the potential of applying FSW to Ti alloys. A section through one of these initial samples is shown in the following figure.

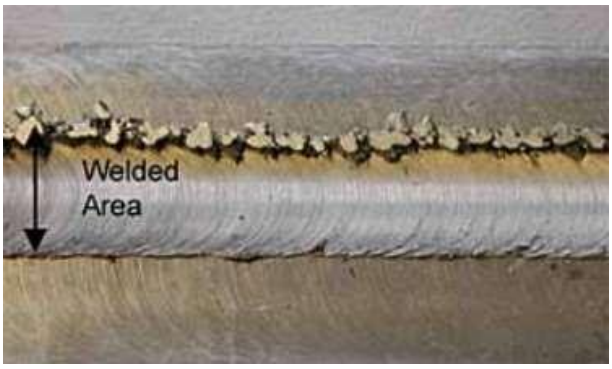

Figure 2. Section of an FSW weld in titanium produced at TWI in 1995

The darker areas in this section show where the material was heated above the β-transition line (approximately 900°C in this material). The lighter coloured areas of the weld were found to be untransformed but with significantly lower grain size.

Examples of FSW welding of Ti-6Al-4V alloy at TWI

Most of the work during the project sponsored by TWI Group on FSW of Ti alloys was carried out on 6.35 mm (¼ inch) thick Ti-6Al-4V plates. After identifying a suitable tooling material, an extensive program of weld testing was conducted to develop effective tooling designs and optimal process parameters for the 6.35 mm thick Ti-6Al-4V FSW plate. This ultimately led to the production of complete, high-quality FSW welds in Ti-6Al-4V, as shown in *Figures 3 and 4[9,10,11]*.

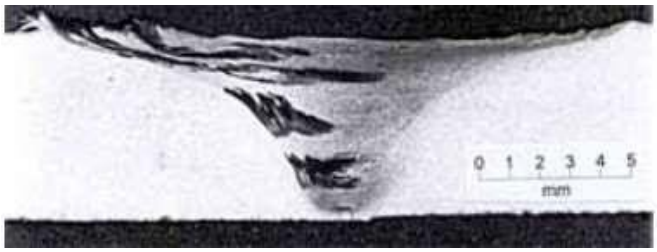

Figure 3. A quality FSW joint in 6.35 mm thick Ti-6Al-4V (photo taken from IWI)[11]

Figure 4. Cross-section of a 6.35 mm thick Ti-6Al-4V titanium FSW weld (photo taken from TWI).

3.4 Laser beam welding of titanium alloys

The industrial use of lasers for materials processing is increasing. Much of this growth is in conventional and thin materials.

However, high-power lasers, which could penetrate deeper, have paved the way for the use of lasers for welding unconventional materials and thicker plates. One such use is welding titanium alloys.

Titanium alloys are notable for being difficult to weld by conventional processes, and when electron beam welded there is the inconvenience of using a vacuum system. The high energy density and low amount of heat introduced into the base metal are characteristics of laser beam welding.

However, the rapid solidification and quenching associated with these characteristics affect the microstructure and properties of the weld, while atmospheric welding and specimen preparation influence the chemical composition of the fusion zone and its mechanical properties.

A case study on laser beam welding of titanium alloys will be presented below, highlighting the variation of mechanical properties of some welds made in Ti-6Al-4V as a function of plate thickness and the influence of the weld preparation mode of pure commercial titanium specimens on their hardness.

The titanium alloys that were used in this study are Ti-6Al-4V and pure industrial titanium, also known as ASTM B265-58T, mark 5 and B265-58T, mark 2 respectively. The titanium plates were 12.5 mm (0.5 in.) thick, and butt welded using unmachined joints [10-11].

The preparation for welding of the plate surface was the same for all plates except those referred to as "uncured" plates and/or welds. Preparation consisted of wiping the surfaces with acetone to remove dirt and grease, followed by immersion in 3% hydrofluoric-nitric acid pickling solution. This was done to remove contaminants in the form of titanium oxide and hydrocarbons embedded in the surface.

The pickling time was about 15 minutes, after which the plates were rinsed with distilled water and alcohol and then dried in nitrogen gas. This was done five minutes before welding to minimize the amount of oxide deposited on the welded surfaces.

A continuous wave (CW) CO2 laser with a power of 15 kW was used for welding.

Welds were made using an output power of 13 kW, with a welding speed of 11 mm/s (25 ipm).

Plasma suppression was provided by a tangential flow of helium, which was accompanied at the bottom and top by a gaseous shield also based on helium.

Weld alignment was achieved using a helium-neon (He-Ne) laser, coincident with the CO2 laser.

3.5. Electron beam welding joining of titanium alloys

Electron Beam Welding (EBM) is a process that uses a high-speed electron beam to join two metals. Electron beams are more precise than laser beams, generate more heat and allow the metal density to remain constant in the joint. The welded seam looks like a string of beads, but its internal structure is homogeneous.

Electron beam welding allows the joining of general and stainless steels in a delivered, annealed, or hardened condition. This process uses an electron beam to create a low-temperature arc between the parts to be joined. This process does not require the use of special joining fixtures or a large amount of heat and pressure to form high quality welds with a small number of contaminants, making it an ideal process for welding plates up to 76 mm thick and up to 1081x1551 mm in size.

A major aerospace company recently dropped an electron beam weld from a height of 14630.4 mm (48 ft) as part of an internal quality test, with the result that the joint was completely unaffected by the impact.

Electron beam welding is a natural choice when it comes to joining materials susceptible to oxidation, such as titanium, because the welding process must take place in a vacuum.

An electron beam can provide penetrations in titanium of up to 1.5" (40 mm), which is far beyond what any other process can provide.

Electron beam welding requires computer control of both the electron beam, the welding environment, and the positioning of the parts to be welded, resulting in high reliability and easy reproducibility.

Titanium parts can generally be welded without prior machining, as long as they are properly cleaned, and the electron beam welding process can be very cost-effective due to automation.

Weld preparation and decontamination

Before welding titanium, the joining areas must be thoroughly cleaned of all oxides and any hydrocarbon contaminants to ensure superior weld quality. This can be done mechanically, by sanding, grinding, scraping or, most commonly, using stainless steel wire brushes to remove oxides[16-19].

There are also chemical cleaning methods, such as immersion in caustic solutions and water, which can be effective. The chosen cleaning method is largely determined by the configuration of the part and the position(s) of the weld(s). Residues in the form of hydrocarbons on titanium are removed using acetone or alcohol-based solvents. Chlorinated solvents can form toxic gases when heated and should not be used around the weld area.

It is preferable that freshly cleaned titanium parts are welded immediately. If this is not possible, cleaned parts should be stored in airtight plastic bags that are filled with a neutral gas, such as argon or nitrogen.

Rules for preparing parts for welding:

- Do not use shop rags that may be contaminated with oil residue to clean parts. Use a clean cloth such as a cheese cloth or paper towels when you want to clean titanium surfaces with solvents.

- If residue needs to be removed from a part, use a bottled gas such as nitrogen or argon. Compressed shop air contains moisture and oil residue that can contaminate the weld area.

- First clean parts and joints using solvents, then clean them with a stainless-steel wire brush. Wire brushing before solvent cleaning usually leads to the embedding of hydrocarbons and other contaminants in the part, making solvents much less effective.

- Always use new or freshly cleaned stainless steel brushes to clean joint surfaces. Older, dirty brushes may contain oils and other contaminants. Brushes used to clean titanium should not be used with other materials, as metal shavings can be carried on the brush.

- Be sure to clean stainless steel wire brushes and etched metal surfaces thoroughly. Residual contaminants and by-products from the etching process can change the chemical composition of the weld pool.

- Frequently clean all wire brushes and scraping/spinning/cutting tools.

An example of a circular weld in a Ti-6Al-4V plate is shown in the next figure -13,14,15,16].

Figure 5. *Circular weld -Ti-6Al-4V*

4. Conclusion

As a conclusion, although titanium is a difficult material to weld, there are various methods of joining it, even other than those presented in this paper. The quality of a titanium joint is ultimately dependent on a lot of factors, from the properties of the material being welded to the skill of the welding operator or the welding parameters set, but if certain basic rules and principles are followed, obtaining a quality joint is not difficult.

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Municipal Solid Waste Management practices: Towards adoption of a Responsible Innovative Model for the City of Harare

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Abstract. This study took a historical retrospective approach to Solid Waste Management (SWM) focusing on how it started, how it became a growing concern with ripple effects to society and ultimately, how the City of Harare (COH) can adopt a sustainable and responsible innovative solid waste management practice. The study adopted a pragmatism philosophy, by making use of mixed method approach. 130 Google online forms and 6 key informant interviews were used to collect data from the respondents. Stratified purposive sampling was used to select the respondents in the 46 wards of Harare. Data was analysed quantitatively using descriptive and inferential statistics generated from the Google online forms, and qualitatively through thematic content analysis. The study found out that the COH's failure to effectively manage solid waste is due to the lack of resources and a lack of sustainable and innovative ways of SWM. Chi-Square test for the two variables was 0.61 and it is greater than 0.05. This shows that there is no association between the types of waste managed or collected and the strategies that they use to improve solid waste management. This led the researcher to accept H0 and reject H1. The study concluded that the adoption of a responsible and sustainable innovative model for the city positively impacted COH's financial performance. It was recommended that the COH improve its budget in sustainable and innovative means for SWM and adopt a cost leadership strategy to reduce its costs and enhance profitability. In conclusion to the above findings the researcher recommends technical and financial support to be given to the community based organizations (CBOs) in all their aims to manage solid waste and wanting to make Harare urban a clean city. Environmentally sustainable solid waste management practices guided by the principles of the integrated approach and invigorated by environmental education must be fully adopted.
Keywords: *Solid Waste Management, sustainable, responsible, innovation*.

Introduction

Management of Solid Waste (MSW) has continuously stood out as the foremost problematic issue for Harare Metropolitan city. The amount of solid waste created in the city is higher compared to the City of Harare`s (COH) capacity to contain the impasse primarily because of limited technical, financial and human resources that are required to parallel and control this challenge. By the year 2025, the Harare City Council aims on its strategic blueprint and on its main objective to attain a first-class city standard, (City of Harare, 2012). The strategic plan of the COH to achieve this, stresses a smart environment devoid of pollution in its operational parameters (Sani, 2018). This demands that there should be clean streets and regularised city activities. Compounded by the non-performing economy after the year 2000,

the city has been experiencing gross challenges including revenue generations and the incapacity of the citizens to pay. Overall, from 1980 to 2001, major cities realised phenomenal growth rates of about 5% per annum in population (Central Statistics Office (CSO, 1982; 2002). Incessant periodic droughts since independence, rural poverty and a shrinking communal farming space coupled with acute socioeconomic challenges continue to necessitate rural to urban migration with Harare being the most affected city. This study focuses on municipal solid waste management practices with a particular attention to City of Harare (COH). The study sought to explore the level of sustainable innovation for the COH waste management practice, to determine the effect of governance as a factor in Solid Waste Management (SWM) and recommend innovative and sustainable SWM strategies.

Background to the Study

Due to high unemployment and shrinking economic space, the majority of the rural to urban migrants become survival entrepreneurs whose activities are in the informal sector which is, in most cases unregulated. While their urban economic contribution is undeniable, it does not translate to the COH's revenue streams to necessitate the reciprocal proportional service delivery in tandem to their use of city space since they do not pay taxes and such fees to the authorities. On the other hand, the COH relies primarily on funds from the central government although these funds are not proportional to the population increase thereby worsening the diminishing overheads in per capita terms and council revenues. As a result, these unforgiving trends continue incapacitating the COH's response to planning, environmental management and basic service delivery (Tibaijuka, 2005). Furthermore, the increase in population growth is a cause whose effect is the rising generation of waste which finds its way to open dumps.

Population growth is synonymous with waste creation because it is believed that the larger the populace the greater the proportion of refuse creation (Medina, 2010). According to (Saungweme, 2012), the waste build-up in open spaces and roadsides is indicative to the miscarriage of service delivery by local authorities. Similarly, (Mafume et al., 2016) postulates that, in many Less Economically Developed Countries (LEDCs) in the SADC region, there is a mismatch in revenue collection in comparison to population growth thereby frustrating municipal solid waste management. The rate of escalating unofficial settlements across the length and breadth of the COH is reflective of the Council's failure to plan and appropriately manage solid waste at domestic level, (Chinobva & Makarati, 2011).

The Zimbabwean government acknowledges that population growth is the major impediment for the urban local authorities in coping with environmental and human health challenges related to the creation, carriage and discarding of SWM (Feresu, 2010). Feresu further highlighted that the majority of Zimbabwe's urban local authorities fail to meet the refuse collection and disposal demand due to the ever-increasing population growth. Mapira, (2012) buttressed this view by affirming that MSW is the major problematic area for urban authorities in Zimbabwe. Masocha & Tevera (2003) assert that about 60% of urban generated solid waste is discarded at official dumpsites 40% is disposed of illegally in undesignated areas that is to say in roadsides, alleys, storm water drains and open spaces. As a result, (Feresu, 2010) reaffirmed that improper disposal of waste pollutes the air, environment, underground water through leachate, ground water and breeding spaces for disease-causing-vectors.

Problem Statement

The COH is inarguably grappling with a multiplicity of challenges which include budgetary deficits; broken down equipment; ineffective and inefficient solid waste collection practices, unhygienic and poorly funded operations; incapacitated environmental control mechanisms; arbitrary illegal littering and dumping; solid waste open burning; and a general public insensitive to SW in their vicinity or to what symbolises responsible and sustainable innovative SWM practices. The effects of these problems is as a result of the COH's incapacitation in its solid waste management strategies. COH's management of solid waste practice therefore requires an immediate remedy that is sensitive to the conception and

effecting of lifelong responsible and sustainable innovative measures. The problem affects its performance and its goal of becoming a world class city by 2025.

Significance of the Study

The research focused at highlighting the possible policy together with practice gaps contributing to the growing problem of SWM for the COH. The paper helps universities and other stakeholders to have an understanding of the relevance of sustainable innovation in case of waste management practices. Furthermore, the study sought to enthuse central government to get a clearer view on facilitating and overseeing responsible, sustainable and innovative SWM. The study highlighted ways to enhance sustainable and responsible innovation in COH's operations and this helps government to implement policies with respect to the effective and efficient use of waste management practices.

Literature Review

Solid Waste Materials: Types, Composition and Location

SWM is the gathering, moving, treating, recycling or relocation, and inspection of SW created by human activities, aimed at reducing its impact on the wellbeing of the environment and its people (UNEP, 2006b). Waste is either fluid or solid and can be decomposable or non-decomposable matter (Hardoy et al. 2001). The average composition of MSW consists of 40-51% biodegradable, 32% fine materials, 10%plastic, 7% paper (United Nations Report, 2004). SW has become a predominant feature in our metropolitan environs giving rise to MSW challenges, (United Nations Report, 2004).

Solid Waste Management Legislation in Zimbabwe

Zimbabwe has numerous pieces of legislation that are in place to regulate how SW is handled and disposed of. The Environmental Management Authority is the regulating board under the EMA, Chapter 20:27 Act. In section 70 (1) of the Act, it states that "No person shall discharge or dispose of any waste in a manner that causes environmental pollution or ill health to any person". Any person, therefore, who has a direct contribution to the generation of waste is obligated to use methods that reduce the waste through handling, reclamation and reusing, among others. Furthermore, the EMA Act in section 83 (1) outlaws littering by declaring that: *"No person shall discard, dump or leave any litter on any land or water surface, street, road or site in or at any place except in a container provided for that purpose or at a place which has been specially designated, indicated, provided or set apart for such purpose".* (Environmental Management Act [Chapter 20:27]) The Urban Councils Act, 2015 declares that gathering, movement together with discarding of SW is the prerogative of town councils in areas of their administrative jurisdictions. The EMA Act and the Urban Councils Act form part of legislation regulating SWM in Zimbabwe.

Sustainable and Responsible Innovative Solid Waste Management (SRISWM)

The COH highly depends on landfilling to manage the bulk of its solid waste. Waste-to-Energy Technologies (WtE) innovation is a welcome renewable energy source that is responsible and sustainable. Waste is a striking all-seasons unusual source of fuel. In Africa, there are many benefits obtainable from the co-operation between (NGO's), (CBO's) and the government within the country. Lee-Smith and Stren (1991) posited that in order to have an essential framework for service delivery in African, the public had a better mediation role. Increased shortage of resources and a lack of innovative technologies create greening opportunities for the waste sector by the growth of the waste market. Globally, the waste market was estimated at 410 billion US dollars a year in 2011 from collection to recycling. This was excluding the large informal segment in LEDCs. UNEP reaffirmed this position by stating that recycling was more likely than not becoming a preferred factor for GWMS, moreover generating decent occupation for many (UNEP/IETC, 2011).

Lombardi, et al. (2015) suggested that incineration was most preferably the most advanced technology to create energy from waste. This involves high temperature furnace burning of waste while

the heat produced is used for electricity generation or heat itself as a resource. Residue and exhaust gas are by-products that can further be processed into construction materials while metals can be removed for recycling. Mostly, up-to-date incineration plants have energy generation adeptness of about 30%. Assimilated Waste to Energy (WtE)-Gas Turbines electricity generators have been poised to increase energy efficiency to at least 40% and in 2012, only Spain, Netherlands and Japan had three of these plants (Branchini, 2012). While this technology is yet be considered matured, the assimilated gas turbine classification appeared to be the future of WtE incineration technologies.

Incineration is believed to be the most preferred option relating to capacity, category of waste cured and capacity decrease (Bosman et al., 2013). The prospective residual economic contribution is an additional advantage of the technology. However, Evans (2016) argued that WtE incinerators are costly among negative impacts to society and the environment. He further substantiated this opinion by stating that establishment costs of WtE incineration infrastructure are very high and people are ordinarily opposed to living close to incinerators due to the adverse living conditions around the site. Toxic gases, dioxins and polluting metals, all products of incineration are injurious to human well-being and contaminates the atmosphere. Nevertheless, it is notable that the amounts produced have lessened due to extensive technological progression in the past few years as a result of governments imposing stringent rules (Scungio et al., 2016).

According to CEWEP (2017), Europe has successfully implemented the technology of WtE incineration. The United Kingdom, Sweden, France, Italy and Germany are the largest investors in this technology which reduce the level of waste disposed of in landfills by 90%, (EU Data, 2016). Incineration allows investors to reduce the volume of waste disposed of in landfills by 90%. Consequently, 26% of waste In European Union (EU) countries, was used to produce energy in 2015 (Sandford, 2017). The energetic valorisation symbolises 1.3% of ultimate electricity usage and 8.9% of heat usage. In 2012, the number WtE plants that were recorded was 409 in the EU and these accounted for burning 74 million tons generating 30 TWh of electric power in addition to 74 TWh of high temperature (Union européenne, 2015).

Theoretical framework

The study adopted the Concept of Institution by Scott (2001) in conjunction with Capacity Building by (Janicke, 1997). These two theories were instrumental in identifying the COH's institutional makeup of Municipal Solid Waste Management (MSWM) systems.

Institutional Concept

Legal systems, government structures and constitutions are formal forms of rules which form the basis upon which an understanding of the concept of institution is attained to embrace casual facets of life. Mungure (2019) postulates that there are three pillars of institutions that are significant. Notably, these are cultural cognitive, regulative and normative systems which Scott (2001) has acknowledged as crucial ingredients of institutions. It is important to regard these three pillars as contributing factors to the interdependent ways and the social framework fabric that binds responsible, sustainable and innovative MSWM togrether. Accordingly, this provides an understanding of how MSWM in a social system can be implemented. The theory brings in the Normative Pillar, Cultural Cognitive Pillar and Regulative Pillar. The theory is useful in the study since the COH is a powerful actor with legitimate power to craft rules and laws and to enforce them for the council to exercise its right for ensuring that residents' wellbeing is achieved.

Capacity Building

Capacity building was adopted in the study to ensure improved performances in providing a thoughtful correlation linking institutions to capacity building in the way organisations are run. Effective management of solid waste in African cities is impeded primarily by insufficient capacity. Mungure (2019) avers that a well-organised, successful and environ-friendly solid waste disposal calls for the construction of organisational competence in both private and public sector administration. This, he

further buttresses, includes the technological competence for operational needs. According to Mungure (2019), there is a dearth of technical knowhow and financial knowledge in many SWM employees from all sectors to operate effectively and efficiently. Therefore, creating competencies across all levels require training. This means that to achieve responsible, sustainable and innovative MSW, there is need for capacitation for all personnel engaged in SWM. Capacity building and Institutional theories are insightful to what an establishment or organisation ought to be. This discourages individualism among actors and encourages group work hence illustration of its relevance in the research for MSWM.

Understanding Solid Waste Management Challenges: Global, Regional, National Trends and Context

SWM is the practice of gathering, keeping, handling and discarding of SW such that it is not hurtful to animals, plants, humans, and the environment generally (Williams, 2005). SW can be described as "any substance or object in solid form which the holder discards or intends to discard" (Waste Framework Directive 75/442/EEC, 1975, Article 1 (a). Williams, (2005) however contends that refuse is subjective in that what may be considered waste by one person may be a resource to another.

Some people dispose of their waste through the process of incineration. They burn their waste at home in the backyard, a process that is easy and inexpensive. However, burning causes air pollution, destroys soil nutrients and kills small insects that take habitation in the soil. Khan (2003) quoted in Chirisa (2013) defines solid waste as "…material that is cheaper to throw away than to store or use." This can either be organic or inorganic material that can be separated for recycling or reuse in society. Organic material decomposes and can be used as manure in farming whilst inorganic material can be recycled for reuse. Only solid waste that is not fit for reuse and recycle should be transported to the landfill.

Research done by Gumbo (2005) discovered that individual residents were dumping between 0.481 kg and 0.301 kg per day of SW and 60–80 % was compostable or eco-friendly refuse. These statistics stood similar to generation proportions in other urban global cities. 50% of this SW were food-stuff left overs with a 50-70% moisture content. The remainder was biodegradable SW made up of tree leaves, natural grass, crop residues and weeds (yard waste). Crop residue is prevalent in Harare due to urban agriculture which has since been accepted as a contributor to the ecosystem, generation of income and health nutrition.

With regards to the disposal of waste, residents are not experiencing a higher level of satisfaction because there has not been improvement in environmental management since independence. In residential areas, only a small percentage of the population separate organic from inorganic waste whereas the majority throw all their waste in the waste bags without systematic separation (Sinthumule and Mkumbuzi, 2019). Afroz et al. (2011) indicated that the majority of people in Bangladesh do not separate waste they dispose of because they do not have time, recycling facilities and incentive. This is the same trend in Harare where people throw solid waste anywhere when they are outdoors because the waste bins are few and unevenly distributed. Bins provided for use in the city are stolen or destroyed. The city has no by-laws or power to arrest culprits who litter or vandalise its assets.

The Problem of Open Dumps: Global, Regional, National Trends and Context

SWM is not only a techno-practical challenge, it is largely affected by economic, political, socio-cultural, resource availability and the environment. These factors are intertwined into complex WMS, (Kum et al., 2005). Urban centres in developed economies generate large volumes of SW and have the capacity to effectively manage SW, (Srinivas, 2003). Research has demonstrated that solid waste that is created in developed nations is evacuated and arranged in a protected and proficient way as proved in these urban areas. UNEP (2002) highlights that most solid waste created in these urban communities is sorted at collection point before it is transferred to landfills. In opposition to this, urban centres in developing nations in Sub-Saharan Region, for example, Harare (Zimbabwe) are still in the process of accomplishing better solid waste administration frameworks since they currently have an inadequate strong waste gathering and poor transfer frameworks (Srinivas, 2003).

SW in LEDCs symptomatically has an extraordinary amount of carbon-based material in comparison to first world cities. For instance, researches carried out in Africa projected that in Juba-South Sudan, carbon-based waste represented approximately 31% of all generated waste by weight (UNEP, 2013), 61% in Ghana (Miezah, Obiri-Danso, Kádár, Fei-Baffoe, & Mensah, 2015) and 54% in Ethiopia (Getahun, Mengistie, & Haddis, 2012). The extraordinary carbon-based content has repercussions for WM comprising reprocessing, but also a prospective cause of ill-health if managed badly.

Desta, et al. (2014) found out in their study that more developed countries produce larger quantities of solid waste than developing countries but the garbage does not pose any challenge in the former. The municipal solid waste creation rate in Addis Ababa was 0.5kg/person/ day whilst in New York City it stood at 4.6kg/person/day (PlanNYC, 2013).

Consequently, the waste creation rate of New York City was 9 times that of Addis Ababa. Desta et al. (2014) found out that the poor municipal solid waste management in Addis Ababa was as a result of unlawful disposal of waste on undesignated sites, open disposals, limited, defective operating equipment, inadequate governance in the waste management system, lack of effective public participation and poor condition of the final dumpsite.

Desta et al. (2014) recommended early key stakeholder engagement and involvement at the planning stage to improve residents' buy-in. 92% of Bulawayo residents, according to the research done by Mudzengerere and Chigwenya (2012) were given refuse-collection bins. Notwithstanding, only 48% were putting environmentally friendly plastic refuse bins to use. They additionally deposed that the only official dumpsite for the entire city is an open dump although it is not accessible to individuals other than the council workers and those authorised to dump. Contrarily, this provides an opportunity for employment creation through recycling of waste.

The study findings done by Chinobvu and Makarati (2011) during their study of SWM in the Highfield suburb of Harare in Zimbabwe indicate that SWM infrastructure is too expensive to run, too old, and largely inadequate. They recommended that residents should be informed on the practicability of the three Rs (reduce, reuse and recycle), compositing and sustainable waste disposal. In Chinhoyi town, Musademba et al. (2011) in their study found that the failure by local authorities to provide safe potable water was a result of ineffective SWM primarily because of irregular waste gathering and disposal which resulted in communicable diseases such as cholera and typhoid.

Jerie and Tevera (2014) in their City of Gweru studies asserted that biodegradable material such as incinerable waste in the form of paper, textiles and rubber and vegetable waste constitute the large amounts of solid waste which is disposed of irresponsibly, unsustainably and with no innovation. Further, they indicate that the City of Gweru is marred by a heightened dearth of transportation equipment for gathering waste notwithstanding the high rate of waste generation for the city. Their study concluded that apart from the erratic SWM for the City of Gweru as evidenced by some waste collectors leaving behind some waste during collection, 32% of their respondents showed a willingness to recycle the waste (Jerie & Tevera, 2014).

Makarichi, et al, (2019) contend that either 6.4% of the commercial and service sector energy consumption or 3.2% of current residential energy consumption can be recovered from MSW Incineration. The gasification probable output was approximated at 4.4% and 8.8% respectively. The study showed that thermal MSW treatment with energy recovery can increase the share of biofuels and waste to electrical energy production in Zimbabwe from 1.3% to at least 2.2%. Given the results reported in this study, the implementation of WtE in Zimbabwe can go a long way towards meeting the challenges related to poor solid waste management. An overview of similar studies in selected African cities shows that more research and promotion is necessary to facilitate the adoption of thermal MSW treatment, (Makarichi et al., 2019).

Methodology

The researcher adopted the pragmatism philosophy as a research paradigm in this study. Pragmatism research philosophy accepts concepts to be relevant only if they support action (Saunders et al., 2012). The researcher adopted the pragmatism philosophy since it accepts that "there are multiple realities out

there that are open to empirical inquiry" (Creswell & Clark 2011). The study took the mixed approach to broaden the scope in understanding Municipal Solid Waste Management (MSWM) for the COH. Mixed approach design helped in triangulation between quantitative and qualitative data for a deeper understanding of a subject under review (Hashemi and Babaii, 2013). The target population included Harare City Council officials (both elected and technocrats), residents and Residents Associations and senior officials from government departments. Data was collected from Council, ordinary residents, Department of Works, Department of Health, the Council Municipal police and the Environmental Management Authority (EMA) respectively.

The study took the stratified sampling method as the most preferred method so as to have all institutions being represented. Stratified purposive sampling was employed to select key informant interviewees. A total of 130 participants were used. Purposive sampling was used to select 6 key informants for interviews. Google Online Form Questionnaires with closed-ended questions to collective quantitative data. In order to address the validity and reliability of the study, Cronbach's Alpha was conducted.

The results of the reliability test indicates the level of internal reliability and consistency in the questionnaire that was used. This therefore proves that the study addressed the quality control tests for the study. The study indicates a Cronbach Alpha of 0.920 which indicates that reliability of the research instrument and questions asked was very high. Therefore, further test can be conducted.

RESULTS, ANALYSIS AND INTEPRETATION

Table 1. Response Rate

Data Collection Method	**Number of Targeted Respondents**	**Number of Actual Respondents**	**Response Rate**
Questionnaire	130	104	80 %
In-depth Interviews	6	4	66.70 %
Total	**136**	**108**	**79.41**

Source: Survey Data (2021)

130 residents were targeted for the study sample for the 46 wards in Harare. 6 key informant interviews were scheduled for the stakeholders directly involved with service delivery.

Rating of solid waste management among other competing urban challenges

Firstly, it can be noted that there were about one hundred and four responses from the study. Ninety responses came from different wards in Harare high-density suburbs, medium-density and low-density suburbs namely Hatfield, Greendale, Mt pleasant, Dzivarasekwa, Mbare, Waterfalls and Sunningdale to mention just a few.

The highest response and average rate were 7.8 % which came from Marlborough, a low-density suburb because people living in these areas are capable to afford the internet, have better living conditions and have better income levels. The moderate response was 3 % on average and came from medium-density suburbs mostly due to the fact they can afford the internet and are capable to afford the bills. The lowest average response rate was 1 % because the wards have low-income levels such as Dzivarasekwa and Mbare.

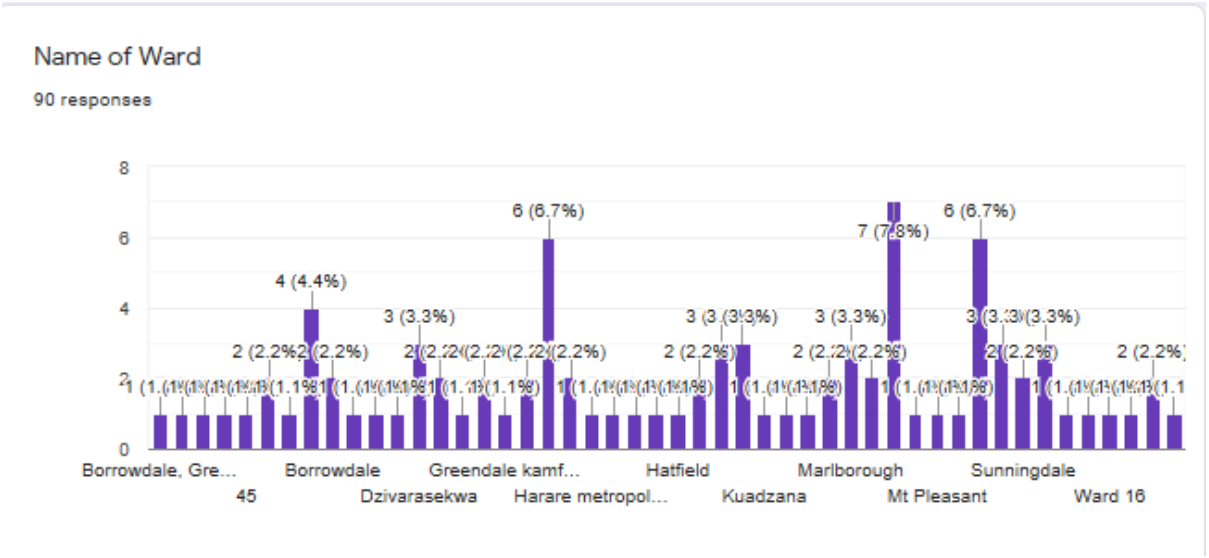

Figure 1: shows the ninety responses that can from different wards in Harare (Survey 2021).

The level of sustainability and responsible innovation for the COH waste management practice

The relationship between different wards in SWM

In carrying out this study, the researcher noted that there are 46 wards in Harare Metropolitan Province. The highest ward which contributed most was Ward 5 with 9% as a result that waste management practices were poor and there was need for a revamp. The second ward which contributed was ward 41 with 6% because the ordinary residents were complaining that waste management was collected twice a month by the local authority. During the study, it was noted that generally, most wards in Harare constituted 1% as a result of poor waste management,

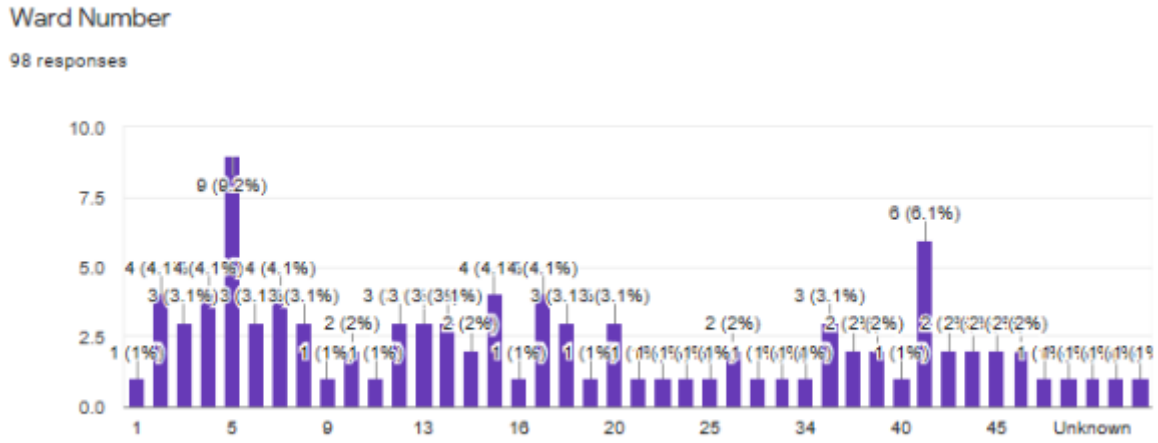

Figure 2. *The relationship between different wards (Survey 2021).*

Relationship of Crime, power and water shortages in SWM in different wards

Crime increased from 10-20% across most wards in the past few years. The highest percentage crime rate during the study was 39 %. This was due to the unlawful ways including burglary, inconsequential stealing, car break-in, and household attack hence the criminalisation and monopolization of removing waste by the COH, especially in high-density areas, where nearby illegal dumpsites have become criminal hide-outs apart from other potential risks of causing waterborne diseases. The moderate crime

rate was 21% and the lowest recorded was 2% in different wards. The conclusion which can be drawn from this study is that the crime rate is generally increasing in all wards. Also, in tandem with crime increasing, most wards have experienced an increase in power outages with thirty-three 33% as the highest percentage from different wards during the study. The incessant power shortages were necessitated by the limited electricity generation capacity at the Lake Kariba South Power Station coupled with lack of foreign currency to supplement the power supply by electricity imports from the region.

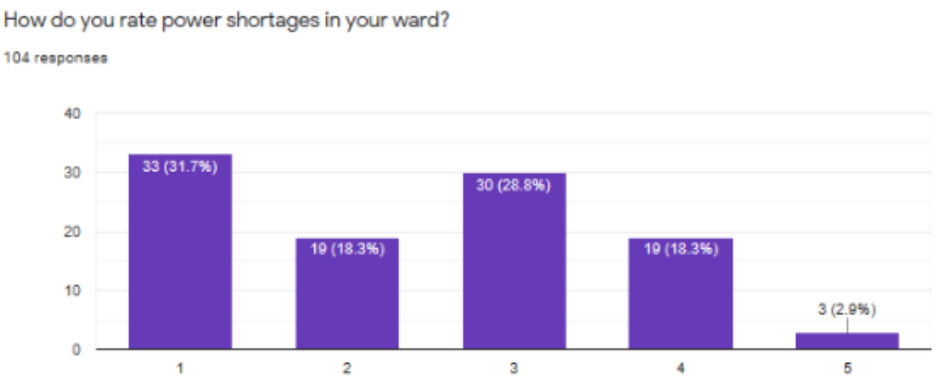

Figure 3: shows the increase of power shortages in different wards (Survey 2021).

The increase of water shortages in different wards

There was an increase in water shortages in different wards in Harare, the highest water shortage percentage was 37 % during the study from the one hundred and three respondents. This was because the city does not have adequate potable drinking water. Resultantly, millions of people are at their breaking point and the risk of cholera or typhoid epidemic that could infect the entire population since there is poor waste management and people are suffering from acute water shortage at home after the main waterworks were shut down. The moderate rate of water shortage percentage was 19% during the study because city authorities said that the drinking water crisis is caused by a lack of foreign currency to pay for the water purification chemicals necessary to purify drinking water that is supplied by dam reservoirs. The lowest rate of water shortage percentage was 1% because most residents resort to fetching clean water from boreholes that are scattered within hard-hit areas facing major water challenges rather than relying upon COH's tap water which seldom is available and dirty whenever it is available.

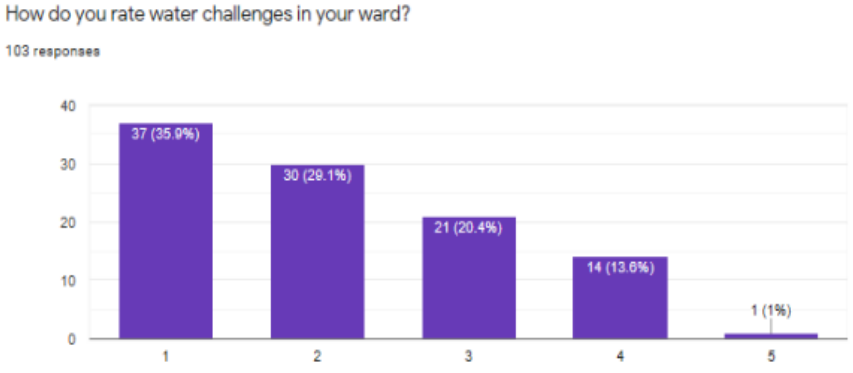

Figure 4: shows the increase of water shortages in different wards (Survey 2021).

Many significant costs that include driver stress, lost time, accidents and air pollution through vehicle emissions are incurred by motorists due to the failure of traffic signals. Traffic congestion and noise pollution were noted to be increasing in different wards gradually with the highest traffic congestion percentage being 31 % during the study from the one hundred and three respondents. This was because the traffic congestion issue is also exacerbated by the residents who are formally employed, those running their businesses and the informal traders usually travel to and fro the CBD at the same time thereby causing congestion. Noise pollution had the highest percentage of 28% as a result of traffic congestion which is usually caused by motorists wanting to move at the same time. More so, water pollution was also experienced in different wards during the study, it can be noted that the highest percentage was 33% and its lowest 4%. The highest water pollution was also experienced due to lack of refuse collection by city authorities, as the Combined Harare Residents Association (CHRA) noted.

The increase of waste management challenges in different wards

In August 2020, the Combined Harare Residents Association (CHRA) petitioned the Parliament of Zimbabwe over poor service delivery primarily the provision of potable water and refuse collection but there has not been traction over the issue. Currently, the City of Harare has (14) fourteen functional refuse trucks to service forty-six wards of Harare most of which have surpassed their life span. Solid waste management (SWM) refers to the gathering, transportation, handling, reusing or transfer, and checking of solid waste materials produced by human activity, and is for the most part attempted to decrease their impact on wellbeing and the environment. During the study, the researcher noted that waste management identifies with materials delivered by human exercises and is embraced to decrease their impacts on human wellbeing, the environment and aesthetics. Waste management challenges were very high with a percentage of 35 % due to the result that the COH has been grappling with challenges of removing sprouting dumpsites in most suburbs due to the non-collection of waste by the local authority caused by a depleted fleet of refuse trucks. CHRA (2021) argues that *"Most of the challenges faced by the COH in this regard have more to do with a management crisis primarily caused, by the interference of the Local government Ministry on the affairs of the City. Key decisions are superintended over by the Minister of Local Government thereby clipping the hands of the council to execute on their primary responsibility, that of service delivery."*

Figure 5: shows the increase of waste management challenges in different wards (Survey 2021).

The City of Harare's failure to regularly collect waste is no secret. While the city has a statutory mandate to collect and manage waste, this study noted that the city could not deliver and that the poor state of affairs on waste management is a testimony to this failure. Thus, mechanisms to boast the city council's capacity to deal with waste management challenges should be explored to avert a potential environmental and health catastrophe. This is because this study has shown poor planning and

misallocation of financial resources as one of the reasons for the poor waste management situation in the city.

Consequently, the HCC was only managing to collect and dispose of 54% of the 1400 tonnes/day of waste generated within the city due to shortages of fuel and the much-needed foreign currency for the repair of an old fleet of vehicles and equipment. This was also evidenced by the fact that the City Health Department now had on paper, 40 refuse collection trucks but only 8 to 14 of them were operational consistently. Litter in some suburbs went for up to two months without being collected. The uncollected waste remained strewn on the ground, littered in open drains or garbage dumps, often resulting in municipal sewer and storm water drains blockages. However, the city's litter crisis is not over as residents from these wards studied continued to dump litter on undesignated open spaces as soon as their bins filled up.

Strategies used for waste management

From the study, the researcher noted that refuse burning was very common in high and medium-density suburbs. This was evidenced by the highest percentage of about 32 % as a result of the fact that the residents depend on burning as a strategy to minimise the huge waste used. CHRA (2021) asserts that *"City of Harare has (14) fourteen functional refuse trucks to service forty-six wards of Harare of which most of them have surpassed their life span."* As a result of this, there is high criminalisation and monopolization of removing waste, especially in high-density areas, where dumpsites have become potential risks of causing waterborne diseases.

During the research, different strategies used for waste management were noted. These include reuse and burying and these were on average very common with a percentage of 30% because Harare residents are forced to employ better solid waste management strategies since the COH has an inadequate solid waste collection and poor disposal framework. Waste practises like sorting, recycling, reducing, and refuse are undertaken whilst most urban authorities usually concentrate on collection, carriage and disposal of waste at the waste dumpsites because of limited financial, human resources and expertise. Therefore, the residents have adopted the 3Rs Concept that is Reduce, Reuse and Recycle to mitigate the unending challenges of waste because waste in general is very subjective; one may deem an item to be waste whilst another might see it as a resource.

In addition, composting is on average a very fair practice commonly known by residents in different wards with a percentage of 35% and separation with a percentage of 33%. This was because the nature of each industry or sector varies thereby necessitating the employment different strategies for management.

The dynamic nature of consumer/end-user products, packaging materials, environmental regulations and public attitudes has made the development of solid waste management strategies an increasingly complex task. Informal waste pickers contribute significantly to waste management separation and resource efficiency by collecting, sorting, trading and sometimes even processing waste materials. Therefore, the researcher noted that house to house collection of solid waste methods should be more organised by using the methods such as the collection of daily waste by using proper scheduling and timings. Maintaining proper recycling units will save valuable raw materials and resources of the country and helps us to reduce the need for landfills space. Promotion of the waste management systems will upgrade the living and the working condition of the waste pickers and other marginalized groups.

Waste management as a challenge

Waste management is a challenging issue from an environmental, political, legal and social point of view. During the research, the researcher noted that managing paper and plastic is very demanding with high percentages (paper 33% and plastic 35%). This has been so because people rarely recycle. However, in recent years, significant progress has been accomplished in solid waste management, through the increased allocation of funds, focusing largely on the promotion of recycling and the expansion of the number of managed sanitary landfill sites throughout the country.

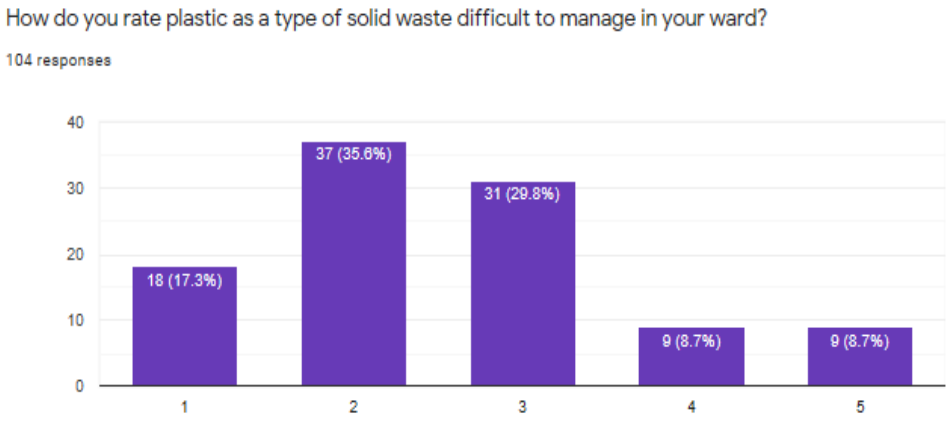

Figure 6: shows plastic as a type of solid waste management (Survey 2021).

In carrying out this study, it was noted that the management of rotten fruits and vegetables was fair with an average of 36 % for fruits and 42 % for vegetables. This was because fruits and vegetables are biodegradable since they easily rot.

Open dumps were very problematic in different areas and wards. The highest percentage for open dumps was 39%. This is so because garbage thrown in the street or open spaces creates a public health hazard, while waste dumped near rivers, lakes and streams contaminates the water supply. Open dumps recorded the least percentage of 6% especially residents that stay in low-density suburbs. Therefore, garbage dumped in the countryside or open dumps is not simply an eyesore but entire landscapes are ruined and unique habitats for flora and fauna are lost.

Analysing the information from the study, 20 and 26% were the present collection average rate and is below 7% in several wards in Harare. However, this may be overestimated by the municipalities due to the lack of scientific recording systems. Citizens dispose of waste within their compound either by unscientific composting, open burning or throwing the waste in the surrounding open space. Collection, city cleaning, and sweeping are not done daily except in main markets, along main roads, and in some residential areas. The rest of the areas are served intermittently from twice a week to twice a month or are not served at all. Therefore, service delivery is very low.

Strategies for SWM in different wards

Clean-up campaigns from the study were noted that on average range from 17% and the highest campaign ranging from 38% as a result that clean-up campaigns are also undertaken by the CBOs and they are supported by City of Harare.

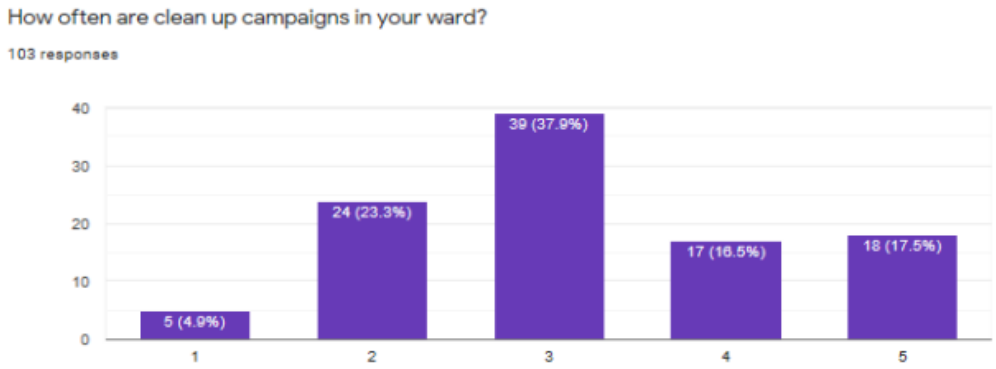

Figure 7: shows clean-up campaigns from the study (Survey 2021).

The practice of recycling by collecting recyclable solid waste is common practice in different wards by different organisations and from the research, the highest percentage practised is 34%, practice for this recyclable solid waste is common practice with an average percentage of 17% due to the method of the 3Rs is showing effect because the community-based organisations are engaged in solid waste collecting, sorting, recycling and reusing. The recycling method has proved to be a huge success because the products that they are making can be sold. They are making baskets, doormats, hats to mention just a few and the products are sold.

During the research, it was shown that it is very possible to have a local waste disposable site, the highest percentage reached being 32 %, this was visible because there is need for a monitoring and evaluation system that helps to analyse the quantity of the waste generated on a daily basis that will help to overcome the challenges. However, it is very low and disagreed to have waste disposable site from the study showing the lowest percentage 10% because the problems facing the COH include waiting for the central government's resolution and approval for land acquisition of proposed landfill sites, lack of technical support, financial constraints, problems in area selection, and strong opposition from nearby communities. Political interference has also been observed in many municipalities as well as technical problems such as flooding, shallow water table, highly permeable soil, and slope instability.

Figure 8: shows how if it is possible to have a local waste disposable site (Survey 2021).

Participatory members are very low in participating strategies for solid waste management with a percentage of at 4% because the demand is higher for other public services in many municipalities and local bodies are experiencing difficulties in developing management plans due to the lack of SWM baseline information and data related to the functional elements of SWM. It is essential to know the quantity and composition of MSW when designing and implementing proper waste management plans that include resource recovery through appropriate methods.

Relationships between mobilizing resources and SWM in different wards

How politics mobilise resources for SWM

The researcher noted that politics to a lesser extent find it difficult to mobilising resources as evidenced from the study that more response rates disagreed. This has been due to t the fact that since the attainment of independence in Zimbabwe, waste management in Harare has been treated as a political football. Responsibility for waste management has changed hands from one department to another within the City of Harare. Unfortunately, each change further deteriorated the system, bringing it on the verge of collapse. Before 1996, the Department of Works was responsible for waste management in the city. This responsibility was transferred to the City Health Department in and after 1996. It was during

this period that the HCC contracted out 56% of the refuse collection to some private companies with the City Health Department retaining responsibility for the remaining 44%. Therefore, the unbundling of waste management was meant to cope with the ever-increasing population of Harare, which is currently estimated to be around three million.

It was found that it's very hard and very low to mobilise finance funds for SWM from the research as noted by lowest percentages during the research f 5 % and 12 % respectively. This is due to the reason that huge finance is needed for best SWM, According to CHRA states that;

"The situation with the COH regarding SWM is quite despicable. The council is failing to meet up to the challenge of the ever-growing demand for proper solid waste management from the basic transportation and disposal of refuse from the length and breadth of the 46 wards of the COH. Right now, the COH is considering procuring new refuse trucks amid revelations that they are no longer pursuing the 15 refuse compactors they bought from FAW Zimbabwe (Mass Breed Investments) but the trucks were never delivered. These financial leakages are the COH's greatest u doing as far as effective service delivery is concerned primarily SWM."

How technology mobilise resources for SWM

Also, it was found to be very achievable to mobilise technology for SWM from the research as noted by moderate percentages during the research f 37 %, 29 % and 21 % respectively technology will change outdated and bring in new innovative ideas. The use of GIS will enable new landfills to be created effectively. The dissemination, updating, and management of simple information will play an essential part in improving planning by the local bodies and monitoring implementation progress. However, technology is costly in our HCC as evidenced by the Acting Mayor for Harare City Council, Councillor Stewart Mutizwa appealed to the public to help with any resource that can assist the city in clearing dumpsites and refuse collection. This happens at a time when the COH has been grappling with the challenges of removing sprouting dumpsites in most suburbs due to the non-collection of waste by the local authority caused by a depleted fleet of refuse trucks.

From the study, the most commonly used technology is the bum with 31 %. The bum was used at the highest percentage because it's an easy method to dump waste. Secondly, the recycling was the second-highest method used during the study because the recycling method has proved to be a huge success. After all, the products that they are making can be sold. They are making baskets, doormats, hats to mention just a few and the products are sold.

Figure 11: technology used in SWM (Survey 2021).

Statistical testing of waste managed and the strategies to improve SWM

The Chi square was used by the researcher as a statistical testing and the types of s**o**lid waste management and the strategies used by the researcher.

Hypothesis

H_0– There is no association between the types of waste collected and the strategies that are used to improve solid waste.

H_1 – There is an association between the types of waste collected and the strategies that are used to improve solid waste.

Table 2: Chi-square test

	Value	df	Asymp. Sig. (2-sided) Pearson
Pearson Chi-Square	4.479a		.612
Likelihood Ratio	6.311	6	.389
No of Valid Cases	30	6	

11 cells (91.7%) have expected count less than 5. The minimum expected count is .20.

Basing on the information shown in Table 3 for the Chi-Square test for the two variables was 0.61 and it is greater than 0.05. This shows that there is no association between the types of waste managed or collected and the strategies that they use to improve solid. This means that there is no one unique strategy that is used but rather all the strategies can be used to improve solid waste despite the type of solid waste. The main objective is that the waste be managed despite the strategies used. This led the researcher to accept H0 and reject H1.

Perception on Environmentally SWMS

According to "Chapter 20:27 Environment Management Act (Effluents and Solid Waste Disposal) Regulations, 2007 ,14 (1),""Every local authority shall designate suitable sites as waste collection sites within its area of jurisdiction for the management of wastes and ensure a waste collection frequency that minimizes accumulation and avoids decomposition of waste on collection sites." Waste management was viewed differently by interviewees as one said that *"The situation with the COH regarding SWM is quite despicable. The council is failing to meet up to the challenge of the ever growing demand for proper solid waste management from the basic transportation and disposal of refuse from the length and breadth of the 46 wards of the COH. Right now, the COH is considering procuring new refuse trucks amid revelations that they are no longer pursuing the 15 refuse compactors they bought from FAW Zimbabwe (Mass Breed Investments) but the trucks were never delivered. These financial leakages are the COH's greatest u doing as far as effective service delivery is concerned primarily SWM. As CHRA, we have in August 2020, partitioned Parliament over the matter but there hasn't been traction over the issue. Currently the City of Harare has (14) fourteen functional refuse trucks to service forty six wards of Harare of which most of them have surpassed their life span."*

An official from the Department of Waste said, *"One of our councillors, Hatcliffe Ward 42 Councillor, Elvis Ruzani was arrested by police for clearing a dump site at Matombo area in Hatcliffe and later released without charge. This happened barely a week after the Acting Mayor for Harare City Council, Councilor Stewart Mutizwa appealed to the public to help with any resource that can assist the city in clearing dumpsites and refuse collection. This happens at a time when the COH has been grappling with challenges of removing sprouting dumpsites in most suburbs due to non-collection of waste by the local authority caused by a depleted fleet of refuse trucks. Therefore the criminalization and monopolization of removing waste, especially in high density areas, where dumpsites have become potential risks of causing waterborne diseases."*

Firstly, different responses were taken from different wards during that include high-density suburbs, medium-density and low-density suburbs. The highest response rate came from Marlborough, a low-density suburb because people living in these areas are capable to afford the internet, have better living

conditions and have better income levels. The lowest average response rate came from low-income levels such as Dzivarasekwa and Mbare.

Strategies used for waste management

The notion of the 3Rs has turned out to be the back of the study and Eco-friendly education consciousness was also recognized as a SWM strategy accepted by the COH. 'WASTE IS MONEY'is a concept used in the gathering, sorting, carriage and disposal of solid waste because not all refuse is refuse since some can be recycled or changed from its original use into other useful purposes. The COH and EMA have the mandate to conduct structured occasional outreach programmes to promote community awareness on waste management.

Solid waste should be managed through a number of activities—waste prevention, recycling, composting, controlled burning, or land filling. Using a combination of these activities together in a way that best protects your community and the local environment is referred to as integrated solid waste management (ISWM). An ISWM program can help reduce greenhouse gas emissions and slow the effects of climate change". (www.epa.gov/osw).

According to (Saungweme, 2012), the waste build-up in open spaces and roadsides is indicative to the miscarriage of service delivery by local authorities. Similarly, (Mafume, Zendera, Mutetwa, & Musimbo, 2016) postulates that, in many Less Economically Developed Countries (LEDCs) in the SADC region, there is a mismatch in revenue collection in comparison to population growth thereby frustrating municipal solid waste management. The rate of escalating unofficial settlements across the length and breadth of the COH is reflective of the Council's failure to plan and appropriately manage solid waste at domestic level, (Chinobva & Makarati, 2011).

Conclusions and implications of the study

The study conclude that Management of Solid Waste (MSW) has continuously stood out as the foremost problematic issue for Harare Metropolitan city. The amount of solid waste created in the city is higher compared to the COH's capacity to contain the impasse primarily because of limited technical, financial and human resources that are required to parallel and control this challenge. While MSW is one of the most pressing negative occurrences for the City of Harare (COH), it is not a new phenomenon. The study further conclude that solid waste should be managed through a number of activities—waste prevention, recycling, composting, controlled burning, or land filling. In addition, the study concluded that governance positively influence SWM practices in COH.

Therefore citizens should be educated about local environmental quality and the effect of existing environmental management practices in view of sustainable and responsible innovative ways of solid waste management.

The mechanism for raising awareness should be through school curriculum, training programs for target groups such as employees of solid waste sector, school teachers, health workers, children, media and public campaigns. It is recommended that future studies focus on other management strategies on different types of wastes. In addition, future studies could focus on developing models to enhance solid waste management strategies.

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Study of the technology of vbration jointing of thermoplastic materials used in the automotive sector

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Abstract. Plastics have a wide use in almost all economic areas, their appearance and use has emerged as a necessity to reduce the consumption of natural products and thus decrease the impact on the environment. In the automotive field, a wide range of plastic products are used due to the additional advantage of weight saving and the production rate of large parts, but which in the assembly process requires joint operations with each other respectively with other objects. An important factor in the studied theme was the challenge of combining 2 different PPMA and ABS materials, taking into account the advantages of each one, namely the PMMA polymer plastic material ensuring the transparency property and the ABS polymer plastic material ensuring the strength and stability of the jointed part. The study presents a part used in the automotive industry for which the process of combining the component materials was detailed

Keywords: *welding, plastics, ABS, PMMA, automotive*

Introduction

The need for joining components arises in situations where the whole part is difficult to manufacture in a single stage of manufacture due to the involvement of different materials and geometric constraints and complexities.

Components can be joined by mechanical fixation (with nuts and screws), chemical bonding (with adhesives) or by physical bonding (welding). The method used depends on the material to be joined, the size of the part, the geometric details in the joining region, the production rate of the parts, the service conditions and performance requirements of the assembly, cost constraints and aesthetic requirements.

Welding is the recommended option if an assembly of parts requires a permanent bonding. There are many welding technologies suitable for thermoplastics such as: centrifugal welding, hot plate welding, infrared welding, ultrasonic welding, or friction welding with/without filler material.

Friction welding and vibratory friction, also called vibration welding, provides a robust method for joining thermoplastics to manufacture complex gap assemblies from simplified injection molded items without using an external heat source, adhesives, or mechanical fasteners. Using only the heat resulting from the inner friction of the joined parts creates precise, hermetically sealed joints between the plastic components, which once glued can become airtight and maintain pressure if necessary.

In the automotive industry this technique is used for welding headlights, instrument panel assemblies, acrylic-acetal gasoline tanks, nylon brake fluid tanks, access doors to the welded polypropylene compartment in 2 planes, etc.

2. Presentation of the process

Vibration welding of plastics uses the energy resulting from the transformation of the mechanical friction energy between the welding components into heat that damages the melting of the material in the joint area [STAS 12147-85] [8].

The work will present the way of joining 2 pieces having as base material PMMA polymer (upper part) and ABS polymer (lower part) resulting in an assembly whose joint must ensure resistance and tightness to air and water, being used on the outside of a car.

The vibration welding method will be used due to its advantages that fall within the previously exposed desideratum of using material and methods that ensure good productivity, lower costs, low energy consumption (vibration welding not needing outside heat) and with low impact on the environment (without smoke).

PMMA (polymethylmethacrylate) is a thermoplastic polymer, obtained by polymerization of methylmethacrylate monomer. It is transparent that is why it is also called "acrylic glass" and good mechanical resistance to scratching makes it to be used in the automotive field in parts that are located outside cars in the outside environment and require transparency, [11].

Acrylonitrile Butadiene Styrene (ABS) is an amorphous polymer produced by emulsion or by mass polymerization of acrylonitrile with styrene in the presence of polybutadiene. The most important properties of ABS are impact resistance and hardness, [11].

The process of welding by linear vibrations is based on a relative oscillating frictional movement of the parts that reach melting (semicrystalline) or softening (amorphous) of polymers due to the compression of particles during movement according to the amplitude and frictional force.

Advantages of the vibration welding process

Polymer

- melted polymers are not openly exposed to air, so there is no risk of oxidation of the polymer.
- no foreign material is introduced, so the welding interface is created from the same material as the welding parts.
- the transparency of the material and the wall thickness do not impose limitations on the welding process as in the case of laser welding.
- heating is largely localized so it is much less likely that material degradation from overheating will occur.

Process

- the process is cost-effective having short cycles and involves the use of simple equipment.
- welding processes are suitable for mass production.
- no smoke is emitted during welding.
- the process works well for a variety of applications.

Aspect

- The weld burrow is formed at the edges of the welded kitties during the process. If this leads to an unacceptable appearance, then a hidden joint is used.

2.1. Welding of thermoplastics

Thermoplastic polymers are composed of molecules in which there are repeated monomeric units attached together in long chains. An important property of thermoplastic polymers is that they soften and melt after heating and harden when further cooling. When two products made of a thermoplastic material are welded, the polymer chains diffuse over the interface and a bond is formed by combining the chains, as shown in Figure 1. This applies to all welding processes for thermoplastics.

In the joints of usual polymers, the flow of molten polymer is not required; the link is formed by diffusion.

Diffusion is not related to viscosity.

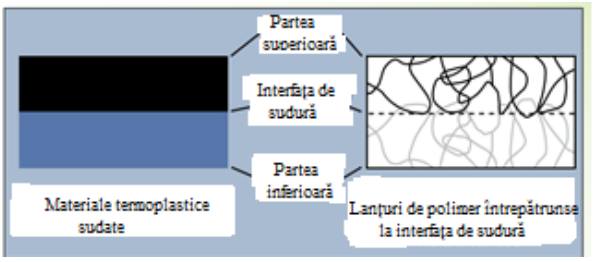

Figure 1. Molecular diffusion and combination due to welding, [9]

The low thermal conductivity of thermoplasts maintains the cooling speed after melting low enough for the formation of strong bonds.

The behavior of thermoplastics is different and advantageous compared to metals where heat is easily transported away from the welding area. Almost any thermoplastic can be welded by vibration: crystalline, amorphous, filled, foamed and hardened.

In the case of welds involving different polymers, the weld strengths are governed by the mutual affinity of the two polymers, so if the two polymers are not compatible, the resistance factors at the welded joint may be substantially less than 1,0, relative to the less potent polymer; for example, pairs of polymers such as PMMA-PBT, ABS-PPO, ABS – PEI, PPO – PC, PPO – PPO / PA (mixture of PPO and PA) and PPO/PA – PC develop significantly lower vibration welding resistances than the resistance of the weaker polymer, [2].

For compatible pairs of polymers, the resistance of the weld under optimal processing conditions can be as high as the resistance value of the weakest of the two polymers in the case of different pairs such as: PC-PEI, PMMA-PPO, PC-PBT, PC–PC/PBT (PBT and PC mixture), and PBT– PEI [2].

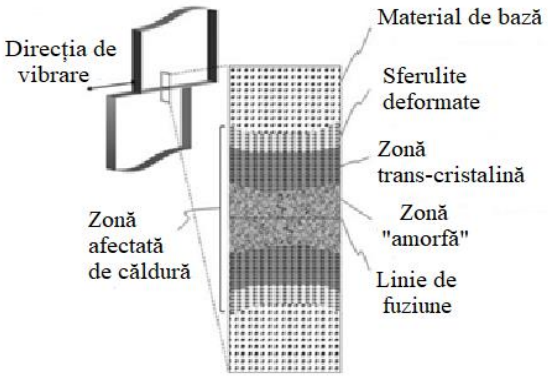

Figure 2. Typical microstructure detail of the vibration welding area of a semi-crystalline polymer [2].

For semi-crystalline polymers, Schlarb and Ehrenstein [5], Chung and Kamal [3, 4] and Varga et al. [7] concluded that the typical microstructures in the heat-affected area of the welds with the best resistance consist of four regions, as shown in the simplified way in Figure 2 (taking into account the observations of microscopic studies reported in [3, 4, 5] the various fillers used in this scheme only serve to differentiate the different regions and are not representative of the actual microstructural characteristics observed):

- the "amorphous" region – located in the immediate vicinity of the welding line, being a region without any visible crystallineness (indication of rapid extinguishing),
- region "trans-crystalline line" - is a recrystallized area with spherulites of various sizes (indicative of melting, flowing and re-solidification).
- 'deformed spherulite transition zone" - ahead of the basic material.
- the microstructure region of the basic material.

2.2. Phases of the vibration welding process

The process takes place over 4 successive phases shown in Figures 3,[2]:

- Phase I – solid friction – the penetration of the weld is not recorded in the friction process. This indicates that normal pressure does not lead to the collapse of any interface as long as the material is solid.

The first signs of displacement that are recorded on the linear displacement of the transducer indicate the onset of melting at the interface, thus marking the end of the first phase.

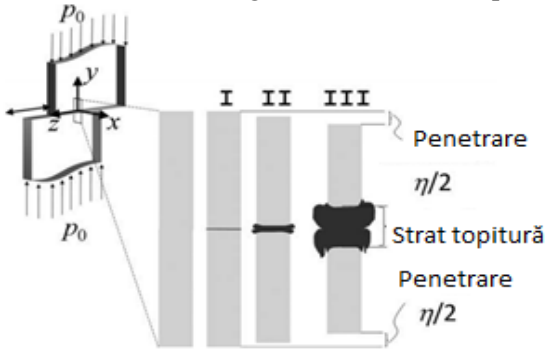

Figure 3. The evolution of the macroscopic appearance that occurs in the area of the weld seam during vibration welding. The scheme shows the cross-section of the weld area in plane x – y with the vibration carried out in the direction z, [2].

- Phase II – unstable evolution of penetration – the beginning of the penetration of the weld marks the beginning of the flow regime and viscous dissipation of the molten material. At first the penetration rate evolves with time, this indicates an unstable state in which the rate of new melt flow within the melt film is not equalled with an output rate in the weld seam, thus indicating an effective accumulation of the melt and the increase of the melt film as shown in Figure 3.

The increase in the width of the joint is actually an increase in the region of the melt flow in the x direction, according to Figure 4, which causes longer periods of stabilization of the flow in that direction.

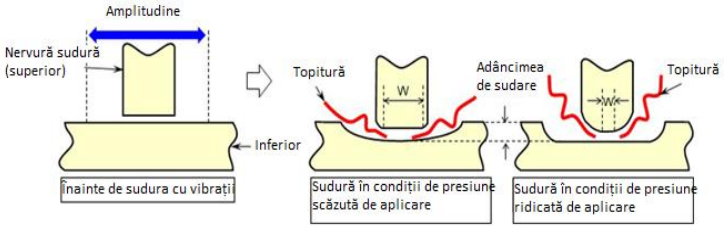

Figure 4. Melting film evolution, [10].

- Phase III – Constant increase in penetration – within this phase, the lateral extrusion to the outside of the material results in the growth of the weld seam.

According to Stokes' measurements for longitudinal vibration welding [6] it is shown that the penetration rates of the equilibrium state increase with increasing weld pressure under the conditions of constant preservation of the weld geometry, amplitude and frequency.

After a certain time, penetration increases linearly with time resulting in a constant penetration rate. Thus, the steady state was established with the rate of formation of the fresh melt corresponding to the rate of melting output in the weld seam, which implies a 0 accumulation rate or a constant thickness of the molten area.

Even from the conception phase of the devices, constructive measures are taken so that in the area of formation of the joint the production of heat by friction is favored. Once the plastic has softened and melted sufficiently, the vibrational movement should be stopped quickly to prevent shearing of the joint area.

Stopping can be achieved either by using a shear pin, which will break when a predetermined shear force value is reached, or by using a clamping device.

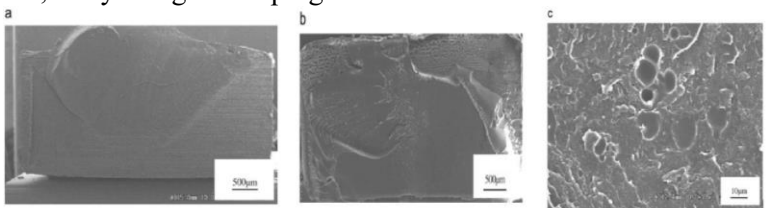

Figure 5. Representation of the breaking surface at the joining interface of a PC material at a welding pressure of 0.3MPa and welding time of 1.5 seconds (a), 3 seconds (b) and 4.5 seconds (c), [1]

The discharge time, unlike the friction time, is not chosen at high values, because when stopping the relative movement, the weld cools at high speed. Figure 5 shows the appearance of broken samples made by welding with different time.

- Phase IV – solidification – after the moment of stopping the vibrational movement causing the friction of the pieces to stop, the previously formed melt begins to cool and then solidify, resulting in the final welded joint. This time is 1 second.

According to research by Stokes it has been observed that the most resistant welded joints are produced when the penetration is at least 0.25 mm [8, 9, 10].

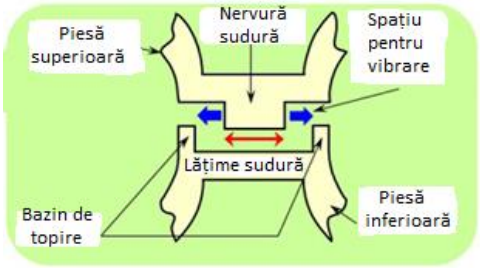

Figure 6. Merging detail of 2 plastics (longitudinal - left) and section (right), [10]

Figure 6 shows a joint detail of 2 plastics in which the cross-section joint is represented, indicating the components of the joint.

The determining factor of the strength of the welded joint is the penetration of the weld. The strength of the joint is equal to the resistance of the polymer of the base material, and this can be achieved when the penetration of the weld exceeds a critical threshold, equal to the penetration that is recorded at the beginning of phase 3 of the equilibrium state.

The resistance of the welded joint decreases for depths less than this value of the critical threshold. The resistance of the welded joint decreases for depths less than this value of the critical threshold. A depth value greater than the critical threshold does not affect the strength of the weld in the case of polymers without reinforcement, or with glass filled, resins or structural foams, but it can increase the strength of the welded joint of various materials [15-16].

3. Case Study

3.1. Preparation of parts for welding

The joining of the 2 pieces that will make up the ensemble will be made along the entire length of the outline of the pieces, whose shape is irregular, figure 7.

The assembly will be empty and airtight.

In order to achieve this type of joint, the vibration welding process will be used, so next only the process and the parameters of this process will be presented.

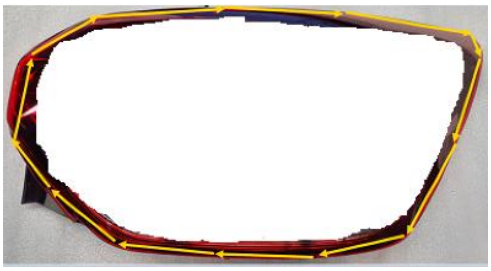

Figure 7. Part contour and direction of welding

The 2 parts made by injection are placed in the devices to be able to allow the welding process. Tools (devices) have the role of centering and fixing the components for welding. These tools must ensure a relatively adjustable position of the elements to be welded. The tools must provide a repeatability of the positioning and fixing of the elements in order to obtain a constancy of the geometry of the assembly of welded parts, which are dimensionally acceptable.

The assembly process must ensure that the scrap due to the welding machine and tools is as low as possible.

The welding tools that will be mounted on the platters of the welding machine must ensure the centering, fixing and detection of the parts that will be welded.

The materials to be used in their construction must provide protection of the parts against scratches and degradations of any kind. They must be designed in such a way as to ensure that it is possible to quickly mount and disassemble in the welding machine in the event of a change of manufacture (welding of the assembly).

3.2. Equipment used

Figure 8 shows an equipment that performs the welding of plastic parts by vibration movement. It is provided with a window that allows the insertion of parts for welding and then closes to ensure the protection of the operator and with a control unit that allows control and adjustment of welding operations and parameters.

The equipment of the vibration systems is electrically operated and consist of 3 main components:

-vibrating assembly (suspended on the springs).

-feeding.

-the pressing mechanism.

The pressing mechanism (which applies the verical pressure to the 2 pieces to be welded) is a hydraulic lifting table, to which the lower fasteners are attached.

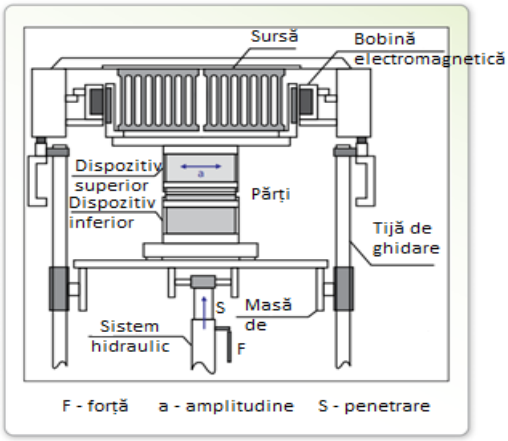

Figure 8. Vibration welding equipment [12].

3.3. Stages of the welding process

The welding process is carried out successively:
1. The parts are cleaned of impurities by blowing with ionized air.
2. The 2 pieces (which will make up the welded assembly at the end) are placed in the welding equipment in the upper and lower fastening device, correspondingly according to the working procedure (WPS) which specifies the way of laying, the control parameters, the loads.
3. The welding jointing equipment closes.
4. The welding process begins by moving the upper and inner devices that drive the movement of the 2 pieces on top of each other to bring the surface joint into contact under continuous pressure.
5. Vibrations which are generated either by a gearbox, by an electric magnet, or by mechanical vibration generators, are transmitted to the devices and through them on articulated surfaces. The movements of the two sides take place in opposite directions, as a result of friction, the temperature rises immediately, reaching the point of plastic melting in less than 1 second.
6. After a predetermined time, an electrical control device stops vibrations while the pressure on the joint is maintained. Simultaneously, the parties are brought into the correct position in relation to each other.
7. The pressure is maintained for a few seconds to allow the molten material to cool and subsequently strengthen creating the welded joint. Then the equipment and devices are opened and the assembly of welded parts can be taken over.

This method is suitable for large parts, parts can be non-circular or irregular in shape, and welded joints can be obtained over lengths of 100 ÷ 150 mm.

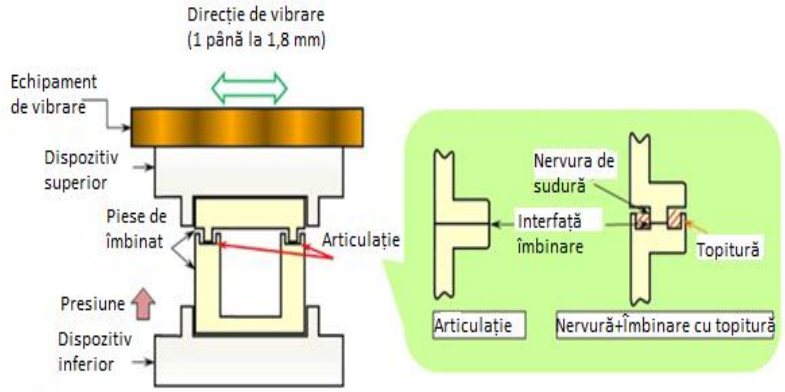

Figure 9 The scheme of the vibration welding process involving sinusoidal oscillations in the longitudinal direction,[10]

Figure 9 shows schematically the vibrating mode of the elements joined in a longitudinal direction, i.e. the parts are vibrated in a direction parallel to the longer edge, being considered "longitudinal vibration".

If the parts are vibrated in the direction parallel to the short side, welding by "transverse vibration" shall be considered. Together, these processes are called "linear vibration" welding processes because the trajectory of vibrational motion remains linear and constant. If the vibrations are applied in several directions, it is considered welding by "orbital vibration".

3.4. Welding Technology
Parameters of the welding process

In the control panel of the welding equipment where the values of the vibration welding process parameters are entered, and in Table 1 the values of the welding parameters are presented.

Table 1. Parameters of the welding process

Nr.	Parameter name	Value
1	Amplitude oscillation	1.5±0.3 mm
2	Welding Race	0.7±0.3 mm
3	Welding pressure	115 lumena
4	Maintenance time	2±1.5s
5	Pressure Keep	80 lumera
6	Oscillation frequency	100 Hz

The lower tool must be provided with sensors confirming the correct location of the body. The adjustment of the sensors can be made from the front of the welding device. The operator shall be positioned at the mounting position at the vibrating welding machine.

The authorization to start the welding operation is made after the operator performs together with the regulation two sets of welded parts that are checked as follows:
- a set of parts suitable for sealing and 3D measurement.
- a set of parts in which the continuity of the weld joint is verified by the destructive sample.

The operator at the assembly station performs the following operations:
- take the lower part from the stroller, a sulfa with ionized air and place it in the recess of the lower device, taking care that there is no play between the part and the device (press and push the parts);
- takes the upper part from the conveyor belt or from the box and makes it a visual check aimed at not having scratches, cracks, sweeps or black dots (according to the control range) and blows it with ionized air;
- the non-compliant upper parts are deposited in the non-compliant box,
- after blowing it with ionized air, place the upper part over the lower one, taking care that it sits according to the standard, on the fixed centrators;
- starts the welding process;
- at the end of the welding cycle, he extracts from the lower device the assembly consisting of the 2 welded parts, makes them a visual check (according to the control range) following the appearance of the weld seam (by comparison with the model assembly) and puts them on the trolleys that then go to the oven.
- the non-compliant assemblies are identified with the red label and are placed on the palette with parts in analysis.
- non-compliant items shall be recorded.

Identification of special features and important characteristics:
- the appearance of the weld seam.
- dimensional conformity.

Examination

After the jointing of the parts is made to check the quality, a series of measurements are made in several important points.

1. Destructive test:
- the weld seam is good, when the red lens remains in the black housing, or leaves deep print.
- the weld seam is not good, when the weld trace is superficial.

2. Sealing test:

The welded assembly of the parts is given pressure of 100 mbar and the loss must not be more than 0,5 mbar.

The causes that can cause the non-compressive jointing of the parts:
- geometric deformations of the pieces: flatness, burrs due to the surplus of material, deviations of elevations not in accordance with the drawing.
- incompatibility of materials at which the melting temperature is different (example incompatible materials at the housing and lens);
- saturation humidity in the piece.
- unoptimized parameters of the vibration welding process [13-14].

Figure 10 shows 2 unsuccessful examples of joining parts (scrap).

Figure 10. Defects in the joints of parts

4. Conclusion

In the work were present a polymer joint PMMA (upper part) and ABS (lower part) resulting in an assembly whose joint must provide resistance and tightness to air and water, being used on the outside of a car. Although PMMA and ABS are different materials, they are compatible with each other and are frequently merged together.

For the jointing of the two PMMA and ABS materials, the vibration welding process was used due to the advantages:

- good productivity,
- lower costs,
- low energy consumption (vibration welding not needing outside heat)
- low environmental impact (smoke-free).

Analyzing the technology of achieving the welded joint obtained, the conclusion is that if the welding parameters are optimized and the recommended welding technology is observed, the part can be obtained in a relatively short cycle, namely 67 ± 5 sec/ cycle.The determining factor of the strength of the welded joint is the penetration of the weld. The strength of the joint is equal to the resistance of the polymer of the base material, and this can be achieved when the penetration of the weld exceeds a critical threshold, equal to the parttundere that is recorded at the beginning of phase 3 of the equilibrium state.

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Knowledge and management knowledge in road transport organization

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Abstract. The scientific work presents a concrete research carried out by the authors in order to implement some concepts of a technical and economic nature so that the readers can become aware of a certain way of presenting the problems regarding knowledge and management knowledge in road transport organizations. It proposes a study, carried out from a managerial point of view with engineering nuances, so that the concept of sustainable development in the addressed field can be viewed in a global context. The work as a whole is intended to be a theoretical approach with correlations in the field of engineering and management, essentially aiming at the sustainable development of road transport. Finally, some conclusions and further research directions in this direction are presented. .
Keywords: *knowledge, management, organization, road transport, implementation, electromobility.*

1. Introduction

Since his appearance on planet Earth, man has sought to develop his cognitive abilities to act, create and decide what is good and what is bad for himself and those around him. He created ideas and added value in the field of knowledge by developing his wisdom. Wisdom defines man's superior ability to understand and judge things. It is represented by the human ability to think and act by using acquired knowledge, experience, understanding, common sense. It also represents the way in which people understand cause-effect relationships in a specific "insight" context *[1]*, manifested by moderation, prudence, temperance. All these aspects are determined by experience and foresight. Wisdom and acquired knowledge are strongly linked, but by always learning it gained new understandings which, in turn, created a new cycle of learning. The wisdom is part of qualities of impartial judgment, of compassion, of self-knowledge and experience, of non-attachment *[2, pp. 1254-1266]*, of qualities such as ethics and benevolence *[3, pp. 215-241]*, *[4, pp. 178-293]*. Starting from this idea, the organizations are increasingly interested in accumulating knowledge, which are seen as resources necessary for survival and training in an environment based on the criterion of economic efficiency. This led to their recognition of the importance of knowledge management in order to become competitive on the market. Within the society in which they operate, the entities with an organizational structure create material goods or services necessary for people's daily living. The organization exists and functions through the association of a group of people who have common conceptions, concerns and ideals, united, in accordance with the provisions of a regulation or a statute, in order to carry out organized activities. Therefore, the organization includes a group of people who

have a baggage of knowledge and who work together to achieve common goals, with the aim of obtaining a product intended for the client *[5, p. 1]*. The concept of knowledge-based organization appeared for the first time between the years 1984 - 1988 and recorded, after this period, different phases of development. Nowadays, road transport organizations, communication ways and transport systems have become so important that they are an integral part of the everyday life. Through the development of the production forces, the social division of labor increased, and the movement of people and goods determined a rapid development of this type of organization, so that today they represent an independent entity. The road transport organization differs from all the other organizations by the specifics of the activities carried out and achieves remarkable results if it knows how to capitalize on its knowledge and if it relies more on the intellectual assets and knowledge held by employees than if it relies on the material assets. In an organization, regardless of its profile, it may have the highest level of endowments, if the existing staff does not value their knowledge to use the technology in the endowment, that organization functions with syncope or can not function. That is why the creation of knowledge within the organization is essential, it is in fact the greatest capability of a company, especially because it leads to innovation *[6]*. In our view, knowledge management in the field of road transport represents a branch of managerial knowledge that is closely concerned with the implementation of knowledge actions. These actions include organizing, blocking, filtering, collecting, storing, sharing, disseminating and the use of knowledge objects, which are identified as information, data, experiences, evaluations, analyzes or initiatives *in the addressed field.*

2. Knowledge and the knowledge tipology

Drucker said about organizations that, nowadays, they started to rely more and more on intellectual assets and less on material ones [7].

Starting from these statements, he believes that the knowledge management systems have become the foundation for building and supporting the intellectual capital. Their use is necessary to create economic value for the organization [7].

The success of a knowledge-based organization lies in the optimal utilization of employee knowledge that is acquired while they are gaining experience in the workplace they have, but can be lost if they leave or are removed from the organization. This is where knowledge-based management must intervene, which can catalog and at the same time correctly manage the knowledge of the staff, even after some employees leave the organization.

In our view, *knowledge* represents the totality of information that the employees of an organization possess, have and are acquired as a result of a learning and education process. They are located according to figure 1, at a higher level than information. They come from information when the user has the ability to understand the patterns based on the information. They can be used immediately or in the future.

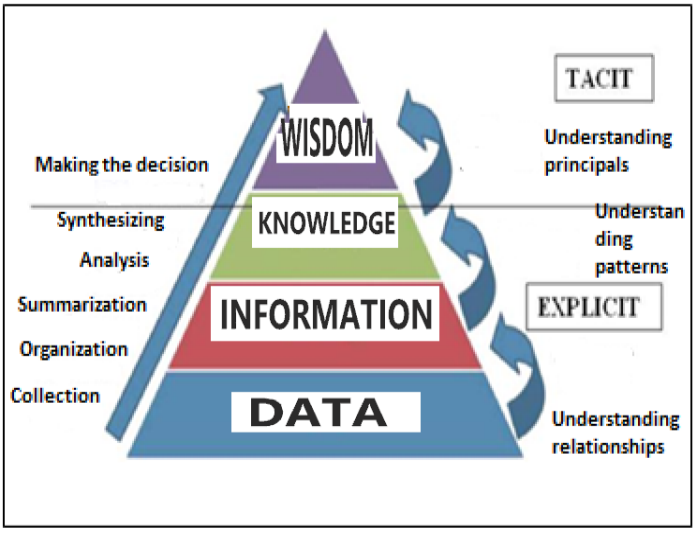

Figure 1 Knowledge typology and theknowledge creation process [9, p. 172]**.**

Many specialists argue that the top of the pyramid is occupied by the concept called ***wisdom***, which represents the ultimate stage in the evolution of all other concepts.

It specifies the aspect related to the implementation within an organization of the tacit knowledge that brings the *know-how (* knowing *how),* which represents the most difficult objective to achieve, this type of knowledge can be measured and at the same time capitalized when a decision can be made by an individual, then observing the consequences. This decision is represented by the ability of people to act in a certain way depending on what happens in the environment in which they carry out their activity, of course if the possible results of the decisions taken are taken into account. To be successful in a business, it sometimes requires a lot of intelligence and experience in a certain field on the part of individuals, to transpose the information they have into knowledge and decisions oriented towards success.

The authors Davis and Botkin stated that the essence of knowledge is actually the ability to learn from the learned [8, pp. 165-170].

For the correct understanding of the typology and knowledge management, according to the data presented in figure 1, we carry out an analysis and further define the concepts of knowledge, information and data, to clearly distinguish what is the difference between them:

- Data represents the properties held by goods. They can come from some context and have no particular meaning taken as such, but when they can fit into that context, or have a certain meaning, sometimes they even become information. We identify them at the base of the pyramid.
- The information represent the accumulation of some data in a logical order, are identified in the section immediately above the data and have a smaller section than the data. They come from data that we can use in a useful way.
- *Knowledge represents the totality* of information that the employees of an organization possess, have and are acquired following a learning and education process. These are located at a higher level than information. They come from information when the user that uses it has the ability to understand the patterns based on information. They can be used immediately or in the future.

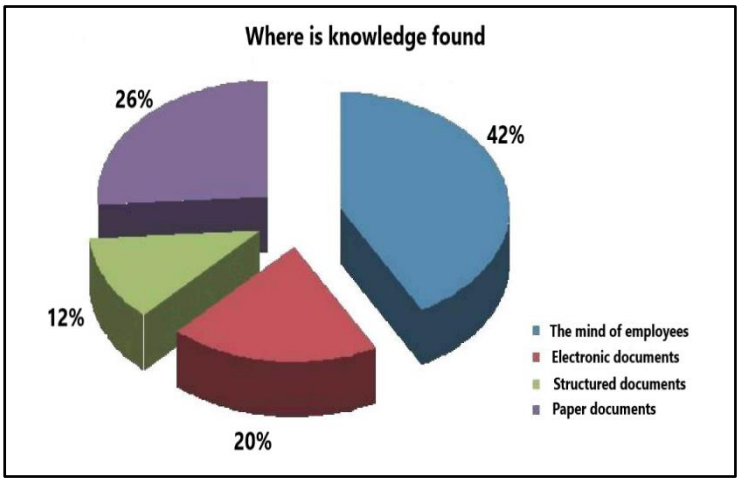

Figure 2 The place where knowledge is found in an organization [9, p. 173].

Figure 2 shows the place where knowledge is found within a knowledge-based organization, according to [9, p. 173].

It's considered that it is not always enough for an organization to have the necessary knowledge and be successful. It is necessary that the use of knowledge is directed to the needs and requirements of the customers.

3. The concept of knowledge management in road transport organizations

The concept of knowledge management in road transport organizations is premised on capturing the bknowledge in the place where it is created, then disseminating it to the entire staff of the organization and finally, implementing it in the process of transporting goods or passengers. Knowledge management involves the dissemination of knowledge and the use of human capital with maximum efficiency, and this must be done when motivation, participation and sharing of knowledge are almost instinctive and are an integral part of the daily activities of the road transport organization at work.

Knowledge is also obtained from the experience of the members of the organization or from the experience of others [10].

In the specialized literature Ovidiu Nicolescu it is also shown, that knowledge must be implemented to fulfill the organization's purpose [10].

If the society of knowledge in the field of road transport is analyzed in a general sense, it can be stated that it represents the peak of the development of human society, in which the knowledge specific to the field of road transport is the last and major source of social strength, following other sources that have shaped the development of mankind namely, force manifested through violence and money representing wealth and richness. They say that without money you can't do much. With money you can buy anything. At the foundation of any road transport organization, among other resources, are financial resources. They constitute the starting point of any element in this field. Without these resources you cannot move the means of transport, in order to produce the money necessary for the continuous operation of the road transport organizations.

Many wonder if there is still a connection between the financial resources of a road transport organization and the knowledge resources possessed by the employees of that organization. However, it can be said that there is a great connection. It is certain that without financial resources you cannot organize meetings and staff training in this field. The body of knowledge in the field of human capital is also defining in the field of road transport.

In the field of road transport, the knowledge that the specialist in the field accumulates throughout their life and acquires and then masters, is divided into three large categories, namely:

- *Explicit* (which can be expressed by words and numbers, which can be easily communicated and distributed within the road transport organization, in the form of scientific formulas that are the basis of fuel and lubricant consumption calculations, economic-financial calculations, codified procedures regarding the activity of transporting goods or passengers, universal principles underlying the operation of road transport means, databases regarding the carried out transports, documents or files that can take a physical form, transport charts, etc.);
- *Tacit* (personal and difficult to formalize, take the form of knowledge, are dependent on the accumulated experience and the characteristics of each individual within the organization, internal, cannot be physically measured and are formed over time through the experience accumulated by managers at all levels, by the economic and administrative staff, by maintenance personnel, by coordinators or dispatchers, drivers, etc.);
- *Implicit* (stored in entities that depend on the practical context – vehicles and motor vehicles, technologies mounted and installed on vehicles or on motor vehicles, road transport planning and organization processes, the entire process of transport logistics, the process of maintenance and repairs of motor vehicles, etc.).

According to what was previously presented, regarding knowledge, within the road transport organization, it is still considered that from this point of view, the basis of any organization is represented by the three types of knowledge possessed by the human capital. Without the professional training of the existing personnel in its state of functions, the road transport organization cannot function. Of course, financial resources are the basis of professional training.

In any road transport organization there is a professional training plan. Today the technology in this field is evolving rapidly and organizations need to keep up with the technology. People have to be trained and upskilled in the field. Organizations allocate huge financial funds for these trainings and improvements. The money is transformed into the knowledge of the human capital, which is then applied by the people in the transportation process, and following this process the money returns to the organization again in the form of financial income which is then transformed into the profit of the organizations. In this way, added value is brought to the road transport organization, and it becomes prosperous in the road transport market. Indeed, transport services are perceived from this point of view as high consumers of energy and financial resources, but their value is included as a value that is added to the final price of the transported merchandise or goods. So in the end, the value of the

transport is paid by the consumers, that is, by us, who purchase the material good, the object moved by vehicles from the property of the road transport organizations.

For example, in the case of passenger transport, the value of the transport is given by the quality of the transport services, the comfort of the passengers and last but not least by the satisfaction of the individual who benefited from the respective transport service. Public transport passengers pay the price of a travel ticket. Most of the ticket price paid by the traveler goes to the account of the road transport organization. The transport organization, in turn, pays a salary to the driver who, in fact, through the exercise of the function, has put into value the knowledge acquired, those accumulated during the training course and those accumulated as a result of their professional training.

The knowledge society opens new horizons for the learning process, which does not need to take place only in educational institutions, but also within road transport organizations. In this context, each organization will become a school, within which each training method organized at this level is a current way of accumulating new knowledge. Here we can mention: staff training; working in teams; participation in planned training courses; participation in brainstorming; participation in advanced training courses; study or professional training visits; individual study, etc.

Drucker, said about organizations that nowadays they started to rely more and more on intellectual assets and less on material ones [7].

Starting from these statements, we agree with the author who believes that knowledge management systems have become the foundation for building and supporting intellectual capital (Drucker, 2002).

Drucker, also states that their use is necessary to create economic value for the organization [7].

In this sense, the knowledge possessed by the members of an organization allows them to improve their performance in terms of creating, storing, sharing and exploiting knowledge. Knowledge management in the field of road transport improves the performance and experience of groups within the projects that the organization runs and eliminates failures.

According to the teacher 's statements Brătianu, knowledge management it is an exciting field of study through its spectrum of ideas and a fundamental pragmatic field in organizational management and leadership. The performance of any company directly depends on how this knowledge management was understood and implemented [11, p. 2].

4. The importance of knowledge management implementation in road transport organizations

Knowledge management is the link between operational and strategic management. It represents the main part of the managerial process in road transport organizations and we can say that it cannot replace classical management. We specify all this because operational management is time-dependent, it is specified from the annual calendar point of view, while strategic management is strictly about decisions that will be made in the future.

In his book the author Brătianu specify: therefore, more or less developed aspects of knowledge management are found in many organizations, but without gaining the necessary coherence to define a new managerial process. When we talk about the implementation of knowledge management, we refer to the organizations in which knowledge becomes dominant resources, and their management must constitute a specific, coherent field and with new responsibilities [11].

The implementation of knowledge management in a road transport organization is supported by the existing, up-to-date technology. This introduction, mostly, encounters some difficulties in implementation, bumping into the strong impact it has on people, the organization itself and management, down to the strategic level. Most of the time, the obstacles that appear are not of a technical nature but of a social, cultural and organizational nature. Knowledge management at the organizational level must be implemented taking into account certain aspects related to space and time when the essential notions specific to the organization of the transport activity changes essentially. The changes take place on: hierarchies (new hierarchies of subordination are created), networks (new connecting networks are created) and theories (they are reformulated in another form).

The difficulties that arise in the case of piloting a knowledge management system result from the multidisciplinarity of the field, because it refers to people who possess knowledge and belong to

different organizations, cultures and contexts, it involves the formalization of knowledge (creation, validation, experience, formalization, protection, dissemination) and requires the mastery of sophisticated technologies [12].

Figure 3 shows the processes and conditions necessary to implement a knowledge management system, according [12, p. 28].

To implement a knowledge management system at the level of the road transport organization, it is necessary to act simultaneously on three levels . The first level is the technology that has the role of converter, catalyst of the change. The second level is strategy which has an important role in change. The third level is the very content of the project that generates the dynamics of change.

Roman says that the dynamics imprinted on the system will have to have three speeds of action: exemplification - to be able to demonstrate the concrete benefits, pedagogy - to learn how to do the coercion - to overcome the last resistances [12].

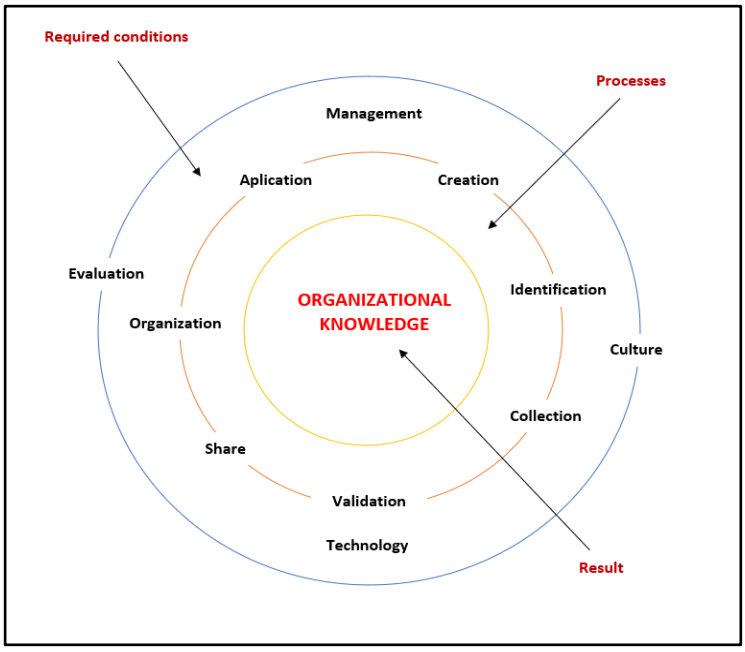

Figure 3 The processes and conditions necessary to implement a knowledge management system [13] apud [12, p. 28].

The implementation of knowledge management in a road transport organization has a strong impact on the organization, human capital, existing technology within the organization, management and strategy. This impact is primarily due to the change, and secondly to the way the methods are organized. It is based on the technological factor and the way it communicates at the level of the organization. It involves an accumulation of information of any nature.

In order to implement knowledge management at the level of any road transport organization, the following stages must be completed (text adapted after [12]): designing an action plan specific to the field of transport; formation of an implementation group consisting of managers and specialists in the field of transport at different levels of the organization, to present the main actions; the purchase of means of transport, equipment, installations, etc., ecological, efficient and modern, competitive on the competitive market; creation of a guide consisting of procedures, laws and regulations specific to the field of transport, resulting from organizational experience.

If these stages are taken into account, the expenses and investments necessary to implement a knowledge management project at the organization level are immediately recovered, of course if a large number of specialists and managers within the organization participate in the action.

After going through the previously presented stages, you must act in two directions at the same time, as follows: 1. Ensuring the necessary conditions; 2. Establishing the path to be followed for the implementation of knowledge management, by developing real projects related to each process.

According to the model proposed by some authors, the stages and factors that facilitate the creation of knowledge in an organization, a model that is very easily adapted to any road transport organization, which we present in the following, are [13], apud [12, p. 28]:

a. Stages of the knowledge creation

- Sharing tacit knowledge; 2. Creation of the concepts; 3. Justification of the concepts; 4. Creating an archetype; 5. Correlation of the levels.

b. Factors that facilitate the knowledge creation

1. Vision; 2. Autonomy; 3. Fluctuation; 4. Redundancy; 4. Diversity.

Knowledge in the addressed field is created by members of the road transport organizations, regardless of the hierarchical scale on which they are located, and knowledge management has the role of connecting all these members with them.

Roman that: in an organization everyone must participate in the creation and dissemination of the knowledge. This is not a domain reserved for gurus. Managers must understand that the tacit and explicit dimensions of the knowledge are not disjoint, but rather combine and complement each other. The development of knowledge is a specifically human activity and will only progress through dialogue [12, p. 30].

5. Knowledge management in the field of ecological road transports

Knowledge in the field of electromobility is directly defined by the emergence of new technologies in the field, requires new ways of thinking and perception of the people, and their management involves new concepts regarding the the automobile of the future.

In order to re-adapt to electromobility [14], people must learn to accumulate new knowledge in the field, because the new propulsion system, the electric motor, the electric charging stations, the electric accumulators, the electric car with its entire structure, the way it is driven, maintained or it is repaired, it represents a new field, a field in which people's knowledge we consider to be somewhat limited.

Knowledge management in the field of electromobility is the process of managing the knowledge, data and information held by a person or an organization about the electric automobile, its logistics and service infrastructure.

Knowing and knowledge have always been quite difficult to manage, and we believe that their management in the addressed field will improve considerably in the near future, as the classic car will lose its popularity, people's tenacity towards electromobility will diminish, and through information they will acquire the necessary knowledge to understand this field, they will know the place, the role and the benefits that the electric car brings them in the society and in their lives. Some authors and specialists argue that the knowledge management should not be done individually, but at a corporate level.

Knowledge has always been managed, but not in the way it is done today, and its management will probably improve in the near future, but it should not be done at individual level, but at corporate level [15, pp. 17-26].

However, my opinion is that in the case of knowledge in the field of electromobility and its management, the managing must be done both at individual, organizational and corporate level. All this is justified and I affirm that the field of electromobility is a newly emerging field, and the population and related organizations, through their reluctance and indifference, have little data, information and knowledge about the electric automobile, its logistics, maintenance and service infrastructure. Although the issue of reducing environmental pollution through the decarbonization of transport and the depletion of fossil fuels has been discussed and is still discussed, the European authorities have legislated the field of electromobility, but they have acted insufficiently and done little to make it as efficient as possible attractive and popular among people and road transport organizations.

Of course, electric vehicles are still unattractive and have a low popularity due to the autonomy of the electric batteries defined by their capacity, the charging time, the supply infrastructure (charging) which is quite deficient in some European countries, but also due to the purchase high price. But to provide services in the field of road transport, you need people trained in the field, who have the necessary knowledge to provide quality services to the customers, in order to meet their needs and requirements.

Some authors argue that: Knowledge-based theory approaches the organization as a market structure, whose resource is knowledge, the main activities focusing on their production, protection and registration in order to obtain economic performance [16, p. ii].

Today, the road transport has become an indispensable element for the human being, satisfying their needs for mobility, communication with their peers, perception, assimilation and satisfaction of the multitude of needs offered by the contemporary civilization. The humanity depends on mobility at this time, and the electric automabile does not currently live up to our demands the way the classic automobile does. It creates discomfort, delays, the insecurity of a fluent, fast and efficient transport. This is where the innovation in electric vehicle technology has to come in.

6. The definition of knowledge in correlation with the ecological - clean concepts

The identity of the words *ecological, ecology* derives from definitions such as *friendly to the environment, friend of nature,* in the sense of behaving and acting correctly, according to some rules of civilized conduct towards the flora, fauna, ecosystems and the habitats in which we live and coexist. If we think about the origin of the word, we will inevitably come across its meaning, which comes from the Greek language *oikos* - house and *logos* - science, that is, in free translation, the science of the house. In this sense, the house represents itself, the ecosystem or the habitat, in relation to the home, the village, the commune, the city in the country, the continent on the planet Earth, and science means knowledge. To know our house, to know everything about it.

An unwritten rule of the universe shows that a certain person belonging to a group of people, who live and coexist within an ecosystem, habitat, through the actions they undertake, bears the responsibility of each member of the respective ecosystem, habitat. This law is governed by the principle: *do unto others as you would have them do unto you*. In this case, the change must come from each of us, and if it also comes from the authorities of a state, then the ecosystem, the habitat will live and develop in perfect harmony, considering the fact that the ecology provides the premises a sustainable development of society and the natural environment in general, leading to the reduction or even the definitive elimination of the factors that create global warming.

But in order to define an ecosystem, an ecological habitat, everything must be done to preserve and keep it clean. An unpolluted environment is important for people's health and the well-being of the habitats in which we live. Cleanliness within the ecosystem means its health and that of the inhabitants who live together. The noise and vibrations produced by the road transport seriously affect the environment and human health. The changes that have occurred recently from a climate point of view, the thinning and destruction of the ozone layer, the destruction of biodiversity and the soil produce serious effects on the human health. Technology plays an important role in this case. The development, implementation and use of modern technologies in the field of electromobility will ensure an efficient, sustainable and durable mode of transport from the point of view of energy, environmental protection and human health.

A special role in the sustainable development of ecological auto transport is played by the sources from which the electric power comes from.

In this sense, our opinion regarding the sources of electrical energy is the following: to prove its total efficiency in the transport market, the ecological automobiles must be powered and use green energy, electricity from renewable sources. Otherwise, they are considered to be polluting similar to automobiles with classic engines. The green energy is a term that refers to renewable and non-polluting sources of energy. Electricity generated from renewable sources is at this time an easily achievable wish in our country. The geographical position, the climate and the relief allow us to do this. The provenance of green energy is very important for powering electric automibiles. Whether it comes from a wind power plant, a source generated by wave energy, tidal energy, hydropower or the sun, the important thing is that it is transported and directed to the fueling stations of ecological automobiles, to be later stored in batteries and converted into mechanical work by their motors, thus satisfying people's mobility needs in a more ecological, cleaner and efficient way.

By choosing renewable energy sources, consumers can support the development of green energies, clean, which will reduce the impact on the environment associated with the generation of conventional energy and which will ultimately lead to the increase of energy independence.

Renewable energy sources of wind, solar, hydroelectric, seas and oceans, geothermal for the electric means of transport, then the biomass and biofuels for means of transport with thermal engines, constitute the basic alternative to fossil fuels and define the basic support of ecological and clean automobile transport.

If we associate these two terms, we notice that they have common features, there is some interdependence between them, their essence derives from renewable energy sources. Green, clean energy represents the triumph of human development against chemical noxiousness and road noise.

7. Conclusions

Knowledge management involves spreading knowledge and using the human capital with maximum efficiency, and this needs to be done when motivation, participation and knowledge sharing are almost instinctive and are an integral part of daily activities in any organization, at the workplace.

Knowledge management improves the performance and experience of teams within any organization. Within the daily activity or the projects that the organization carries out, it eliminates the failures and develops the path to success.

The current developments in the economic environment with an orientation towards the development of the knowledge-based economy have been permanently accompanied by attempts to explain the levers and mechanisms that underlie them, but also to create new models, new tools and new concepts to allow everyone to react promptly and understand the new current challenges of the contemporary society.

The road transport organizations do not produce material goods. They produce transport services with vehicles or motor vehicles. Due to this, their achievements are measured in abstract units, but, in fact, productive processes in the field of movement of goods or people are carried out inside them.

The knowledge acquired, accumulated and appropriated by the members of any organization enables them to improve their performance and facilitates their skills and potential for creativity, storage, sharing and exploitation of the knowledge throughout their life.

By having the necessary knowledge, most of the time, if we talk about performance, small organizations achieved remarkable successes, which in a very short time managed to capitalize on the information they had at a given time all other organizations together. Of course, the basis of the success was the transposition of the informational baggage into viable solutions for everyone's needs.

Through the management of knowledge in road transport, the most important resources are developed that contribute to the smooth running of the processes necessary for the safe movement of the goods or passengers. They increase the performance of the organization and eliminate what is old and outdated. If an organization in the addressed field achieves that performance of identifying, applying and exploiting certain knowledge more quickly within it, success on the road transport market is guaranteed.

At the level of any road transport organization, in order to implement an efficient and effective knowledge management system, elements from the past or present can be taken as an example because there are elements from the past that can be taken as an example to ease our present and anticipate easier the future, although the connection between the human factor and the technological factor cannot be broken.

In the near future, theinnovation and technology will have their say in the issue of the autonomy of electric batteries, charging times, powers and the existence of electric charging stations on traffic arteries, and people will become more and more interested in electromobility. All other issues regarding infrastructure, purchase price and charging times will no longer be an obstacle to the accumulation of new knowledge, data and information in the field addressed. Of course, all this involves additional costs and expenses that decrease the popularity and make the electric automobile unattractive. It all depends on the state of the standard of living and the socio-economic situation in that region or country. To solve these problems, the state authorities must intervene to support the population and transport organizations. The population must be trained and educated in this regard.

If people will have knowledge about electromobility and protecting the environment, then they will become much more interested in the electric automibile, and the road transport system will become truly green, clean, sustainable and durable.

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The integrated challenges of sustainable agricultural systems in relation to climate change

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Abstract. In the face of climate change challenges, the study empirically explores general challenges closely related to the productivity responses of sustainable agricultural systems. Addressing the effects of climate change at different stages felt by agricultural systems implies the adaptation of a new vision of the Common Agricultural Policy closely related to the adaptation mode and constitutes an important volume of information related to eco-conditionality. Also, the study underlines the closely related relationship between reporting to the forestry management of forest areas in terms of protecting agricultural and forestry crops from climate variables. The evolution of forestry systems and the conversion of the forest surface into another type of land use is very important to analyze because deforestation generates a large amount of GHG emissions, an analysis of the forest fund captures the current state from this perspective. The information was collected from the Agridata and Eurostat databases, being the basis of the research through the prism of common agricultural policies. The ability of the methodologies to support the advancement of agricultural adaptation to climate conditions involves research and development in all processes related to the purpose of adaptation.
Keywords: *climate change, sustainable, agricultural,biodiversity.*

Introduction

The depletion of natural resources, the increase in pollution and the intensification of climate change lead us to reassess the effects of integrating sustainable models of biodiversity protection and increase the need for adaptation. Carbon storage in the soil, the intensification of the efforts of the common agricultural policy adapted to the climate and re-technology are levers to reach ambitious production systems in terms of emissions, but what are these costs. Existing natural environments, climate, and agricultural practices worldwide as well as there is an acute need to maintain these areas soils, plants forming a circle in which pesticides have their role. The relevance of this study is based on the importance of the elements of good practice in the management of forest areas and forest curtains for the protection of the natural habitat at the foot of the development areas in Romania.

Another important point in the scientific literature on emissions from land use change is their correlation with deforestation. The conversion of forest area to another type of land use is very important to analyze because it generates a large amount of GHG emissions. Land use emissions are

the second largest contribution to greenhouse gas emissions, after emissions from fossil fuels. Their causes are multiple, but among the causes are also due to deforestation.

Also, some studies present estimations of emissions generated by the land conversions which indicate for example a minimum of 591 tonne CO_2/ha when conversing tropical forest into arable land and a minimum emissions of 260 tonne CO_2/ha when conversing temperate forest into arable land (Overmars et al., (2011).[8] Here is that although in competition in demanding environmental conditions through the PAC vision these deforestations are divided but common, the responsibilities regarding biodiversity cannot be addressed individually, therefore when we talk about pollution what affects others sooner or later affects you as Popescu reveals. (2021). [19] Furthermore, Acemoglu et al. (2012) show that technical progress towards a clean intermediate sector is optimal in terms of long-term growth in the presence of optimal environmental regulation according to Hemous, (2016). [2 - 3]

In addition to the capacity to capture carbon from the soil, there are several other important considerations in assessing agricultural systems for their potential and feasibility to mitigate climate change.

While carbon dioxide is the main driver of climate and anthropogenic change and has been the main focus of mitigation efforts, there are other greenhouse gases (GHGs) that make significant contributions to climate change. The presentation's main goal is to highlight the external obstacles that encumber the agricultural system in forest regions.

The inventory of methods used in agricultural systems does not necessarily reflect a standard of zonal development, but as a form of conservation instinct, nature reserves the right to prove its usefulness, the forests leaving room for meadows. The role of these meadows is vital for farmers, and there is a subsidy plan that stimulates the maintenance of meadows.

It is true that climate change also entails new innovative production models precisely to find new sources that are sustainable, meant to reduce costs for sustainability. This new approach is of particular interest to farmers alike and to researchers, the interference between needs and standards shows that the existence of an ongoing debate on how best to adapt agricultural practices to climate change is still relevant today.

Against the background of these debates, the whole world is facing higher levels of vulnerability. Our goal is to provide a visual representation of the dangers of a sustainable agricultural economy in the context of climate change's demands, as well as its worldwide repercussions. From this viewpoint, we emphasize why it is vital to prioritize vulnerabilities in the agricultural sector, the link between costs and subsidies, and the use of agricultural management in mountainous and hilly areas to prioritize the protection of forest areas and meadows.

2. Literature Review

Innovation Forest management is a primary concern in forest management, having ecologically focused technical, organizational, and economic content. During the research period, artificial regenerations accounted for a smaller percentage of total regenerated area than natural regenerations and soil, providing care for immature crops and helping natural regeneration. As claimed by Leal et al., 2019), agricultural land would represent one of the sources of atmospheric greenhouse gas emissions (GHG) in the context in which the not inconsiderable forest biodiversity could reduce this gap by capturing forest C. [5,9,10,11] The designation of indicators from agricultural systems is still an area to be explored for research to generate new solutions in the contribution of forestry to global climate change. Romanian forests offer tremendous potential for multifunctional land use, functioning as a source of social amenities as well as environmental preservation, in addition to their economic relevance. Davis et al. (2014) considers that it is not enough to know the amount of land use emissions, but also requires the allocation of these emissions to activities and products and that this correlation can be achieved by distributing land use emissions in space and time taking into account

the production and proxy area, permanence policies, space and time of consumption of products and their impact on other countries.[4] Some studies provide estimates of emissions from land conversions which indicate, for example, a minimum of 591 tonnes of CO_2 / ha for the conversion of tropical forests to arable land and a minimum of 260 tonnes of CO_2 / ha for the transformation of temperate forest into arable land (Overmars et al., (2011). [8]

At the same time, specialist research (Aznar-Sánchez et al., 2019 indicates that carbon absorbers are as important as reducing emissions. contributing to the increase in efforts to protect biodiversity, and the large-scale adaptation of conservation measures through the use and the management of the forest area facilitates an increase in the success in the local areas in terms of reducing emissions. [1,15] More over half of Romania's forests (52%) are designated as having specific protection functions (soil, water, climate, wildlife conservation, and leisure), while the remaining forests serve both production and protection purposes. Many observations on land usage demonstrate that agricultural management approaches, such as boosting soil performance using fertilizers, can help to offset large ecological imbalances.

Romania has a significant biological variety, with natural and seminatural habitats accounting for about half of the country's surface area. The forests have a total area of 3,0043,946 hectares, accounting for 96.7 percent of the state-owned forest fund's entire area. Table 1 shows Forest land in Romania from 2015 to 2020, the forest background with primary trees, which is mostly found on the hill mountain plain. The forest land in Romania has registered a slight increase over the observed period. In 2021, the area of forests was 6.427 million hectares, with resinous species covering 1.915 million hectares (respectively 29.8%), and deciduous species 4.512 million hectares (respectively 70.2%), with a tendency to increase the woody mass. harvested, in the period 2013 - 2020, according to Table 1.

Table 1 The evolution of harvested wood mass, in the period 2013 - 2020

year	2013	2014	2015	2016	2017	2018	2019	2020
'- % -	103.1	95.6	96.9	91.9	97.9	104	101.1	105.1
Harvested woody mass	19282	17889	18133	17198	18316	19462	18904	19652

Source Eurostat (2020)

From conserving and increasing biological diversity by reducing negative impacts and rebuilding ecosystems and damaged habitats to banning the use of nonselective pesticides and rebuilding ecosystems degraded by over exploitation, each regional development area is addressed separately. Structure of harvested wood volume, in 2018, harvested wood volume percent, coniferous trees 36,6%, oak trees 10,5% beech trees 33,8%, various strong species 11,3%, various soft species 7,8%.

Some of the delicate concerns that cause the management plan to be adjusted according to the local geographical location include restoring shrubs and establishing protective curtains, as well as preventing the loss of biological variety.

Alternative agricultural approaches for reducing greenhouse gas emissions, biodiversity loss, deforestation, and soil erosion have become increasingly important.

They include legal requirements for management, good agricultural practices of the land, and maintenance duties, all of which are in conformity with the regulations on cross compliance.

Permanent grassland areas at the zonal level are indicators in the following categories:

Permanent grassland areas at the zonal level are indicators in the following categories:

- environment, climate change, and healthy agricultural land conditions;
- public health, animal health, and plant health;
- animal welfare.

Cross-compliance rules are mandatory for farmers requesting direct payments, transitional national aid, beneficiaries of support, measures for afforestation and creation of forested areas, agri -

environment and climate payments, support for conversion to organic farming, support for maintaining organic farming practices, payments for areas facing natural or other specific constraints, payments for forestry commitments. [7]

The degradation of the environment, manifested in the last decades by radical modifications of the geosystems on large spaces, with the installation of some chronic ecological imbalances, requires the taking of urgent ecological reconstruction measures. [16] The distribution of the National Forest Fund in development regions and counties is uneven, depending on the physical-geographical conditions and the economic-social development of the area. Artificial regeneration 9071 ha in 2018 compared to 12508 in 2014, in plantations in number of 9008 softwoods were 5467 ha, and deciduous 3541ha, decreasing compared to 2014 , 5328 ha and 7127 ha while direct sowings were 63 ha in deciduous and softwood in equal proportion. During the analyzed period, apart from the planting of 19.4 million forest saplings, 11,240 hectares of state forest fund were regenerated, of which 7,537 hectares through natural regeneration and 3,703 hectares through artificial regeneration, as well as afforestation works, including 90 hectares forest curtains, the year 2022, as a consequence the applied forestry management gave growth results, by carrying out regeneration works on 14,057 hectares, of which 9,354 hectares through natural regeneration and 4,703 hectares through afforestation works. The degradation of the environment, manifested in the last decades by radical modifications of the geosystems in large spaces, with the installation of some chronic ecological imbalances, requires the taking of urgent ecological reconstruction measures.

An important environmental factor that can be directly influenced and that effectively contributes to preventing and combating environmental degradation is forest vegetation. The forest vegetation is a real biological barrier both against pollutants of any kind and against harmful climatic factors.

By creating forest protection curtains, the climatic, economic, and aesthetic sanitary improvement of the land is achieved. Of the total areas subject to the regeneration process, 17972 hectares (66.5%) were natural regeneration, 676 hectares more than in 2017, while 9071 hectares (33.5%) were represented by artificial regeneration, with 1665 hectares less than the previous year. By its legal nature, the forest fund includes, as shown in Table 2, the way in which the forest fund is represented depending on the form of ownership. In 2018, public property accounted for 64.3% of the total area of the National forest Fund, being managed mainly by the National Forests Authority - Romsilva, and private property accounted for 35.7%, being managed mostly by the private forestry structures. The distribution of the National Forest fund to development regions and counties is uneven,

Table 2 Artificially regenerated surfaces, by types of artificial regeneration (2011 – 2020)

Types of artificial regenerations	2015	2016	2017	2018	2019	2020
Artificial regenerations – total	11846	11615	10736	9071	8443	8027
plantation	11790	11578	10709	9008	8418	8009
from deciduous species	5632	5398	4613	3541	3937	3592
– from resinous species	6158	6180	6096	5467	4481	4417
Direct sowing with forest seeds	56	37	27	63	25	18
from deciduous species	31	30	6	32	10	18
–- from resinous species	25	7	21	31	15	-

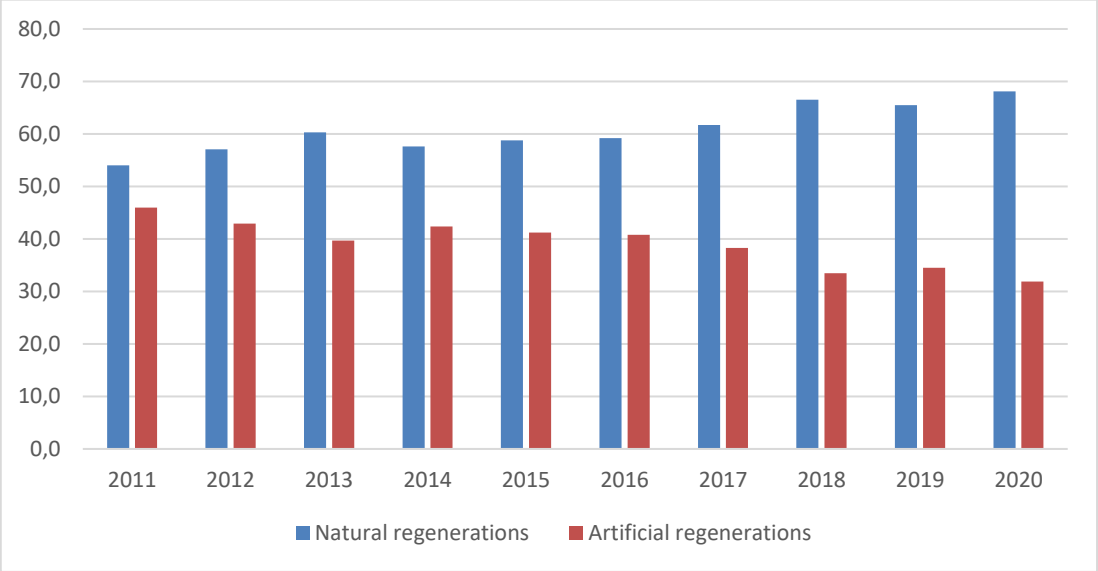
Source Data from the European Environment Agency

In the last five years, 72,892 acres of state-owned forest have been restored (47,335 acres by natural regrowth and 25,557 acres through clearing operations), with 141.37 million new forest-related trees planted. In terms of forest species, softwoods account for 42.0 percent of the total harvested volume of woody biomass, followed by beech at 31.1 percent, oak at 9.6 percent, various hardy species (alcacia, paltin, ash, walnut, etc.) at 10.7 percent, and various soft species (linden, willow, poplar, etc.) at 6.6 percent. Work on regenerating the forests on 25.189 hectares was completed in 2020, an increase of 189 hectares from the previous year 17162 hectares, or 68.1% of the total

suprafețe subject to the regeneration process, were natural regeneration, 1146 hectares more than in the previous year, while 8027 hectares, or 31.9 percent, were artificial regeneration. The importance of achieving a correct management of the forest fund implies, first of the importance of forest protection curtains - which represent formations of forest vegetation located at a certain distance from each other or with an objective to protect it against the effects of harmful factors and / or for the climatic, economic and aesthetic sanitary improvement of the lands. In the methodology we highlighted technical modalities for relaying the management of these forest curtains through their role in climatic zones that favor more or less the vulnerabilities of the neighboring agricultural ecosystems.

An important environmental factor that can be directly influenced and that effectively contributes to preventing and combating environmental degradation is forest vegetation.

Figure 1. The evolution of regenerated surfaces, by types of regeneration (2011–2020)



Sources: Eurostat data extracted 12 july 2022

The forest vegetation has multiple roles working as a filter and represents a real biological barrier on the one hand against harmful climatic factors, but also against pollutants of any kind. The National forest Fund on December 31, 2019, registered an increase of 9165 ha. This increase is mainly due to the redevelopment of forested pastures and the introduction into the forest fund of degraded lands and nonforested lands, established under law1

According to our analysis, different agricultural management approaches can be used depending on how the cyclical ecosystem yield process affects biodiversity, the resilience of natural capital, and, on the other hand, the sustainability of agricultural ecosystems. Thus, a fair study of production practices reflects the advantages of agri-environmental policies and subsidies.

3. Methods

The statistical studies cited in the article, which are in accordance with the Forestry Code and the Council Resolution of December 15, 1998 on the EU Forestry Strategy, are from national forest funds or organizations that provide forestry services. [18-22] The spatial analysis of the progression of data stolen from Eurostat based on the forest fund, as indicated in the most current OECD studies on the topic, was used to assess the modeling of the forest fund evolution in all systems affected by climate change and calamities (2021) .[13]

In the most succinct statistics, the reforestation efforts of the mountain pastures are in the first phase associated as a factor of the evolutionary progression of the forest fund growth, but they are also a result of the introduction of those more degraded and undegraded lands into the forest fund. -forested lands, which the applied methodological plan included into the afforested plan. From a methodological point of view, the amount of removals from the forest area was deduced directly from the databases reported by EUROSTAT, when they were available, or otherwise from the data reported by FAOSTAT. It is unclear how irreparable damages, such as logging residues and other losses from natural disruption, have been determined. We will briefly discuss a few methodological provisions from the National Statistics Institute and Eurostat in order to correctly interpret data, analyses and conclusions.

4. **Results**

Establishing and assessing the causes of injuries is an important aspect of determining the health of forest ecosystems, as well as a prerogative in determining the symptoms caused by distinct groups of hazardous agents. The management of regeneration operations in line with the provisions of forest management or specialized studies for carbon sequestration is highlighted by the soil carbon inventory, notably the form in which it is stored, capacity, persistence and bulk density, and soil textural class.

The agriculture and rural development sector remains traditional and dominant in the Romanian economy in terms of land use and population. Over 15% of total GHG emissions are attributable to agriculture, which is also very vulnerable. Annually, the net absorption of CO_2 from the atmosphere by the forestry sector offsets about 20% of the emissions of other sectors at national level. As the main CO_2 absorber, the forestry sector offers a wide range of mitigation measures such as preserving and increasing existing C deposits, improving the rate of atmospheric CO_2 uptake and optimizing the quality of the absorber and the tangible and intangible benefits of land use they would be given other destinations. Romania's forestry sector is an important carbon and CO_2-absorbing deposit, with the potential to play a significant role in reducing the impact of SC. Carbon sequestration contributes to the overall goal of lowering greenhouse gas concentrations in the atmosphere. The incorporation of the vegetal mass in the soil on the agricultural lands where green crops are established, contributes to the sequestration of carbon.

The result of this objective will be quantified by monitoring the areas on which green crops have been established, as well as by quantifying the amount of plant biomass resulting from afforestation. Romania has the largest intact area of natural and naturally regenerated forests in Europe. The forests of Romania cover an area of 6.539 million ha. In recent years, the forestry sector, including the wood processing industry, has contributed between 2.2% and 4.5% of gross domestic product to GDP, source Abrudan et al, 2009, FAO, 2012, FAO 2014.[14] The conversion of forest area to another type of land use is very important to analyze because deforestation generates a large amount of GHG emissions.

Another important point in the scientific literature on land-based emissions - change of use is its correlation with biofuels, which means that the negative effects of land use change must be overcome by using land in a sustainable way, even if many years of now they have to move on to really see the benefits of using biofuels (Lewandrowski, J. et al., 2014).[25] Moreover, it is necessary to determine how to manage with risks and uncertainties for a proper management of the land. Plevin et al. (2013) showed that policies where risks are associated with uncertainty have better results in reducing GHG emissions from land use. [9]

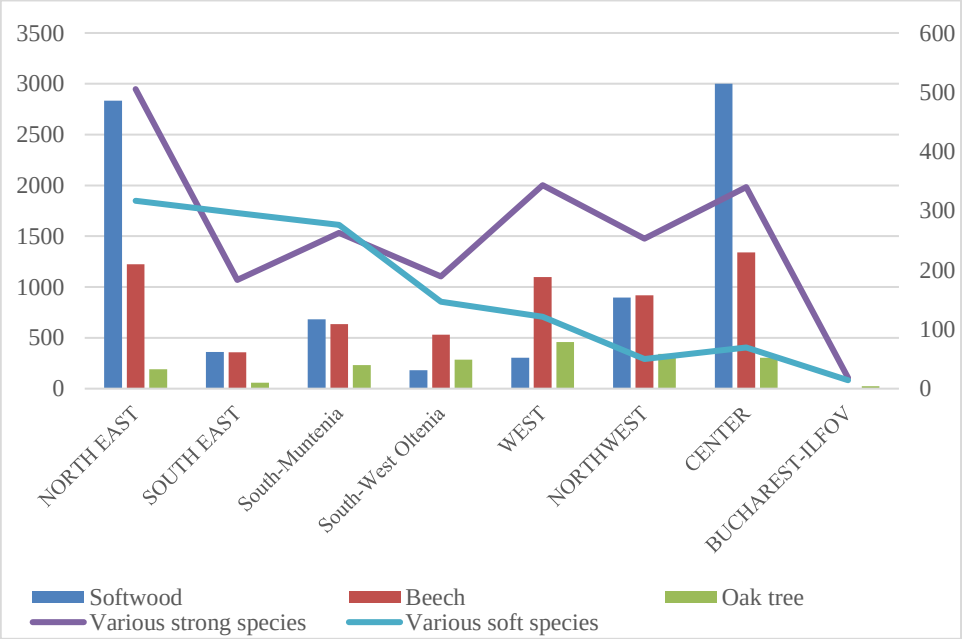


Figure 2. The structure of harvested wood mass species, by development regions, in 2020
Source Owner recherché from data Eurostat (2015-2019)

The importance of involvement in proper forest fund management is highlighted in the geographical ensemble of Romania by regions of forest fund development through the interdependence represented by the role of forests in the agricultural ecosystem, regenerations by development regions. The attribution of a direct relationship between the area of the forest fund, by categories of use, in the period 2013 - 2018, thousand hectares presented in Figure 3 reveals similarities shown next to each other in the structure of the value of agricultural production by development regions.

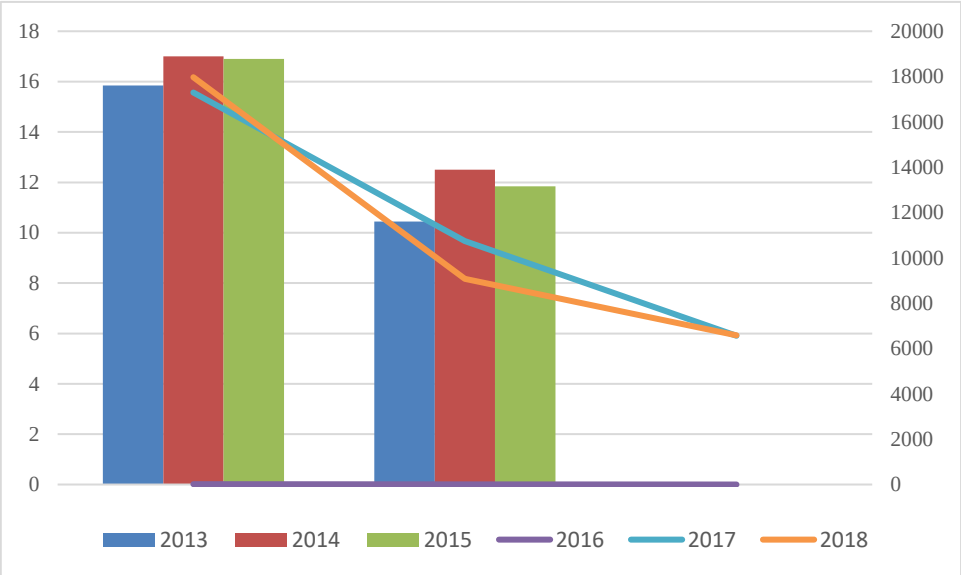
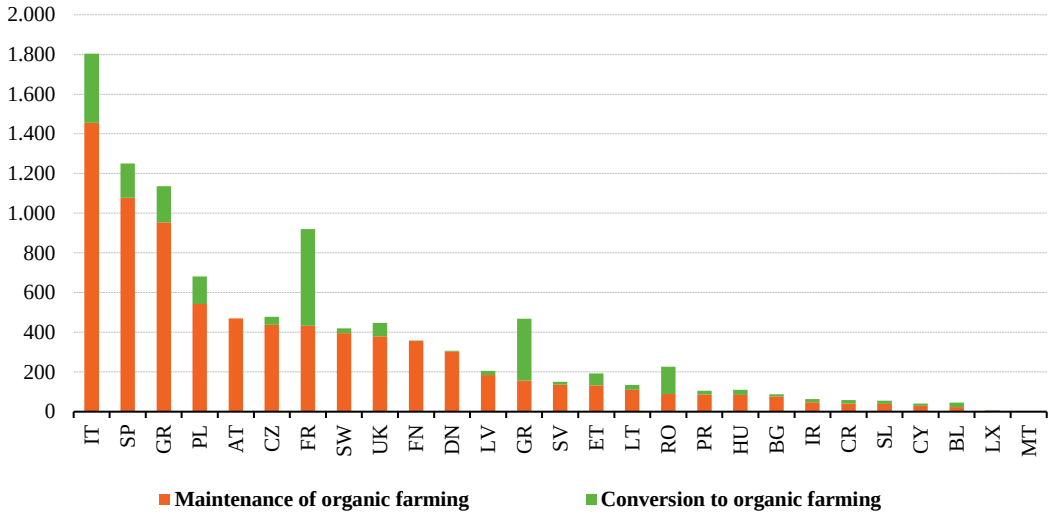


Figure 3 The area of the forest fund, in the period 2013 - 2018 thousand hectares (Romania)
Source OECD statistical databases.

As the agricultural economy grows, there is a very real risk that GHG emissions from agriculture may rise once more. This is especially likely to happen if animal populations rise and/or crop production intensifies once more. The highest concentrations of carbon are found in agricultural ecosystems, and these ecosystems have the potential to store even more carbon through a variety of localized practices like cultivating old pastures, continuing extensive agricultural practices, and avoiding applying pesticides and fertilizers to pastures with high natural value. These grasslands are crucial for the storage of carbon, the upkeep of systems that provide crucial environmental services, and the support of millions of small-scale farmers. Therefore, it's not out of the question that a regional assessment of carbon emission reductions in forest regions will be more effective than the agricultural production indices shown in Figure 4 as a typical forest growth process.



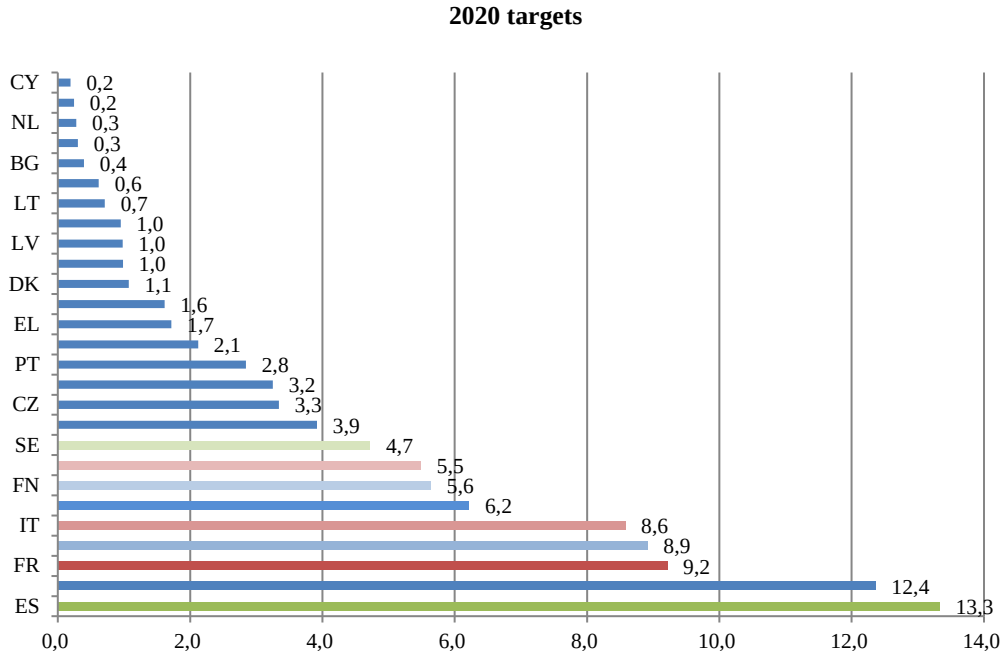
Source DG Agriculture and Rural Development (RDIS2, 12 June 2017)

Figure 4 Share of area under maintenance of and conversion to organic farming commitments, targets for 2020

Analytical causes can include assessing the health of forest ecosystems and the right to assess the symptoms brought on by groups of agents that have the potential to degrade the ecosystem. The assessment of the symptoms brought on by groups of agents that contribute to the degradation of the forest system can be one such analytical cause. By listing the factors that contribute to greenhouse gas emissions from agriculture, particularly production areas, agricultural farms, and livestock in areas of development, production, and coverage geographical areas indicating connections with environmental indices, the analysis of the convergence of the agricultural economy to the achievement of environmental conditions was approached holistically.

As a result, it can be claimed that some causes, like the consequences of climate change, can be managed using different techniques provided by nature. A fundamental requirement of sustainable forest management, in accordance with the terms of management plans recognized by law, in the case of protected natural areas, is to make the national forest fund more accessible.

As shown in Figure 5, payments for forest and climate commitments are an objective to increase the area occupied by forests at the national level by promoting afforestation of agricultural and non-agricultural areas, helping to support carbon sequestration, adapting to the effects of climate change, reducing erosion, restoring the biodiversity capacity of water retention, as well as restoring and conserving local biodiversity.



Source: DG Agriculture and Rural Development

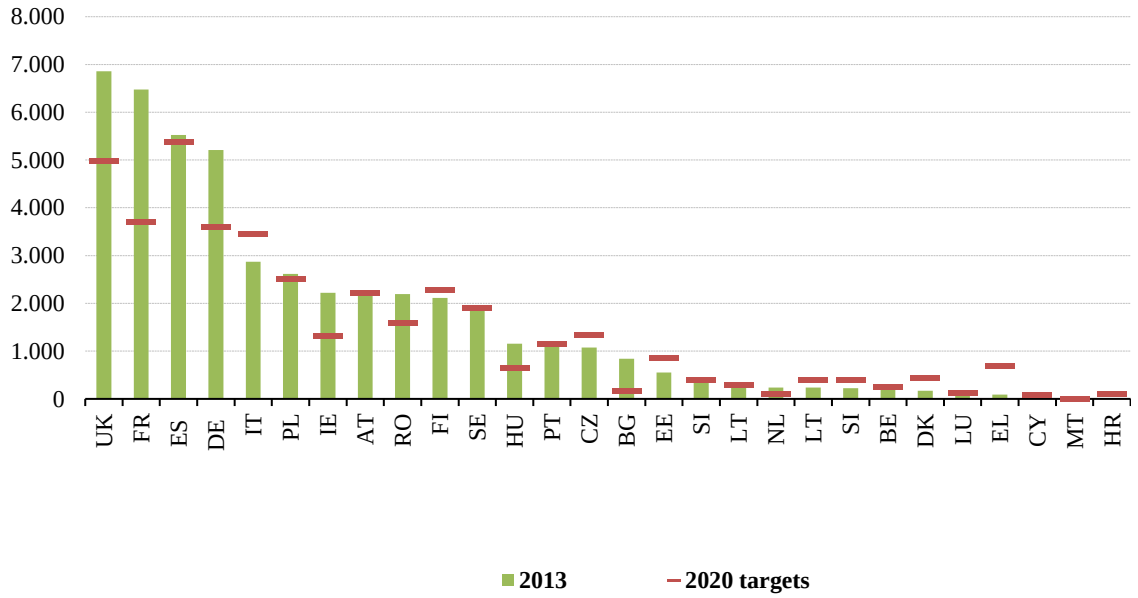
Figure 5: Member States' share of EU-28 total agricultural land under agri-environmental measures; targets for 2020

In addition, as illustrated in Figure 5, qualified beneficiaries of Member States' share of EU-28 total agricultural land under agri-environmental measures, targets for 2020, as defined by the Common Agricultural Policy's goal. [7] Among other purposes, the European Commission is attempting to give tailored methods to the EU's worldwide resilience to climate change, and is prepared to actively aid sustainable rural development (EC, 2021).[17] Figure 5 shows that in ES, FN, FR, IT, and UK, all climate and average measures of rural development spending were above average, with various nations highlighted in each measure with figures representative.

Romanian agriculture has low productivity, and rural areas are disproportionately poor. An important factor in low productivity is the large share of small agricultural holdings. The sector needs to consider adapting to a changing and less favorable climate going forward, as well as mitigating Gree House Gas (GHG) emissions. The stress factor of the plant, which represents a form of causality of the main determinants, a factor that cannot be excluded, represents a margin of error in adapting the techniques and practices used in production, and it is related to the pollution factor even through fertilizers not adapted to the climate, is also noted as an interdependence between the fertilizing aid adapter factors acts in response to the climate-ground-water.

In Romania, especially in the Romanian Plain, the southern development area is analyzed the climatic changes made by large commercial agricultural holdings being different from those of subsistence, of very small dimensions. Climate change is expected to affect farmers in the south and south-east region of Romania in general and individually. Given that large farms have highly specialized products, such as seeds and oilseeds, they are particularly vulnerable to the impact of frequent and long-term droughts,

Additionally beneficial to the property and the neighborhood is the inclusion of soil modifications, which can also help enhance soil structure, pH balance, and, in some situations, help bind toxins and limit exposure. A farm that employs effective soil management techniques can contribute to environmental enhancement, stormwater management, greenhouse gas emission reduction, and increased access to wholesome, regional food. An image of agricultural holdings and cultivated area, by categories of agricultural area use is presented in Figure 6.



Source: DG Agriculture and Rural Development[16]

Figure 6 Agricultural land under agri-environmental measures, 2013 and targets for 2020

Due to the general framework of the CAP, in which objectives are found in the support for rural development, including for activities in the food and non-food sector and in forestry, which contribute to the achievement of the objectives of favoring the competitiveness of agriculture, ensuring the sustainable management of natural resources and combating changes climatic conditions are indicators that have favored a slight increase in agricultural holdings and cultivated area, compared to 2017 by approximately 14% by category of agricultural area use. Intelligent land management for carbon sequestration is highlighted by the soil carbon inventory, in particular by the form in which it is stored, the capacity, persistence and bulk density, the textural class of the soil. In some areas, especially on soils with a thin substrate of limestone, there is an imminent danger of groundwater pollution. Depending on the local specificity, this danger should always be taken into account when applying organic fertilizers in such risky areas.

Activities to improve woodlands also have an impact on climate, such as clearing out competing vegetation, pre-commercial thinning to change the stand's density, composition, and structure, cutting treatments to lessen the need for stair fuel, lessen the impact of pathogens (like white pine blister rust), and improve the quality of future wood products, and fertilization treatments to maintain and increase soil productivity. As a result of bettering the timber stand, forests will be healthier and more productive, hazardous fuels will be reduced, forests will be better able to withstand the effects of drought, insects, and disease, and animal habitat will be more diverse.

The study found that using a management strategy based on the interdependence between soil quality and production, carbon absorption, and liquid or solid fertilizers has a synergistic effect on climate change, with climate being a significant impact. Land use changes also contribute to variations in soil carbon. Schmidt,M. (2011) [23]

Programs for planting trees and creating curtains can be evaluated in terms of carbon sequestration and other environmental advantages, but a more thorough evaluation of the advantages is required. As they provide essential ecosystem services, such as the production of lumber, non-timber forest products, and the hydrological regularization of river basins, whose values are typically under appreciated, forests play a significant role in enhancing society's adaptation to climate change. Therefore, preserving forests with protective functions that encourage the sustainable use of resources can increase their flexibility, aiding in the preservation of biodiversity and lowering greenhouse gas emissions at the same time.

5. **Conclusions**

The foundation of new visions of conservation, protection and improvement of environmental quality, including the conservation of natural habitats and species of wild fauna and flora, has constantly evolved contributing to the achievement of essential community objectives and of general interest, from environmental perspectives. Thus a evolution of scientific and technical knowledge is very important considering the evolution of environmental change that has direct effects on natural biodiversity, consequently, supporting scientific research work is an important resource. [20-21] The strategy outlined in this study is based on the fusion of already existing data sources at the national statistical institute level that are connected to data taken from Eurostat databases. Because there is a dearth of data on the forestry industry in Romania, particularly economic data, estimates of how much emissions will be reduced as a result of key forestry sector initiatives cannot be presented. From this angle, the study offers details on the management of the forest area and its current state. possibility of lowering greenhouse gas emissions.

A zero priority is the vision of new agricultural systems ready to respond to more severe climate change that make effective use of resources and natural capital, boost soil carbon levels, and increase biodiversity and agriculture's resilience to climate change. With one exception, it is possible to regulate carbon reserves in agricultural soils by changing specific agricultural practices. Carbon shock absorbers, according to research, are equally crucial to lowering emissions.

According to Westhoek H et al., avoiding exploitation damages of trees that have been harmed or destroyed during the technical exploitation process could result in the loss of the forest fund, causing certain inequalities in the affected area (2014). [28] Without strategic consideration of the need for effective management, in order to maintain and streamline that natural balance over time, forestry and forests should not be seen as a source of income for logging. Instead, the forest economy should be shown to be a productive means between the ecological role of the forest and costs, as well as solutions that add value in balancing the interests of the natural ecosystem for long-term gain.

The stated goals can be helped by agricultural systems that are more predictable as a result of integrated management. Nancu et al. (2022) [24] Furthermore, we have demonstrated that maintaining forest curtain conservation criteria through the application of real world ecorurality solutions is one of the factors enhancing C sequestration in the soil. In order to achieve the goal of lowering greenhouse gas emissions from agriculture, this vision also guided us in reaching the standards outlined in the Common Agricultural Policy.[25] In conclusion, it is critical to promote the use of innovative, environmentally friendly agricultural production techniques that preserve the environment, conserve biodiversity, and enhance the quality of water, soil and natural landscapes in order to conserve and improve natural resources and habitats. We require a clean environment based on the sensible use of natural resources in the fields of rural development, agricultural economy, and economic environment. We also need to increase competitiveness by establishing industry best practices. Additionally, the requirement to manage the results of fertilizer and soil treatments used in agriculture can assist in comprehending the economic and financial implications of storing a portion of carbon dioxide on the farm.(Popescu L. 2021) [27]

In this perspective, different agricultural management approaches can be used to address the risks that influence biodiversity, the resilience of natural capital, and, on the other hand, the sustainability of agricultural ecosystems, depending on the strategy for preserving ecosystem yield.

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The Metaverse, at the crossroads of creating a new world and ambiguous predictions - analysis of trends, features and impacts on consumers and businesses

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Abstract. Massively embraced during Covid-19, the digital environment remains one of the key components of our life for various activities. From working to studying, socializing to shopping in what is called the 'new normal' post pandemic life. The Metaverse is taking this digital world to the next level through a 3D immersive virtual experience. Identified as one of the biggest trends nowadays, The Metaverse concept raises a lot of questions from various perspectives such as business, social or psychological. The favorable forecasts about its evolution are built on quite attractive assumptions. The Metaverse will open a new, boundless world, full of possibilities that is also financially tempting by the anticipation of new revenue streams. As promising as this new world appears, there is still a flip side with a lot of ambiguity. This article looks at the opportunities and challenges of the Metaverse, through the lens of responsibilities that companies and authorities should take in the rise of this new world.
Keywords: *metaverse, digital, virtual, trend, customers, marketing, impact, risks, preparation*

Introduction – an amplifying phenomenon

Metaverse word started to get more public awareness since Facebook company rebranded itself under the name Metaverse, in 2021, communicating their objective *to bring metaverse to life*. To start with an example for virtual reality popularity, there was already Fortnite, the virtual game for teenagers that gradually became a place for events, being very popular especially during Covid-19, with around 350 million monthly active users (based on 2021 figures). The virtual reality extends incrementally more and more nowadays from entertainment and gaming towards professional and social area; this new world seems to attract increasingly various fields. Expanding between virtual and physical life, over business, financial, entertainment and even education, Metaverse is seen today as the big next thing, in most of the main forecasts trying to predict tomorrow's landscape,

At global level, Metaverse is a market estimated at almost USD 40 billion in 2021 and it is expected to expand at a compound annual growth rate (CAGR) of 39.4% until 2030. With most of the world's leaders tech companies already investing in this virtual world, followed by big global consumer brands, it looks like this is the new future. A future showcasing the concept of anytime, anywhere, and rolling out a new way of life emerging experiences: virtual retail, concerts, work, learning or travelling. Next to its huge economic potential, Metaverse seems to open the door to a new experience of buying, interacting and eventually, a new way of living.

1. Introduction – an amplifying phenomenon

1.1. The beginnings and following evolutions

The word Metaverse gained more public awareness when Facebook rebranded itself under the title in 2021. This was to communicate their objective to bring metaverse to life. [1]

While Facebook changed our digital behavior many years previously, the purpose of Metaverse was to bring new dimensions to our daily lives by embracing mixed reality (MR), virtual reality (VR) and augmented reality (AR). Doing so would help users to better interact, perform activities and eventually live. There is a flip side to this enormous investment with several questions such as 'How the Metaverse will magnify current digital issues?' and 'How it will be used by its creators?' The Metaverse is the newest concept about web evolution, Web 3.0. The development of the web itself brought a lot of opportunities but equally several controversies. The Web version 1.0. was an online space dominated by names such as AOL, Yahoo and a few other portals. Users and organizations were mostly using it for consumption with very little contributing in terms of content creation.

The next big phase, Web 2.0, changed the online model massively, bringing almost a revolution in terms of content creation. The creation of social media platforms, blogs and forums allowed enormous user involvement in content creation and created new opportunities for publishers and big online companies. The phrase Content is King became one of the central motifs in all online discussions and programs. During this time the environment is majorly influenced by 'GAFA' the internet's big players: Google, Apple, Facebook and Amazon. With data collection and processing becoming probably the second biggest theme of internet usage. All advertising and promotion strategies are built around segmentation, targeting and even micro-targeting, based on the individual's data which is used to conceive the campaigns level.

Eventually, society and authorities realize the impact of this data harvesting and compromising of the individual's privacy. Actions begin to be taken to regulate the environment, for example the Global Data Protection Regulation (GDRP). The private data access and usage, combined with the lack of ability to control and stop proliferations of false information currently represents one of the biggest challenges for users, authorities and even publishers in the virtual environment. The impact is significant, with long term effects for users' individual perception of reality and an influence on user's mental health.

These effects are projected on future web phases. The difficulty is trying to predict and prevent the negative impact as it is almost impossible to anticipate all possible issues that might arise in Web 3.0. However, using a decentralized model and blockchain technology, the Web 3.0 is an environment that will give more power to the individual. Giving back control of personal data and monetizing creators own content. [2]

1.2. The next internet battleground?

While this next phase 3.0 promises to bring a fairer internet, by positioning the individual as the one having control, there is still a lot of uncertainty in how this will actually apply and what will mean for our daily's lives. Metaphorically, it sounds like a David vs Goliath situation, with individual becoming sovereign of their own micro-universes, their content and data. This was previously used mainly by the giant, centralized platforms to their economic advantage. As good as it sounds, how realistic is this scenario though, in a future virtual world that is built to integrate us more and more? This is what the Metaverse concept aims for a MR, VR and AR. How thin will the border become between our physical life and the meta- one? And how important is it to keep these limits, especially for the younger generations?

Known by the industry as the future of the internet or the next internet battleground, the Metaverse has already attracted billions in terms of investments, a sign of huge opportunities behind this move. This type of virtual experience is not new at all, existing already especially in the gaming field. An example of the popularity of virtual reality gaming is Fortnite. The game designed for teenagers has gradually become a place for events, being very popular especially during Covid-19, with around 350 million monthly active users (based on 2021 figures). However nowadays virtual reality has extended its reach

outside the traditional sectors of entertainment and gaming and towards professional and social spheres; this new world seems to be attracting an increasingly various and diverse industries.

At global level, Metaverse is a market estimated at almost USD 40 billion in 2021 and it is expected to expand at a compound annual growth rate (CAGR) of 39.4% until 2030. With most of the world's leading tech companies already investing in this virtual world, followed by big global consumer brands, it looks like this is the new future. Expanding between virtual and physical life, over business, financial, entertainment and even education, Metaverse is seen today as the big next thing, in most of the main forecasts trying to predict tomorrow's landscape. A future showcasing the concept of anytime, anywhere, and rolling out a new way of life experiences: virtual retail, entertainment, work, learning or travelling. Next to its huge economic potential, Metaverse seems to open the door to a new experience of buying, interacting and eventually, a new way of living. Promising a fully immersive experience in a VR and AR, who will include elements from the real life (under various aspects like working, making money, studying, entertaining, interacting and maybe even more than these), in combination with growing capabilities and control of the Artificial Intelligence (AI), Metaverse aims to position itself as the next paradigm of the Web 3.0. [3]

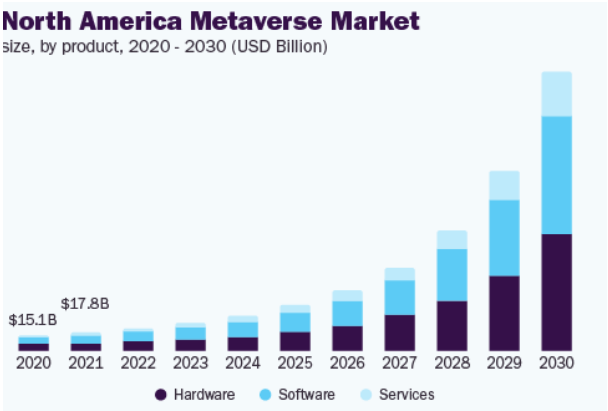

Figure 1. North America Metaverse market forecast

1.3. Pro and cons about Metaverse future

Even though today there are not many scientific researches and surveys available to give strong figures, the opinions of future web predictors remain split, between those seeing Metaverse advancing in the coming decade and those giving it less credit. The big business potential of this new emerging world represents the main driver for those believing in the rapid growth of Metaverse, followed by the continuous technological development that will give mainstream access to new experiences.

Creating this new virtual experience where people are fully immersed in a 3D dimension replicating real life (XR) could become a breaking point in the digital development, and there is much more likely to attract various segments of users, going beyond the current niche segments. On top, the believers in the ascension of Metaverse genuinely believe in its capacity of contributing to the greater good by facilitating a richer educational experience, better online medical procedures, creating stronger communities thanks to superior interactions, new virtual travelling experience and last but not least creating more opportunities for business exchanges.

As we are still in the age of predictions and hypothesis for the Metaverse and online environment evolution, current premises make the above probability likely to happen. Still there are important issues emphasized by the sceptics in the rapid adoption of this new online experience. In this regard, they expressed doubts concerning the useful aspects of the Metaverse for the lives of real people, the idea that of most of the population will get fully immersed in a VR and AR or even the limits of technologies to allow the promised experience.

However, there is the fear of losing even more the control. On one side some key powerful rich companies or platforms will play more of the role of "Big Brother" by gaining control of data and

affecting people lives, by influencing their online reading habits, their opinions and, gradually, their behaviors, no matter whether if that'll be for economic, political or any other purposes. On the other side, there is a potential danger that the Metaverse space, by its almost real-life experience will amplify and worsen the existing issues such as discrimination, fake news, bullying (especially for the teenagers, but not exclusively) or this fully immersive digital experience to induce the feelings of loneliness in the real life creating even more mental disequilibrium and anxiety.

Even though the above pros and cons concerning the Metaverse are not scientifically sustained at the global scale, these are data collected by empiric or ad-hoc researches expressing the main questions, doubts or arguments circulating today when referring to this virtual space.

2. Highlights – features and technical aspects

There are various factors impacting the current analysis concerning the Metaverse, from its features to its technical characteristics that are integrated in the macro-context release potential opportunities and challenges. According to Deloitte's definition, the Metaverse is seen as "a converged world of the virtual and the real", integrating a virtual reality, aspects of real world, pure virtual elements and the junctions between these two dimensions. Even though the Metaverse is built on a virtually transposed vision of the real world, it can exist without being tied to physical assets. It's less dependent on the data integration based on sensors, which obviously doesn't exclude that great amount of data could be collected. Its main characteristic is the necessity to immerse in the virtual experience. This represents at the same time the way to encompass great experience, while also being a potential entry barrier as it's more difficult to be accessed by anyone from any device, at least so far. [4], [12]

2.1. Technological challenges for rapid growth of Metaverse

To make this 3D development for virtual experience possible, advanced technological assets are needed. Tools such as AR, VR, AI, the Internet of things (IoT) and blockchain technology are among the most requested and used. All these technologies and the necessary knowledge behind them might represent a barrier to entry in this new field for less technological companies but, at the same time, a great opportunity to develop new competences and skills for these jobs of the future. Moreover, the speed of development and technological capacities are also a key influencer for the Metaverse future evolutions. While the Metaverse may seem highly promising there are clear technological limitations that have to be resolved quickly to achieve the goals. [5]

Even though the virtual experience is quite advanced, the full 'real-life' replica is not yet there. We can experience advanced 3D immersion but this is still far from the reality - for example, multi-sensorial experiences that humans have in real life, including all emotions are still not integrated well. There is also the financial and business aspects that need to be addressed. The Metaverse announced they will rely on blockchain technology and NFTs (non-fungible tokens). The financial industry and big business will need to familiarize themselves with and proactively use these technologies. Something the general population will also need to do however currently these terms remain abstract.

As long as people don't have knowledge about these new opportunities and don't understand them, it's much less likely they will adopt or invest in this project. Building the awareness of the above technologies under some simple, educational initiative might then be the logical action to be taken to stimulate Metaverse usage. In a similar situation, the IoT requires more accessibility for the public to become mainstream. Embraced mainly by certain groups, much liked by the young generations, the IoT continue to expand, but at a moderate pace, due mainly to aspects like costs, security concerns and the capacities of the technology itself. As long as this keeps a rather average growth pace, it will impact Metaverse implementation at a large scale. The new digital experience will equally require very performant mobile communication network, at least 6G, which means that in the very short term there will still be room for many developments at least from this perspective. [6]

Also, most of the future trends suggest that computing power will evolve more and more and there are increasing efforts for the construction of computing centers. All the evidence suggests the clear need that technology has to accelerate even more for its development. This is necessary to sustain and enable the futuristic scenarios that the Metaverse promises, such as stimulating business, empowering people self-expression in this new world, create new possible experiences in health, education, culture,

entertainment or encourage people's interactions to create communities. This refers to everything that can assure and allow access to the new digital world, to all the technical application needed behind the experience itself, to the tech platforms and engines (AI, digital twins blockchain, NFTs) and of course to the technical infrastructure, with a focus on the cloud computing as the future key enablers for data.

The question is how ready will the technologies be to provide all the above in a fluent and sustainable way? And how open are the main players of the industry to collaborate in terms of software, hardware, internet providers and other technological suppliers? Even based on the few empiric research studies communicated so far, there is a quite clear agreement that Metaverse, which is still in the infancy of its existence but on upwards path, still has a long way to go to get to maturity in the future. Close to these rather positive views from technological angle, it remains the uncertainty concerning the significant risks related to psychological impact on users, private data, trademark and intellectual rights, profitability, control, regulations or governance.

3. Metaverse - a new way of living?

With huge financial sums already invested and further investment to be announced, some of the biggest global brands are raising billions in short-term to fund their long-term vision in the Metaverse. It looks like a new way of living is opening up. As long as a significant part of our daily life or our friends' and families' lives could happen in Metaverse. Be it for interacting, entertaining, buying and studying – does this mean we have to prepare for a new way of living? There are certain reservations to be kept in mind, especially about the practical evolutions.

Metaverse is promoted like the new digital environment that will change our way of living. Even though there are still significant reservations about the impact of the previous statement, the virtual world evolves in a direction that could strongly impact our daily lives. [7]

3.1. Major anticipated impacts of Metaverse on daily way of living areas

3.1.1 Shopping

With big brands already present in the virtual world, the Metaverse will impact the way we shop. Using AR and AI, brands will be able to present their product from a perspective that is not accessible today, such as to display the composition of their products to emphasize the quality or sustainability of their production process. As a consequence, users will get to fully access immersive retail experience, from cosmetics to furniture or to car maintenance.

3.1.2 Learning

The way of learning could be positively impacted, thanks to technologies like VR or AR, which will allow students to be transported to different places and even times with digitally recreated events. The very first virtual learning experiences have started to receive positive feedback.

For example, during history classes, students will "travel" back in time, with past experiences recreated in Metaverse.

3.1.3 Healthcare

Advanced immersive technologies are already use in some areas of healthcare for example AR is used in complex surgeries. The Metaverse will aim to use this in our current healthcare checks, thus some procedures to be done either in a full digital environment or using many virtual enablers (like for example VR goggles for therapists). It will be interesting to see if this will bring more confidence to patients, who could feel in safer in a well control environment. Or would this have the opposite effect with patients lacking confidence in such a practice and having a tendency to avoid them.

3.1.4 Travel

Thanks to VR and AR, people can travel and explore places that they might have never reached any other way. From exploring hotels' room to visiting tourist attractions. Getting a cultural experience

from a distance and feeling like you are there. This is already a very appealing opportunity for many businesses including, travel operator, hotels, cities, to count only few key players of the industry.

3.1.5 Entertainment

The Metaverse was first built with the entertainment industry in mind. Particularly the gaming industry. The adoption rate among these users is one of the highest. It is already well known that gamers are already quite active in this virtual world and large gaming communities have been created. On top of gaming, which is more likely to stay as one of the main drivers for Metaverse adoption, there are also other type of entertainment experience, for example musical events. These events have been organized in the virtual reality have had hundreds of millions of users participating.

3.1.6 People interactions

If social media changed the way we meet, connect or stay in touch with other people, the Metaverse will bring all this to the next level. Being at the convergence of the physical and digital worlds, it promises to give users endless possibilities to create and re-create themselves and to interact with other people. Great opportunity for creativity, fully new experiences and 3D profiles in the virtual environment. It looks like a world of infinite possibilities where people can socialize, relax and entertain. But what will be the impact of all this be on our identity and personality? How much will this impact our self-awareness and perception on reality? And what will be the impact on communities and their behavior. And what will the consequences in the real world? All these are questions that experts or researchers can't answer so far, as multiple parameters for estimating the real social impact are too complex and it's still difficult to have an in depth understanding. They can only try forecasting some answers, based on projections and the few early researches conducted in this field.

A survey conducted by McKinsey over more than 3,400 consumers around the world, revealed that two-thirds of the respondents "are excited about transitioning everyday activities to the Metaverse, especially when it comes to connecting with people, exploring virtual worlds, and collaborating with remote colleagues". Based on the same research, "almost 60 % of consumers prefer at least one activity in the immersive world versus the physical alternative and 79 % of consumers active in the Metaverse have made a purchase". Even though this is one of the few systematic research projects about Metaverse, the above figures should be considered useful information in the projection of various Metaverse growth's scenarios. [8]

4. Question marks for today and tomorrow in Metaverse world

One of the first questions concerns the identity and the configuration of Metaverse. So far, it has been announced the virtual world will replicate and highlight the physical real world. Here for people and organizations including social, economic or legal aspects. Still the big question remains: What will be the mental impact, the capacity of Metaverse to stimulates people feelings and emotions. By encompassing this key factor that defines us as human, Metaverse aims to be more than just the sum of different parts of our lives, it could be a new world, where everything is connected and amplified and where one plus one could become three. No clear answers so far for important questions concerning the virtual world impact on: our mental health, on young people as Gen Z, on the new consumption behaviors or on data protection – to count only a few. There is already a discussion concerning the social and cultural impact of the Metaverse. Effects are still hard to predict due the early stages of the phenomenon. Still the exercise starts to shape if we integrate Metaverse in the context of:

- An increasing anxiety especially among younger population and with focus on Gen Z;
- A prevalence to develop the side hustle, again mainly among millennials and Gen Z population;
- The new way of working and studying created by the digital push during pandemic and kept in the post pandemic age, known as the smart way of operating.

While matching the above points with the full virtual immersion required by the Metaverse, it immediately raises several questions on how this will affect the daily life of people from economic, social and psychological point of view. The possibility to create and explore an almost boundless

world, lacking the inherent physical barriers of the real world, under an avatar giving the user practically a new identity, opens a multitude of opportunities and threats. Cleary we can already anticipate positive effects for interactions, business, exploring new experiences, but also the darker side of all this, the impact on people's self-awareness, self-confidence, behavior and even business risks. Another big question is about how to obtain a profile in the Metaverse and live in a virtual life, and to what extent, how to keep a proper and healthy balance with the real world, where one can't hide one's own identity. If the human imagination is the limit in Metaverse, then where is this limit between the good and bad, how fragile is the barrier and how prepared is the population and especially the young for this? And, from marketing point of view, there are other key questions arising about what the Metaverse will represent for brands: another channel in the marketing mix or an entire environment including its specific distribution and communication strategy? There is also the possibility that the Metaverse fades in time and take just a minor role in marketing strategies. In the absence of any clear answers, businesses and brands should start to properly analyze and understand how the Metaverse functions by evaluating the opportunities and risks, envisaging possible strategies and being prepared to take action.

5. New horizons and challenges for businesses and brands

Still if consumers do adopt the Metaverse, adjust their virtual behavior and bear with these transformations, how should most of the brands react to not miss this potentially great opportunity? How brands can deal with the risk adversity and the skepticism waves against the Metaverse? Will most of the brands wait and see how serious the Metaverse really is or they will take risks now? It will be interesting to closely follow developments and for marketeers be part of these evolutions, this is certain.

In the meantime, it's interesting to see what global brands do. If the high tech and consumer market-oriented brands might be more opened to invest in the Metaverse. The large mass of brands, adopting the follower-strategy, are still reluctant or, at best, in an expectative position. This situation shows similarities to what happened years ago with the creation and rise of social media: While some brands were pioneering adopters willing to use the platforms to interact and give their customers more power on the content creation. There were many other brands waiting to better understand social media, without being yet prepared to jump in to the new digital environment.

As millennials were driving social media usage as consumers at that time, now Gen Z is immersing itself today in the Metaverse. It started with gaming but there is a high probability it will continue into other areas of activities.

5.1. Early data from branding field

Following the survey conducted by McKinsey with over 450 senior leaders, the executives seem more reserved to express enthusiasm or even strong opinion. Still, they agree on one thing: "95 percent of them believe the Metaverse will have a positive impact on their industry". Around 30 percent of executives think the "Metaverse can bring significant change in how their industry operates". 25 percent of them have confidence that "Metaverse will generate more than 15 percent of corporate revenue in the next five years". With consumers being very open to this new technology (at least according to McKinsey survey) and leaders seeing quite a lot of business potential there, it looks like the Metaverse appearing to be the big next opportunity. According to another survey conducted by McKinsey over 1,000 consumers between 13 and 70 years old, the respondents were quite enthusiastic to see and interact with brands in the Metaverse, "two-thirds of them indicate they would be excited to engage in a digital experience with their favorite brands". [8]

Obviously, if consumers embrace this new technology, brands should follow suit and take advantage of the new opportunities. And companies have already started working on their presence in the Metaverse, to build their road map and strategies on how to operate in this world. Even though these strategies should be built for long term, the business leaders are aware of the fact that the Metaverse will continue evolve. For those companies that want to succeed in the Metaverse, one of the main skills they must possess or acquire is to be agile. As marketing history has already showed us, we

should expect seeing different reaction among companies in terms of adoption, investment and creating virtual consumer experience. In fact, there are brands that have already stepped into the Metaverse with a clear vision of their future path and seeing the advantages of being the early adopters. There are some other brands that have been preparing intensively for their virtual experience and have created a business model for this new world, but still have some uncertainty (fast movers). Finally, we can see a big category of brands that prefer to wait, being more skeptical, or maybe just less prepared to accept the Metaverse as a impactful future world. They prefer to wait and see what this virtual environment's impact will eventually be. They will watch how other brands manage and then subsequently build their own strategy. The main technologies could have low penetration today but are expected to become mainstream in the near future (and the proof of confidence is represented by the millions of dollars invested in this field). The consumers show clearly their openness to be part of the new Metaverse world and to try unique virtual experiences. Based on all this, is becoming quite evident that brands won't want to miss the next big opportunity. The customer represents the main driver of the business environment evolution. However, those companies that might chose to not adapt their strategy to the new environment will still be a big question mark over whether they made the correct decision: is this the right way of anticipating the future or do they risk making the biggest mistake of their evolution? Marketing courses are full of examples about big brands that missed important changes in customers preferences and behaviors, thus compromising or even sometimes destroying their image, reputation and business profitability.

According to Douglas Rushkoff, digital theorist and host of the NPR One podcast "Team Human", quoted in the Pew Research, "the only true purpose of the Metaverse or the 'decentralized' Web3 blockchains administrating it is to create more 'surface area' for the markets. The purpose is to quantize and monetize more aspects of our world and experience". While only the future will show us the real purposes of Metaverse, there is no doubt that the above affirmation is funded on the reality of economic interests that can't be denied in the virtual environment. But we can already try to anticipate the strategies and movements of big business names within the Metaverse space. [9]

In the current context, with trends announcing Metaverse rising and shinning, based on predictive logic, most of follower-strategy brands still need to work their fundamental approach to get prepared for the new possible evolutions. The first step is whether a brand decides to join the Metaverse or not. It will be interesting to see if this remains a real option especially as there were some other tentative moves to build a virtual life in the past, e.g. Second Life. Or will it be that brands won't actually have a choice especially if they want to maintain and grow their market share, as was it the case in the past with other channels like social media.

If current favorable forecasts are to be believed concerning the incremental increasing of the virtual reality, those pioneering brands that will first enter the new environment will get the most of the advantages and opportunities of Metaverse. From brand image (bold, innovative, advanced) to business growth by generating new sources of revenues. As the Metaverse aims to be a virtual replication of the real world, it's expected customers will have both the current and new needs, wants or demands also in the digital world. The appetite for possession is quite likely to exist in the virtual world too. For businesses and brands this represents a great opportunity to attract new customers. They will try to meet their specific expectations in this new world and create a fully new experiences for the audiences.

From a marketing point of view, all this will translate not only in higher financial results but also in a better brand image and affinity, as these companies have higher chance to be perceived as daring, advanced, futuristic, thus to raise a positive feeling among their customers. As for the brands highly positioned and well perceived in the virtual world, we might see a transfer of positive influence in the real world. They may be seen as inspiring for traditional customers. Last, but not least, being part of such an immersive and real time environment, will give these brands the opportunities to better understand much their customers and even their employees' preferences and behavior.

This unprecedent connection to the user experiences can create stronger competitive advantages for these brands, which eventually should be translated into better returns. Even from an organizations internal perspective, if we look through the rose-tinted lenses, the Metaverse could be the perfect new way of communicating. This was observed during the Covid-19 pandemic, by reducing the need to gather people together in a physical place, lowering the costs for travelling and still offering a great

'almost-real' experience. There are, of course, pros and cons – We've already seen, post Covid, many employers asking their staff to return to work and to have real human, face to face interactions. And this type of request for human, direct connection surprisingly comes from the younger generations, this is in contrast to the fact this age group is mostly associated with usage of the digital world. It's clear that the Covid period helped to develop people's familiarity with virtual activities. It also revealed a stronger and deeper need for direct human connection. And this might be one of the premises for moderating the enthusiasm of those voices sustaining that the future is in the Metaverse. But also, subduing and pacifying skepticism for those considering that the Metaverse is just the "buzz" of the moment but will remain a modest presence in the future.

5.2. High hopes and avoiding risks?

Brands are already facing fundamental strategic questions while thinking about their strategy to adopt the Metaverse. Even though for many companies, the Metaverse could represent the "blue ocean" in terms of marketing and business, where they can build their business, there are still important aspects to be considered before opening the business in the virtual world. All the positioning steps will have to be re-evaluated while preparing for the Metaverse. Starting with the key targeted segments, to understand how likely are they enter the Metaverse, who are they in the Metaverse how will they behave and how different their needs and expectations could be in this virtual world versus the current one. For brands targeting mainly the younger generations there will be a pressure to speed up towards this new environment, as long as their consumers will be expecting them to do it, otherwise they risk being replaced by a more agile competitor.

On the other hand, those brands that today are targeting a more conservative customers segment, risk losing an important opportunity in the long run, as future generations are happy to live part of their lives in the new virtual world. It's normal that the Metaverse raises strategic question marks about segmentation and targeting for all brands, no matter what their current strategy is. As mentioned previously, not all the brands have the same speed or pressures to understand and project themselves in the virtual world, but once the direction becomes clearer and big brands will move there, it's quite likely that followers and waiters will start doing the same. If the impact of the Metaverse on people, individuals and consumers is widely discussed and becomes the subject of several research studies it will be interesting to have more data and projections concerning the impact for the business to business (B2B) field too.

Huge businesses revenues are coming from the B2B area, so it shouldn't be dismissed as the Metaverse positions itself as the next big milestone in peoples, societies and business evolution. The potential penetration of the Metaverse in the B2B markets might actually represent a strong indicator of the real amplitude of this new world at least from business perspective. If the Metaverse can manage to attract interest of biggest private and public commercial deals, then indeed we could say it does represent a big shift and is opening a new age. But how big is this probability?

Today's existing data predicts a clear impact on people, with probably most entry points in area like entertainment, games, shopping and probably going further towards education or even medical health. But how possible will be to create a world that supports big business's interests? So far, it's not something that is really appealing based on the existing information. This is why, even though in the B2B field, big brands names might be in the followers category concerning the Metaverse adoption. Most probably, the brands might consider trying this new virtual world, but only for awareness and image reasons in the first phase, without aiming to go deeper into the brand funnel, towards the purchasing stage. [10]

On top of the reservations identified by McKinsey while questioning the top or senior executives of companies are not necessarily translated in skepticism. This could rather show big brands' need to have a long run vision and approach. The general public consider the Metaverse to be the next big thing and they would test and experience this first out of curiosity. For companies the reasons to enter Metaverse are different. They need planning, investments and also to make sure they can remain consistent in terms of their vision, value and brand personality in virtual world. To ensure all this, brands will need to properly anticipate their actions, position themselves strongly in Metaverse. Next to the business financial aspects, brands need equally to protect themselves and their reputation.

Once the decision to enter this new world is taken, fundamental business decisions need to be analyzed concerning what business model to use in Metaverse. From this perspective it's important to understand the way of monetizing the new environment. Next to this, there are other important strategic pillars such as: identifying company's goals and strategies for the Metaverse, understanding the behavior of consumers in virtual worlds, defining audience segments, creating ways to transpose the unique brand identity in this world – all these are some of the main challenges that brands should face now. Product and services will also take on different forms in Metaverse and there is still a challenge to have a clear view on how to offer them in the virtual word. For example, one question concerns the NFTs , are they representing the only way of virtual possession and trading, or some other means could be identified later? [11]

To put all of this in action, brands will need to think what platforms they need to use for Metaverse, to re-asses and most probably upgrade their technical capabilities, to create new partnerships in order to better leverage their performance in Metaverse. And, of course, on top of all the above, brands should be able to measure their actions, to clearly define their KPIs (key performance indicators) and what units they will use to regularly track them. Being a new world, it will be interesting to see how much the current marketing metrics (for brands, media, sales performance) will actually apply in Metaverse and how much an adaptative versus innovative approach will be requested. Another challenging area of concern is within the legal sphere. From data protection perspective, the overall the digital environment is not yet fully regulated (even though some important steps were created with GDPR in Europe for example). However, the new virtual life is still far from having clear rules protecting data, identities or against other virtual risks.

In order to cover all the above previously discussed, the right capabilities will be needed for making decisions and implement them. New skills will have to be developed and not only from marketing perspective but with a holistic mindset of doing business, from top management to sales, customer-care, financial, legal and any other relevant field.

6. The big next - uptrend or at a crossroads?

Closely linked to the internet environment evolution towards Web 3.0, where users become both content creators and owners, Metaverse is identified today as one of the most promising trends that will keep growing, and significantly impacting our lives. It's still hard to predict how much people are eager to embrace this virtual world and move part of their life into this new space. Today's numbers seem to be favorable to that possibility. However, it's difficult to say to what degree this will continue and if there might be a breaking point where the current trend could start declining or simply switching to something else that we can't even shape yet.

According to Deloitte conclusions, the Metaverse will present 6 main characteristics: realistic immersive experience, complete world structure, user generated content, big potential economic value, new regulations and big uncertainty. This synthesis puts forward the essence of the Metaverse as it reveals its main objectives, from creating excitement among users, bringing complex elements of real life into the virtual environment (from business to deep personal emotions) to unlock users' creativity and give them the control over the content (or according to skeptical voices at least the feeling of control). This rather reserved attitude is mainly due to the many unknown factors and open questions concerning the Metaverse's way of operating over the medium and long term. If there are two things the analysts and researches can agree on, it's the ambiguity of predicting the future of this new world. And one of the most important questions concerns the governance of Metaverse. [12]

As long as Metaverse projections indicate a high economic and public power, it is critical to ensure a fair and ethical management of the whole structure. This is key to build a Metaverse world that brings real value, not only from business point of view, but especially for what could really help and inspire people in their daily life, from working, creating, interacting and more. Looking a bit deeper into the value of the Metaverse, our analysis reveals also questions about its capacity to strengthen what we recently saw that really matters to people, from deep emotional connection to personal and spiritual development. In this landscape, Metaverse can contribute to enrich people experiences and feelings by allowing them to discover places, people or notions and to stimulate their creativity. Even though all this sounds very appealing, so far it looks more like a utopic projection and not necessarily

because of the skepticism manifested by some voices. This is mainly due to some quite practical factors like the technical accessibility, security and privacy concerns, huge complexity for storage and computing power resources and lack of clear governance.

Let's go one step further with the projection and assume that all the above will be possible in a perfect world, with a perfect set up. Even in these conditions, the main silent question remains: will human beings be ready to make this switch and live in virtual world? The mirage of a perfect world where everyone can be whoever they want to be. Will that be appealing enough though? And even if the answer is yes, what will be the ultimate costs for human beings in terms of mental, social, developmental aspects? This shift impacts people lives, the biggest risk being that some of the effects might be irreversible. Or, maybe, people will adopt Metaverse as a place to escape and build an alternative ego, a better one or at least, one closer to their real deep convictions. But how sustainable is this approach and what will be the medium- and long-term consequences? Obviously, it is still far too early to get answers to these questions but various scenarios can be anticipated. This is based on current observations of the effects social media environments have on people's psychological health, emotional health and their behavior.

From this perspective, a full immersion of our lives in the digital world has some worrying side effects, questioning the actual purpose of the Metaverse. These aspects will bring us back to the main points about governance, as this will represent the central driver for the Metaverse's usage and mission. The main players in the Metaverse, the way how they cooperate and compete, will set the direction and the "tone of voice" for this new virtual world. Will this be profit-oriented with the risk of "exploiting" human emotions and data or will the Metaverse reach that level of maturity to favor a sustainable, healthy and creative environment? Using the positive scenario, the mental shift happens, the virtual existence is accepted and people start using the Metaverse. All of our lives' dimensions become part of this virtual ecosystem.

The impact will be huge from all angles mentioned already (emotional, economic, social, cultural, technological and so on) and could expand continuously, as Metaverse growth is limited only by the human imagination.

7. Various projections for future evolutions

However, while this new promising world continues to develop, it is important that companies and authorities use previous knowledge from past experience with new channels and environments to ensure a safe and sustainable experience in the Metaverse. Alongside the individual and the private sector, the Metaverse could represent a great opportunity for the public sector to reinvent itself in a virtual world. It could help it to come closer to its citizens, to improve the city services and the improve administration processes. A big challenge to direct all the actions and interests in the Metaverse - those of consumers, companies and authorities – towards the greater good, to create an environment that will be safe, inclusive, fair and ethical.

We know these are serious concerns that are not fully controlled yet in social media –- fake news, data protection, bullying and virtual pressures. This, in turn, is creating real life anxiety and deviated behavior especially among the younger users. The Metaverse is at a crossroads about how to create a healthy environment. But how could they go a step further and use the amazing virtual evolutions to actually improve people's lives?

Web 3.0 and the Metaverse is here and all the premises indicate it's to here to stay and is developing over time. No doubt this new age will enable people and society to live experiences that we were so far just imagining. It will also open the doors for new business models. While huge amounts of money have already been invested in the Metaverse, it seems this is just the beginning. One of the big questions refers to how open or closed the Metaverse will actually be: Will it be for real users who have actual control? Offering them endless opportunities as promised? Or it will serve the interests of a tiny elite from the big tech sector?

Finally, the Metaverse and any technology are just tools eventually. The only thing that matters is how they will be put at people disposal and to what purposes will be used. Both positives and negatives have been learnt from the digital world so far, in any of its forms, including social media. While logically all that has been learnt, should be addressed and integrated into the Metaverse for it to

be a better digital world. There still remains concerns that the Metaverse could only worsen things no mater it's about data privacy, money control, dependencies or other psychological effects.

There are certainly big questions concerning the Metaverse's evolution, such as: Will it have the capacity to overtake the current technical limitations? Will it have the power to create new profitable business models to attract companies? Will it have the inspiration to take it to the next level? To transform the way how humans identify themselves and connect to each other, while giving them a full new world to develop and express their creativity? Whether all this remains possible, then at what speed will this all happen? Will it be a gradual evolution or an abrupt sprint? And most importantly, how is all this going to happen and what will be the consequences for people? Based on the above analyzed hypothesis, the Metaverse will possibly change things for the better or the worse, emphasizing positive and negative aspects of our current lives. I also see even bigger challenges in how we can take advantage of all these incoming opportunities of a boundless world, so far only imagined.

There is a new world ascending, full of possibilities. But at the same time authorities, companies and society, each of us, will be responsible for making sure this new world is sustainable and best used by all of us. And this might be the next big test for humanity.

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The role of universities in the development of smart cities. Case of Harare.

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Abstract. The role of institution of higher education in smart city initiatives is increasing with government`s intervention in the increase of innovation hubs in Zimbabwe. Curriculum alignment through education 5.0 which includes innovation and industrialization is promoting an atmosphere for research and development (Ministry of Higher and Tertiary Education Science and Technology Development, 2019). As a result, a principal component analyses approach was conducted in determining factors which enhance universities` engagement in smart city developments using varimax approach of rotation space (Mishra *et al.*, 2017; Leech et al, 2020). Qualitative approach was conducted on 390 respondents from various universities in Zimbabwe where reliability tests indicated 83% degree at 95% confidence interval using Kaiser Meyer Olkin`s measure of selection adequacy (Bonett and Wright, 2015); (Taber, 2018) . Factors which enhance universities to take part in smart city initiatives were extracted which are smart city education, innovation hubs, financial institutions and government support (Ransom, 2015; Sambuli and Whitt, 2017).
Key words: *Smart City, Principal Component Analysis (PCA), Innovation Hub, government, collaboration*

1 Introduction

The ministry of higher and tertiary learning has expanded its mandate of teaching, research and community service termed education 3.0 (teaching, research and community service) to education 5.0 which includes innovation and industrialisation (Ministry of Higher and Tertiary Education Science and Technology Development, 2019). The purpose of education 5.0 is to inculcate graduates with spirit of innovation concerning communal developments through technology knowledge application that enhance the living standards of city`s inhabitants. As a result, technology knowledge can be applied in the development of smart city applications that serve societal problems. The government of Zimbabwe is using National Science Technology Innovation System (NSTI) for strategic innovations management. Smart city (SC), a repetitively growing thematic domain, looks as an umbrella term that hosts multidisciplinary research on particular areas such as mobility, energy, environmental management, data, and governance. As the term entails, the core of the subject lays in real-life sensations and things in the dynamically varying life environments for a repetitively increasing population all over the world. Cities, as such, involve of vast amount of people and knowhow such as use of big data, internet of things and smart metering for billing that enable constantly advancing abilities for people to perform in better-

quality ways. Universities helps in the improvement of ICT infrastructure as an initiative of smart city development while alleviating the problem of unemployment through intervention of many companies (Brennan and Cochrane, 2019).

Figure 1. Source: Picture taken by the Authors Harare City Copacabana 22 May 2022 time 11:41hrs.

The government of Zimbabwe has made decision to ensure that no one is left behind through development of smart cities through digitization and new technologies like use of Tap-card by Zimbabwe United Passenger Company was useful in Covid-19 pandemic lockdown era (Thupeyo, 2021). As a result, the government sent representatives to United Arab Emirates to study solutions such as autonomous vehicles to tackle some of the transport, urban density, water sustainability and energy resources management problems. This move may result in cities like Harare collaborating with Chinese companies like Huawei to mount closed circuit television cameras (CCTV) as a means to help safety within the city's perimeter (Hove and Saki, 2020)**.**

2 Literature review

The Zimbabwe Global Climate change and lingering economic instability are also contributing to numerous challenges for cities such as economic stagnation, air pollution, traffic congestion, crime and droughts among other natural disasters. Hence going green through smart cities is a solution to rise to basic needs such as health, clean safe drinking water, healthcare and education among other factors (Jiang et al, 2020); (Tawanda, et al., 2020). The relationship between universities and city fathers are altering along with the engagement of universities in public service as they are the most noticeable research institutions (Liu, 2019). As a result, universities can be involved in smart city development through, coming up with actual working solutions as a requirement for students` projects and research collaborations that can generate revenue for the university (Lisdorf, 2020). The position of universities in the development of smart cities is vital as some researchers discovered that, universities act as knowledge managers (janitors, knowledge suppliers and knowledge assessors) (Ardito *et al.*, 2019). Systematic interaction and contextualized learning through organizational capabilities were identified as key mechanisms for strengthening relationships between universities and industry (Brekke, 2021). The concept of triple helix accentuates the relationship between state, companies, and universities. Thus, university can play a big role in innovation of smart cities and facilitating not only as technology and knowledge transfer supporting the economic development but also working as an intermediator and organiser between the other constituents of the ecosystem (Soe *et al.*, 2021).

Table 1. Definitions of key terms.

Key term	Definitions
Smart City	According to OECD (2020), "smart city concept primarily bring up initiatives that use digital and ICT-based innovation to increase the efficiency of urban services and produce new economic opportunities in cities ". While McKinsey Global Institute (2018) defined a smart city as, " an urban set up that applies technology to enrich the benefits and reduce the limitations of urbanization for its citizens". According to Lisdorf (2020), as defined by International Telecommunication Union International, "A smart sustainable city is an innovative city that practices information and communication technologies (ICTs) and complementary resources to improve quality of life, proficiency of urban operation and services, and competitiveness, while safeguarding the needs of present-day and future generations with respect to economic, social and environmental facets."
Smart City Model	Smart city model was established by the Centre of Regional Science at the Vienna University of Technology as indicated by Halegoua (2020). Hence it was defined by Halegoua (2020) as "A set-up of metropolitan management that put emphasis on the importance of intellectual capital and sustainable improvement for local growth". This archetypal is based on six key features which are smart economy, smart living, smart environment, smart people, smart mobility and smart governance (Pawlikowska-Piechotka *et al.*, 2017; Chigwenya *et al.*, 2020).
Smart Economy	A smart economy involves wealth and resources of the city through capacity for transformation, flexible labour market and solid economic reputation. A smart economy encourages human capital development towards smart city projects where population increase will open opportunities to accommodate the needs (Alagan and Waleed, 2019).
Smart Living	Residents are no longer beneficiaries but also players in smart city policies where investment in ethnic and educational facilities, processes to ensure public safety, optimal health, city attractiveness and social cohesion need to be upheld (OECD, 2020a). Hence, improving the standard of living for citizens is critical where these aspects can uphold and bring the cultural agenda and health (Perrone, 2014).
Smart People	Smart people entails placing more value on learning and acquiring new skills, compassion to social and cultural diversity, and inspiration of flexibility, creativity and chipping in public life. As a result, a smart city will advance as long as there are smart people and technologies to support it. Smart people are measured based on their level of knowledge through education, creativity, innovations and participation among other components. The number of people who have undergraduate degree, masters and PHDs within the population can indicate the level of literacy in an economy
Smart Environment	Smart city environment implies that all stakeholders put more effort on the protection of the environment. Likewise this involves a zero tolerance to litter, prohibition of dumping, lower levels foot carbon print, preservation of wetlands and consistently sustainable management of resources and. When breached it attract penalties, fine or lawsuit. The government would want to reduce carbon footprint through upgrading to greener vehicles (electric vehicles like Tesla in United States of America) and more efficient waste management. Hence, a smart environment includes urban infrastructure,

Key term	Definitions
	environmental protection sustainable resource management, water and energy usage and carbon footprint among other factors Halegoua (2020).
Smart Governance	Smart governance involves residents` involvement in the resolution making process, in safeguarding the acceptability and quality of public and social services and also promoting governmental transparency. Each smart city will have its own vision and goals where this results in a new form of economic structure. As for instance in Toronto, there is SmartTrack as regional express rail route which is expected to bring economic soundness to the city (Halegoua,2020).
Smart Mobility	Smart mobility refers to a city that is actually easily reached locally national and on the global market. According to Hernández *et al* (2018), smart mobility places ICT infrastructures at the exposure of all of its citizens, and that uses viable, innovative and secure data transport systems. Transportation is one of the imperative facets of mobility metropolitan where, people need to quickly and efficiently travel from one place to another. As for instance New York has an underground tunnel mass transit (subway) for people to get around, where more efficient and reliable approaches of transportation are essentially considered smarter. Furthermore, the use of cashless system through smart cards like use of Zupco Tap card, pre-booking online in Zimbabwe for transport system is a big trend in many smart cities.
Smart from the start cities	Smart from the start has been adopted in the developing countries like Zimbabwe Mt Hampden investment of a new parliament, malls, offices and other infrastructures. Infrastructure gaps, burdened utility provision and the need for cost effective methods of managing urban activities and monitoring pollution and traffic (Hernández *et al*, 2018). As a result, Smart from the start cities are heavily dependent on the logics of capitalism and complex private and public partnerships like the industry-sponsored advocacy group smart cities council (partners include Microsoft, MasterCard, Intel, Cisco and others). This type of city is an entire city constructed from scrape with digital infrastructure and data analytics as integral facets of the master plan. The Gramercy district under construction near Washington Dulles International Airport in the United States of America (Hernández *et al*, 2018).
Retrofitted Smart City	The assimilation of digital infrastructure and data analytics to drive urban governance and management and respond to and influence urban undertakings is known as retrofitting a city (Pawlikowska-Piechotka *et al.*, 2017; Hernández *et al.*, 2018; Access *et al.*, 2020). As compared to vendor driven, technological determinist approaches incorporate several smart city planners and researchers for strategies that privilege the place of the city, experiences and social exchanges among citizens and place making activities they regularly engage in. According to Katharine Willis and Alessandro Aurigi, the city is viewed as a series of ongoing, socially constructed activities that contextualize technology use in people`s everyday lives Hernández *et al* (2018).
	Social cities are rooted in foundations of civic society such as social cohesion and democratic governance in favor of optimization and environmental

Key term	Definitions
Social Cities	control. As opposed to other types of cities, on engaging the predictive analytics that monitor urban behaviour, urban technologies could be built in consultation with citizens. During the process the city fathers could invite people to collaborate in shaping their urban environments. As a result Hernández *et al* (2018) mentioned that, "Researchers Michiel deLange and Martijn de Waal focused on the relationships between digital media and urban culture and position the social city with conversations about participatory culture, collective intelligence, and do-it- yourself (DIY) hacker cultures and ethics where diverse populations come together to solve shared problems."

Chigwenya (2020) conducted a study on the digital content and urban governance in Zimbabwe using the case of Masvingo. The researcher advised the city of Masvingo to adopt the smart city concept of urban management. The research was conducted using mixed methods approach to inquiry, where both qualitative and quantitative methods were used for data collection. A questionnaire survey was used as the quantitative tool and in depth interviews and field observations were used for qualitative approach. It was found that, Masvingo was lagging behind the adoption of ICTs in urban planning. The government was urged to take a leading role and the private sector was also recommended to be involved in financing the development of infrastructure and networks for digital and e-planning in the city.

Bandauko et al, (2016) conducted a desktop research where they realize the transportation scheme in Harare dominated by private operators alone was unsustainable. The city was characterized by high levels of congestion, travel delays and irregular bus fares among other factors. The introduction of smart urban systems and the use of mass transit were identified as solutions as mass transit systems such as modern trains carry more people, are very fast and more efficiency. Mass transit systems were identified as answers to the economy, public, energy and environmental experiences in the city of Harare as they have lower negative effects on the external environment.

Table 2. Role of Universities in economic development Source: Hirsu et al. (2018).

Harare	Johannesburg	Sanandaj	Dar es Salaam
- Institution of higher education should be at the lead of the economic development drive. -Provide empirical based resolutions -Universities need to contribute to hands-on planning and development (Muchadenyik, 2015). -Universities deliver extension and civic services	-Academies provide high impact industry and commerce development projects. -Permit communities. - Universities offer user activism	- Universities support national development efforts. -Have close link with regional and provincial establishments. -Add to urban advancement by training the labour force. -Offer consultancy and backing to city fathers. -Universities carry out "research, enterprise, and community engagement activities".	-Institution of higher education develop human capital for the government and civil service. -Universities are tools for development. -The institution of higher education`s assignment is agreed in terms of public services outreach and consultancy. -"The 3rd mission is viewed as quite new and not fully operationalized". -Universities are mediators of knowledge transmission and

Harare	Johannesburg	Sanandaj	Dar es Salaam
			commercialization with the public/ private sector.
-Industry creating Hubs	-Town Market system	-Entrepreneurship Units and Growth Centres, Support Incubators, Science and Technology Parks.	-Institution of Production Innovation -Research and development Institutes.

Positioning of various stakeholders, persuasive nature of policy documents and universities' positions where mission narratives should focus on engaging into problem solving of various communities to have an impact (Hirsu *et al.*, 2018). Maphosa, (2020) evaluated the app he termed My Lupane State University app to enhance student engagement and promote a smart town at a rural university in Zimbabwe using case of Lupane State University. His study engaged design science research methodology, an approach used for the development of objects that are aimed at solving societal challenges. The app promoted student engagement as it was easy to use as it enhances smart university towns. University-city engagement is emerging as an important avenue for social innovation, necessitating tertiary institutions to act as change agents in their local settings (Petersen and Kruss, 2021).

3 Methodology and Instruments

A case study approach using city of Harare was adopted using qualitative research in determining the role of universities in smart city development (McLeod, 2008); (Fleming and Zegwaard, 2018). A sample of 315 respondents was drawn from different universities which are University of Zimbabwe (UZ), Harare Institute of Technology (HIT), Zimbabwe Open University (ZOU), Catholic University, Women University, Midland State University (MSU) and National University of Science and Technology (NUST) as stratas and few respondents from other universities. A random sampling technique was used for data collection from respective universities from both staff members and students (Arnab, 2017).

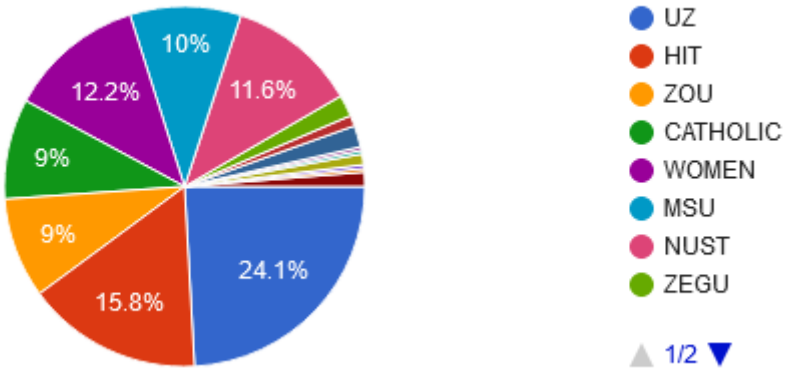

Figure 2. University participants.

3.1 Principal Component Analysis

A principal component analyses approach was performed to select the variables which have direct impact in determining the role of universities in the development of smart cities (Leech et al, 2020).Principal component analysis (PCA) is used to reduce the dimension of data set as there were many interrelated variables, while retaining as much possible of the differences existing in the data set.

This model was first introduced by Pearson in 1901, and later developed independently by Hotelling in 1933 (Jolliff, 2010). As a result, this multivariate analysis was performed to summarize the information relating to the engagement of citizens in smart city initiatives in a reduced set of influences with a least possible loss of reliability. PCA can be generalized as correspondence analysis (CA) in order to handle qualitative variables and as multiple factor analysis (MFA) in order to handle various sets of factors (Abdi and Williams, 2010). An exploratory factor analysis can be performed statistical software for social science (SPSS) (Hernández *et al.*, 2018).

One of the major objectives of PCA is to identify arrays in data through cointegration test among variables, reduce dimension if there is a strong correlation among variables by a linear combination of normalized. The degree of variance explained by the rotated components matrix should be higher than 60% in order for the solutions to be considered to be satisfactory (Hair et al, 1995).

3.1.1 Assumptions

- **Linearity**: Linearity structures the challenge as a change of basis. Numerous areas of exploration have discovered how applying a nonlinearity prior to performing PCA could extend this process known as kernel PCA.
- The principal components are orthogonal. This hypothesis provides an intuitive interpretation that makes PCA soluble with linear algebra decomposition techniques.
- Mean and variance are adequate statistics. The formalism of appropriate indicators captures the notion that the mean and the variance entirely describe a probability distribution. The only zero-mean probability distribution that is completely explained by the discrepancy is the Gaussian distribution (Fosså *et al.*, 2013).

3.1.2 The steps of conducting Principal Component Analysis

- **Step 1**: Getting Some Data for analysis is the first stage which may be a set of questions addressing the research area.
- **Step 2**: Subtracting the Mean is another stage as part of data standardization preceding to PCA since the principal components are susceptible to the scale of measurements.
- **Step 3**: Calculate the Covariance Matrix .Then, we can find correlation matrix or covariance matrix from which eigenvectors and eigenvalues can be extracted.
- **Step 4**: Calculate the Eigenvectors and Eigenvalues of the Covariance Matrix Eigenvalues represent the total sum of variance that can be explained by a given principal component. The eigenvalues should possess positive values where a negative value incur an ill- conditioned model, while those values close to zero indicate that, there is a challenge of multicollinearity in the data set (Syms, 2008; Abdi and Williams, 2010). Eigenvectors signify a weight for each eigenvalue where if we multiply its square root gives the component loadings which can be interpreted as the correlation of each factor with principal component (Sanyanga, 2015); (Fosså *et al.*, 2013) . We then need to arrange eigenvalues in descending order. Further, we select k eigenvectors that represent the largest eigenvalues.
- **Step 5**: Choosing Components and Forming a Feature Vector, from the eigenvectors, we can construct the projection matrix M.
- **Step 6**: Deriving the New Data Set Once (Mishra *et al.*, 2017) Finally, the original data can be transformed to find k-dimension (reduced dimensions) via projection matrix M (Alagan and Waleed, 2019).

3.2 Instrument development and data collection procedures

For researchers to understand group dynamics in smart city development, various research methods were used, surveys and telephone interviews. In case of surveys, data was collected through observations, telephone interviews and e-mailing of questionnaires with help of social media platforms (WhatsApp and Facebook) sharing google form and reminders (Pandey and Pandey, 2015). The questionnaire had

an option for asking consent where 93% of 390 respondents who participated in the research had consent to participate in the research.

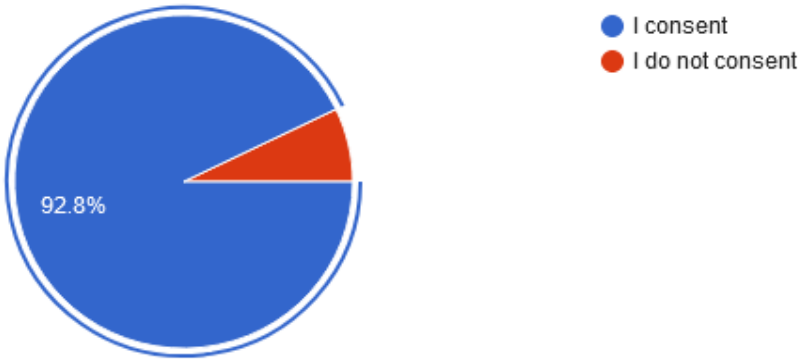

Figure 3. Consent to participate in the research.

3.2.1 Quality Control Protocols

The researchers conducted a miniature data collection where reliability of the instruments used was tested using Cronbach`s alpha in SPSS software. The test of sample adequacy was performed using Kaiser Meyer Olkin`s measure of sampling adequacy to ensure that the data we collected was suitable to run a principal component analysis and for that reason, it determine whether or not we have set out what we intended to measure. A response rate of 83% at 95% confidence of interval was obtained and considered sufficient as it was above 0.5 and the closer it is to 1 the better (Flynn and Kunkel, 1987); (Bonett and Wright, 2015); (Taber, 2018).

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.837
Bartlett's Test of Sphericity	Approx. Chi-Square	1886.173
	df	78
	Sig.	.000

Figure 4. Kaiser-Meyer-Olkin Measure of sampling adequacy.

4 Role of universities in smart city development

The survey that was conducted indicated that research and development and offering incubation facilities should be the key selling point for universities in smart city initiatives of the country as shown on the diagram below.

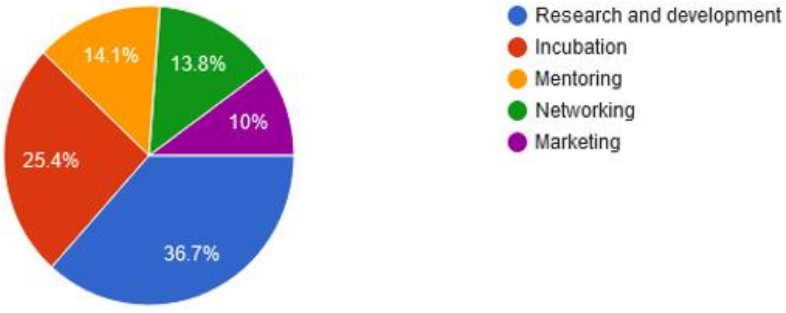

Figure 5. Cointegration Test on smart city variables.

Correlation Matrix[a]

Variables	ROLE	Innovation_Spirit	Innovation Hubs	Educational Facilities	Hub will	Industry Networks	Network Coverage	Market Conditions	RESOURCES	Smart City Education
	Variables									
ROLE	1.000	.000	.045	.016	-.091	.012	-.012	.045	.138	.024
Innovation_Spirit	.000	1.000	.116	.173	-.065	.143	.098	.136	.050	.116
Innovation Hubs	.045	.116	1.000	.157	-.072	.649	.079	.538	.038	.667
Educational Facilities	.016	.173	.157	1.000	-.053	.181	.469	.160	-.042	.158
Hub will	-.091	-.065	-.072	-.053	1.000	.025	-.118	-.019	.045	-.037
Industry Networks	.012	.143	.649	.181	.025	1.000	.107	.516	.066	.740
Network Coverage	-.012	.098	.079	.469	-.118	.107	1.000	.030	-.097	.042
Market Conditions	.045	.136	.538	.160	-.019	.516	.030	1.000	.113	.593
RESOURCES	.138	.050	.038	-.042	.045	.066	-.097	.113	1.000	.027
Smart City Education	.024	.116	.667	.158	-.037	.740	.042	.593	.027	1.000
Government Regulations	.046	.064	.401	.084	-.017	.399	.021	.775	.044	.499
Government Support	.068	.119	.684	.188	-.118	.582	.121	.547	.015	.599
Financial Instituitions	.058	.127	.712	.136	-.033	.650	.047	.592	.048	.649

Figure 6. Correlation Matrix.

There is a strong relationship between industry networks and innovation hubs where proto types commences (0.649), government support and innovation hubs (0.684), financial institutions and innovation hubs (0.712) to mention a few as shown on the diagram above. As a result, as there is relatively high correlations among the variables, it was a good sign for conducting factor analysis (Principal Component Analyses (PCA)) (Shahu, 2013).

4.1 ***Total Variables extracted using Principal Component Analyses***

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.651	35.775	35.775	4.651	35.775	35.775	4.536	34.894	34.894
2	1.530	11.767	47.543	1.530	11.767	47.543	1.569	12.072	46.966
3	1.149	8.842	56.384	1.149	8.842	56.384	1.154	8.879	55.845
4	1.032	7.941	64.325	1.032	7.941	64.325	1.102	8.480	64.325
5	.936	7.196	71.521						
6	.902	6.936	78.457						
7	.789	6.071	84.529						
8	.516	3.972	88.500						
9	.482	3.709	92.210						
10	.307	2.364	94.573						
11	.294	2.258	96.831						
12	.239	1.841	98.672						
13	.173	1.328	100.000						

Extraction Method: Principal Component Analysis.

Figure 7. Total Variance Explained.

Eigenvalues explain variance which is always positive as shown on the diagram above implies that, our model is not ill-conditioned, in other words fits for the data where values close to zero imply there is multicollinearity (Abdi and Williams, 2010).

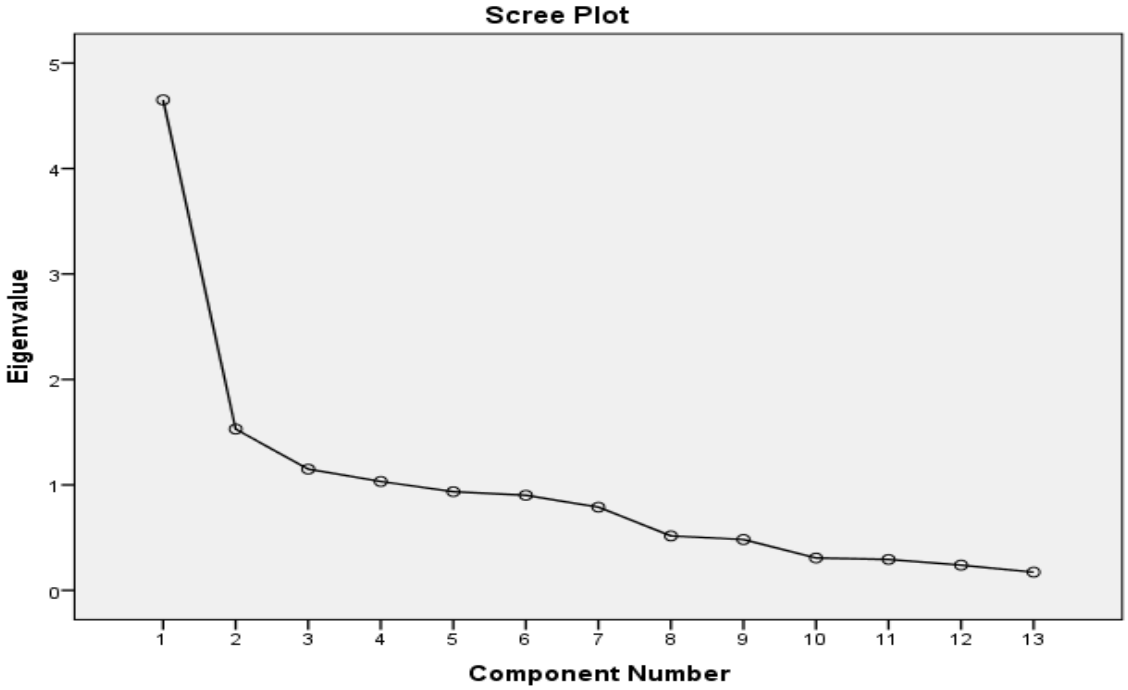

Figure 8. Scree Plot.

The scree plot displays the eigenvalue against the component number, where from the elements that have lesser strength the line start to get flatter, meaning each sequential element is accounting for smaller and smaller amounts of the total variance. In general, we are interested in keeping only those principal components whose eigenvalues are greater than 1, in this case at component number 4 (Beaumont, 2012); (Shahu, 2013). Components with an eigenvalue of less than 1 account for less variance than did the original variable , and so are of little use (Pandey, 2008).

Component Matrix[a]

	Component			
	1	2	3	4
Smart City Education	.841	-.078	-.091	-.025
Financial Instituitions	.836	-.075	-.036	-.062
Innovation Hubs	.829	-.028	-.045	-.104
Government Support	.817	.030	-.002	-.153
Industry Networks	.809	-.017	-.096	.076
Market Conditions	.797	-.140	.042	.098
Government Regulations	.673	-.173	.011	.040
Network Coverage	.140	.806	-.003	.063
Educational Facilities	.264	.748	.045	.242
ROLE	.071	-.056	.756	-.192
RESOURCES	.074	-.275	.611	.488
Hub will	-.073	-.290	-.360	.708
Innovation_Spirit	.201	.308	.226	.372

Extraction Method: Principal Component Analysis.
a. 4 components extracted.

Figure 9. Component Matrix.

Component Matrix contains component extractions, which shows the correlations between the variable and the component. The correlations values should fall between negative one (-1) and positive one (+1) (Brooks, 2008); (Syms, 2008; Mishra *et al.*, 2017; Abrate *et al.*, 2018).

Rotated Component Matrix[a]

	Component			
	1	2	3	4
Smart City Education	.848	.059	-.019	.014
Financial Instituitions	.840	.053	.005	-.047
Innovation Hubs	.828	.081	-.037	-.085
Government Support	.806	.120	-.045	-.160
Industry Networks	.802	.143	.013	.084
Market Conditions	.797	.044	.168	.047
Government Regulations	.685	-.029	.114	.033
Educational Facilities	.124	.821	-.019	-.010
Network Coverage	.006	.791	-.176	-.129
Innovation_Spirit	.109	.459	.308	.082
RESOURCES	.038	-.034	.827	.079
Hub will	-.033	-.080	.161	.829
ROLE	.024	-.041	.523	-.583

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 4 iterations.

Figure 10. Rotated Component Matrix.

The Rotated Factor Matrix diagram articulates factor loadings after rotation (in this case using Varimax approach). **Kaiser normalization** is a technique to retain stability of solutions across samples.

Component Transformation Matrix

Component	1	2	3	4
1	.982	.174	.056	-.043
2	-.159	.926	-.266	-.215
3	-.086	.080	.802	-.586
4	-.053	.325	.531	.780

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Figure 11. Component Transformation Matrix.

Varimax rotation is the most popular orthogonal rotation. The benefit of Varimax rotation is that it maximizes the variances of the loadings within the factors while maximizing differences between high and low loadings on a particular factor (Norman, 2011).

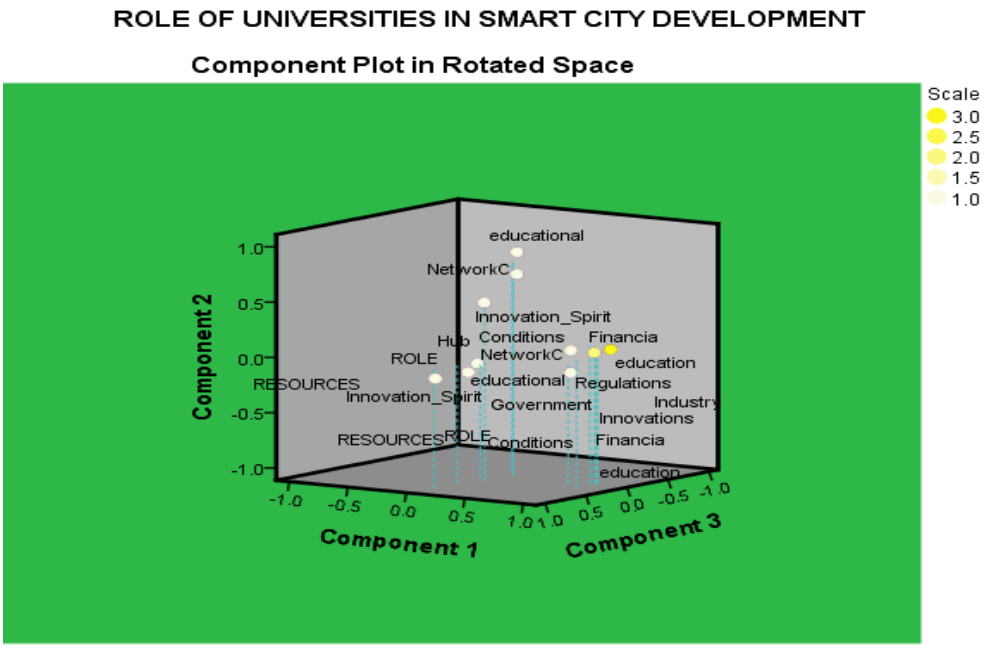

Figure 12. Component plot in rotated space.

The component plot in the rotated space using varimax approach indicated that Smart city education, financial institutions, innovation hubs and government support are the key components that can enhance university`s role in smart city development. Those factors that had an eigenvalue greater than 1 are indicated by the scale which shows the strength of each variable in the rotated space (Fosså *et al.*, 2013).

4 Discussions

The research analyzed the role of universities in the development of smart cities and the requirements that can smoothen the process or initiative (Brekke, 2021). Research and development was established as the primary role that can be played by universities in smart city development through developing and testing new technologies (Ransom, 2015), (Brennan and Cochrane, 2019). A positive relationship was established between smart city education (awareness campaigns and smart city curriculum), innovation hubs (incubation facilities and improves the quality of innovations), financial institutions (creditors, attorneys, banks) and government support (incentives, research grants, policy formulation) (Ardito *et al.*, 2019; Antwi-Afari *et al.*, 2021; Zhu and Alamsyah, 2022) . Government intervention through increasingly opening their data for public consumption in the form of Open Government Data (OGD), can expand the innovative potential and helps avoid duplication and unnecessary reinvention (OECD, 2020b). The growth of incubation hubs has led to the growth use of big data in other countries such as South Africa, Ghana, Nigeria, Kenya among others leading to successful innovations such as mPesa, Esoko, and mPedigree (Owusu, 2016). Smart city education is a basic prerequisite for achieving sustainable development and a key tool for achieving this goal. An education should link and balance the three spheres of thinking: economic, social and environmental, and that requires interdisciplinary teaching (Sukiennik, Zybała and Fuksa, 2021). Governments and policy-makers that are more open, more transparent, collaborative, participatory and accountable, less restrictive financial support where additional government funding could be injected into activities across the innovation ecosystem. This kind of financial support would ease the infrastructure cost burden borne by hubs, such as rent and telecommunications (Sambuli and Whitt, 2017).

5 Conclusions

Principal component analysis (PCA) may supplement and build up the summary of findings by the use of regression modelling techniques (Mikkelsen, 2019). Sound policy that creates an enabling environment and that encourages collaboration with ease. In preparation for the smart city, institution of higher education and city leaders need to collaborate in order to have successful innovations. City fathers should aim to be both 'smart' and flexible, with academies teaching a creative and highly skilled labor force. As a result, connecting with city leaders to use data and technology to mend the urban environment. It was agreed that, problems of the future will increasingly be tackled by cities themselves, supported by universities and a wider system of cities as advocated by (Ransom, 2015); (Kasim *et al.*, 2020); (Brekke, 2021; Petersen and Kruss, 2021).

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Exploring strategic innovation in the success of private health care business: A conceptual model

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Abstract. Private Healthcare business is important to developing economies as they are less populated hence imperative for emergency healthcare assistance since public hospitals are overburdened and short staffed. These objectives are important for Zimbabwe since Covid-19 wreaked havoc on the country`s healthcare industry in ways no one expected. In Zimbabwe, state hospitals were overburdened, so those with more disposable income flocked to private hospitals. The private hospital faced challenges of more patients and speed to attend to patients who require emergencies in order to cope with new healthcare trends brought on by the pandemic. Operational costs remained high yet innovation provides an opportunity for cost management and improving chances of success. In view of these possible contributions, this paper sought to establish whether strategic innovation can improve success of private healthcare business. This paper contributes to literature on technology acceptance, strategic innovation, and success of private healthcare business. To achieve that, the researchers reviewed and developed a conceptual model using literature on strategic innovation, technology acceptance, and private healthcare performance. The model and paper at large are original in that it takes a strategic innovation and developing country perspective.
Keywords: *Strategy, Innovation, Healthcare, Technology*

Introduction

The healthcare industry has seen significant transformation in the last year, with new business models, unanticipated collaborations, and expedited schedules forcing firms to rethink how they operate. Many of these shifts are expected to continue. The healthcare sector has traditionally been a delinquent throughout digital adoption, according to Dal Mas et al (2020), but the pandemic has thrown a major jolt of pressure to integrate new tools and technologies. Providers quickly scaled their offerings, and within a few months into the epidemic, they were seeing 50 to 175 times the number of patients via telemedicine. Providers have also embraced digital connection with patients and communities in a more widespread way, such as sending out proactive messages about COVID-19-related protocols. Meanwhile, pharmaceutical and medtech firms have increased their spending on digitally connected clinical trials and customer engagement models (Zanman, 2020). The epidemic has highlighted the extent to which healthcare may be offered remotely, including virtual care and remote patient monitoring, as well as virtual collaboration for pharmaceutical and medtech industry specialists. This concept allows for more flexibility and allows enterprises to tap into a larger pool of talent. Leaders in the healthcare industry are also rethinking old working standards and implementing new policies, such as providing aid to overcome videoconferencing fatigue (Berry et al, 2019). Many healthcare companies will have to modify their operations and their mindsets to adapt to these shifts, as well as a slew of others.

Prioritizing innovation during a crisis, according to previous research, can assist unlock development in the recovery if executives approach it with dedication and build crucial competencies and processes (Kodoma, 2018). Covid-19 wreaked havoc on the healthcare industry in ways no one expected, and in Zimbabwe, state hospitals were overburdened, so those with more disposable income flocked to private hospitals. As a result, private healthcare businesses were forced to strategically innovate in order to cope with new healthcare trends brought on by the pandemic. Because this is a developing field with no way of knowing when the pandemic will end, private healthcare institutions must be innovative in order to meet demand and stay in business.

This concept paper will identify the strategic innovation measures used by private hospitals and assess the effectiveness of the strategic innovation measures used by private hospitals. The outcomes of concept paper may aid the private hospitals and other stakeholders in understanding the importance of strategic innovation in achieving success. The concept paper could also help private hospitals improve its strategic innovation efficiency. Furthermore, end users of private hospitals will benefit from the study because they will gain a better knowledge of why it is critical for private hospitals to embrace strategic innovation in their business and how this will improve user experience.

1. Significance of Private healthcare business

Private hospitals have the greatest advantage in that their capacity is limited, allowing them to give individualised care to their patients. Instead of packed hospital beds and shared rooms, as well as a dearth of staff and practitioners, these clinics will provide patients with the immediate attention and care they deserve (Kruse et al, 2018). This makes the patient's experience as pleasant as possible by paying close attention to detail and providing thorough care. The patient's experience is further influenced by the fact that certain hospitals provide 24-hour care while others handle simple procedures and checks. Specialist treatment is often provided by and in private clinics and hospitals. As a result, services may be more limited yet targeted, and patients are more likely to see a highly skilled, specialised healthcare professional. Aesthetic medicine and drug and addiction therapy are also available through private businesses. The private hospitals concentrate on providing a small number of specialised therapies to patients who need them, allowing them to focus on service delivery and excellent care (Creixans-Tenas et al, 2019). The patient-to-doctor and staff-to-patient ratio is what allows private hospitals to provide such individualised treatment while also reducing wait times. The doctor-to-patient ratio is also substantially lower on average, allowing the healthcare professional to devote more time and attention to the patient's concerns and condition. Private clinics invest considerably in the greatest technology and equipment because of their privatised setup and specialised clientele and services (Dewanto and Wardhani, 2018).

2. Private Healthcare drivers in Zimbabwe

Murewanhema (2022) states that private healthcare drivers in Zimbabwe include the staffing expertise. Most of the public hospitals expert staff end up going abroad to work because of meagre salaries they will be earning in Zimbabwe. Therefore, as stated by Tadokera et al (2021) the private healthcare sector in Zimbabwe manages to attract the expert staff because of attractive salaries and allowances they offer which on the current rate being paid by the government is more than ten times.

The other driver to private healthcare in Zimbabwe is technology that is possessed by private hospitals that is not available in public hospitals. Nhapi (2019) highlights that the Trauma centre Borrowdale was during the onset of Covid-19 the only hospital that had a ventilator and other technology that were recommended for critical patients with progressive Covid-19. Therefore, a lot of people end up choosing private hospitals over public hospital because of the availability of essential technology.

3. Major Challenges to Private healthcare business

The dynamics of both hardware and software are shifting in today's tech ecosystem. According to Maborekwe et al (2019), IoT connects 48 percent of medical equipment, with that number predicted to rise to 68 percent in the next five years. According to Gnanlet et al (2019), the connected medical device industry is predicted to triple in size between 2019 and 2023. Advance technologies such as AI and

machine learning are now being employed in hospital software applications such as Appointment Management System, Patient Administration System, and Laboratory Information Management System. To fully realise the promise of healthcare technology to revolutionise health systems and create a more connected healthcare environment, healthcare leaders and physicians must strengthen their relationships with other stakeholders. This is a challenge for a developing country like Zimbabwe with a disintegrated healthcare system.

The healthcare expense crisis is not new. Many parties, including device makers, medical prescription producers, payers, and insurance policy providers, have a vital role in setting the cost of healthcare services. When there are so many stakeholders engaged, conflict is unavoidable. And reaching an agreement takes time and careful effort. The rising cost of healthcare has a direct impact on private healthcare organisations' revenue, as increased costs discourage people in a variety of ways, from obtaining lab testing to following up with regular follow-ups after a visit, resulting in poor patient outcomes (Kodoma, 2018).

4. Methodology

Desktop review approach was used in the study. Scanning the literature, assessing secondary data, and compiling a reference list are all part of the desk review process, which ensures that all papers are organised and accessible to all team members. The desk review process was led by the team coordinator in cooperation with the other supervisors of this concept paper. To improve the overall effectiveness of study, existing data was summarised and compiled. Research material released in research reports and other comparable materials is considered secondary research.

5. Assumptions

It will be assumed that all study participants presented their ideas, insights, and suggestions honestly, autonomously, and as correctly as feasible. During the study's period, the financial, judicial, and geopolitical environments held steady.

6. Conceptual framework

For this concept paper the key operative word is strategic innovation and is fundamentally the independent variable of the conceptual framework with aspects like technology, perceived ease of use and perceived usefulness being modifiers of the independent variable. Thus, PSMI is the dependent variable. Hence the health success of private organisation in the form of PSMI will depend on the strategic innovation that are deployed whether in a positive or negative manner. Equally, the conceptual framework will have what are known as moderators as posited by Smith (2018) which modify the independent variable (strategic innovation) such as perceived ease of use which consequently influencing the outcome on the dependent variable which is dependable.

7. Discussion and conclusion

According to Zamnan (2020) in the United States, the US Food and Drug Administration deployed a range of measures (such as issuing new guidance, establishing new industry engagement models, and issuing emergency use authorizations) designed to support the COVID-19 response across the range of products it regulates. In several instances, the FDA stipulated or requested that manufacturers gather data derived from the real-world use of products in order to better characterize performance, understand supply-chain vulnerability, and support additional development activity, both throughout and beyond the pandemic (Zaman, 2020).

Berry et al (2020) suggests that the COVID-19 pandemic has highlighted the benefits of nontraditional and creative partnerships and collaborations in quickly finding creative solutions to urgent problems—from the health and auto industries teaming up to build ventilators, to pharmaceutical sector competitors collaborating to hasten the development of a COVID-19 vaccine, to healthcare providers partnering with technology companies to deliver COVID-19 apps and solutions. Experts expect such extensions of the healthcare ecosystem to be the way of the future, with more partnerships

and consortia that pool capital, assets, and capabilities, both to bring operational synergies and drive innovation (Berry et al, 2019).

Strategic creation is the application of reimagining or redesigning an institution's company's strategy in effort to enhance company growth, add value to the firm and its customers, and obtain a competitive advantage (Grillitsch et al, 2019). Businesses must use this type of innovation to keep up with the rapid speed of development progress. Companies that embrace strategic innovation are not need to modify the products and services they sell to their clients, nor even the technology enables these services, in order to thrive. The term "strategic innovation" refers to initiatives that take place at the executive level (Mohamed et al, 2020).

According to AlQershi et al (2021) corporate strategies could include the following considerations: what services or products need to be reinvented or developed; what markets to compete in; what business models to develop; how to optimize business processes; how to expand the customer base; how to position the company's brand in relation to target customers; how to make the supply chain and value chain more efficient; and go-to-market strategy. Although strategic innovation initiatives are led by senior leaders, they need to foster a culture of innovation that encourages collaboration across business teams and functions.

In his study of a strategic innovation in an Asian organization, Kodoma (2018) uncovered a phenomenon called as disruptive innovation. According to his research, the company provided a novel business strategy which challenges or disrupts the business models of opponents. As a result of the Asia industry's choice to give free delivery, other e-commerce businesses have been compelled to offer free or reduced shipping in that area. Berry (2020) discusses radical innovation, which he claims necessitates technological innovation while remaining compatible with the present economic paradigm. Companies like Infarm, which employs remotely managed farming technology to grow vegetables within stores, rely on the traditional retail model to serve customers with fresh local produce. Architectural innovation is the other type of strategic innovation, which is essentially a combination of new technology and a change in business model. Architectural innovation can be the most difficult to implement (Berry et al, 2019).

The need of carefully planning the implementation of health information technology by businesses is highlighted in the study by Mukono and Tokosi (2019). The major users of the health information implementation at PSMI must be engaged and involved in order for them to embrace and own the system. This will increase the likelihood of future health information technology project implementations dramatically.

Gwayagwaya (2020) assessed the surveillance of antibiotic prescribing practices and resistance trends at an accredited private hospital in Zimbabwe. The researcher of the aforementioned study discovered that PSMI's surveillance system for monitoring prescribing practices and reporting resistance patterns in low-income countries' healthcare facilities will help to reduce antibiotic resistance by adding data to national health systems and assisting in the development of national antibiotic policy and antibiotic stewardship programs. However, adoption levels at PSMI were quite low.

Chisveto (2017) looked at how a centralized treasury management system affected business operations, with a focus on PSMI. The study looked into the reasons for the company's use of a centralized treasury management system, the costs associated with the current treasury management system, how the centralized treasury management system affects the flow of goods and services across the company's business units, and drew strategic conclusions about centralised treasury management for the company. The findings revealed that finance managers from strategic business units are only involved in financial data consolidation. The findings point to the necessity for an effective hybrid treasury structure that combines the advantages of both centralization and decentralization. A supportive information technology system is also recommended by the organization to facilitate effective decision making and resource allocation among the strategic business units.

The findings from the review of local literature highlight that strategic innovation has low impact on performance of private hospitals. The findings are accurate for strategic innovation developing countries as the study by Palesa (2018) of a company in Zambia demonstrated that because of limited technology

advancement and complex organisation structure made it difficult for strategic innovation to be implemented and ultimately be successful.

The study via literature review also found that some private hospitals in the form of PSMI for instance as stated by Berth et al (2020) have started using big data analytics to provide faster and more accurate diagnoses for its patients. The new system can comb through thousands of data points about each patient to diagnose the condition and find treatment options nearly instantly.

Mpedu et al (2021) indicates that strategic innovation in healthcare can drive drive economic growth by improving efficiency and increasing productivity, as well as optimizing patient outcomes.

The study also noted the key barriers to the effectiveness of strategic innovation. Lee et al (2021) states that inadequate effort devoted to effectiveness made strategic innovation to fail. Lee et al (2021) observed that cost-effectiveness is generally not rigorously assessed during the course of development. Drug and device development are an expensive and lengthy process. It is hard for companies to justify further dollars and time in cost-effectiveness studies, particularly as there are no agreed-upon set of measures by the industry and payers. As result, there is an opportunity to develop a stronger and commonly agreed upon scientific foundation for cost-effectiveness measures and studies.

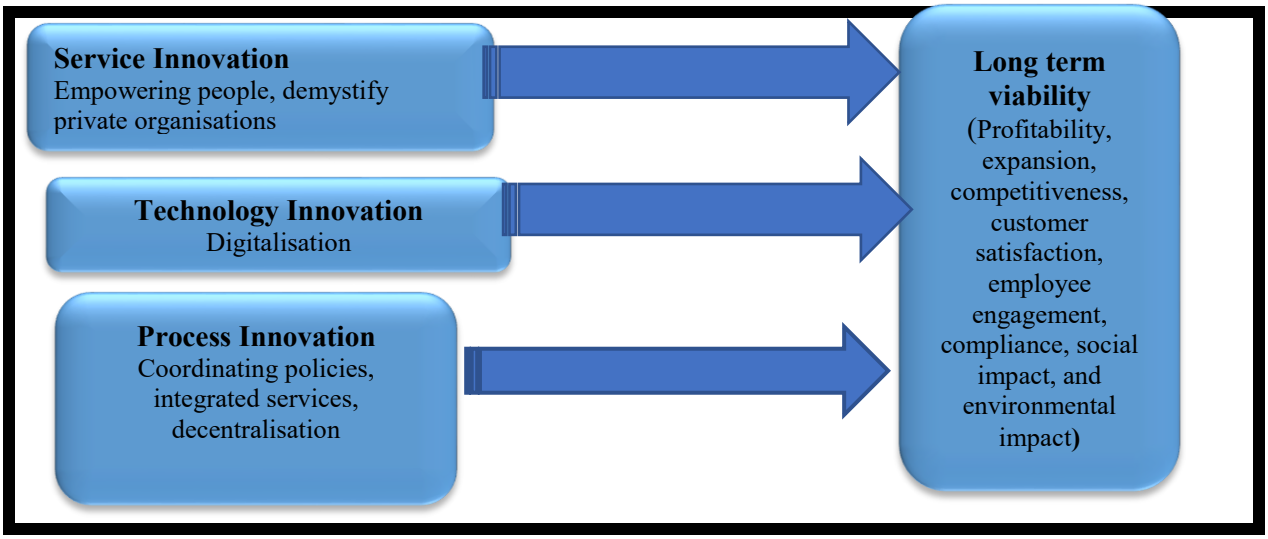
Not enough patients entering RCTs (randomized controlled trials). The study by Goldberg et al (2020) identified several reasons for this. Patients are reluctant to accept the default arm of trials, often not considered an equivalent therapy. For many patients with cancer, treatment is a "one-shot chance" and they want to take the option recommended by their physicians. Further there is less reliance on evidence-based medicine in cancer treatment and too great a tendency for premature adoption of therapies based on presentations at major conferences. Finally, managed care plans generally refuse to encourage participation in trials.

Mpilo et al (2021) stated that reimbursement policies not friendly to innovation. The underuse and overuse of medical technologies suggest that the right incentives may not be in place. Jen et al (2019) suggest that fee-for-service payment systems reward individual acts by individual people. They do not support very well integrated delivery capabilities increasingly necessary to treat a wide range of chronic conditions, such as congestive heart failure and diabetes. Public policy changes a major uncertainty for venture capitalists. With regard to investing in medical innovation, venture capitalists understand how to evaluate technology and development risks, it is difficult for them to assess the degree to which the public policy rules will change. Mee (2019) said that to foster innovation public policies must be consistent in order to have a salutary effect on prices, the investments required, and the timeframe from idea to marketplace. He asserted that price controls are disincentives to investment and speculated that a mandatory pharmacy benefit under medical insurance would likely be accompanied by price controls and therefore could be a disincentive to investment and innovation. Shortening the life of patents is also a disincentive to investment. In addition, a consistent approach to coverage and reimbursement decisions is desirable.

In recent years investment costs have been increasing. It has been 10 years since the discovery of the cystic fibrosis gene and there is still no therapy derived from this discovery (Gin and Bee et al (2019). The timeframes and the amounts of money needed to develop genomic therapies are still unknown. The requirements for clinical trials and regulatory review are important determinants of overall development timescales—up to 8 years out of a typical 15-year development cycle for a new drug. Bloom et al (2019) said that recent public policy changes have helped with carrying out clinical trials, and over the past few years the time for regulatory review has also improved.

8. Recommendations – A Conceptual Model

Independent variables **Dependant variable**



9. Tenants of Conceptual Model

9.1. Investing in Digitalisation

PSMI needs to invest in digitalisation in order to foster strategic innovation timely. Advances in digital health can also benefit healthcare professionals. By greatly boosting access to health data and allowing individuals greater influence over their health, digital tools provide healthcare providers with a comprehensive perspective of their patients' health. As a result, efficiency has increased and medical results have improved. Digital health technology aid clinicians in reducing inefficiencies, increasing access, lowering costs, improving quality, and personalising treatment for patients. At the same time, digital health technologies make it easier for patients and consumers to monitor and track their health and wellness activities.

9.2. Setting up of Coordinating policies

Moreover, the review laid out that there is no union as far as guaranteeing accessibility of key framework at strategy level where the vast majority of key suppliers, for example, network access suppliers focus on arrangement of such administrations in currently evolved regions disregarding the not so worthwhile vacation destination zones consequently these regions remain minimized. Created nations running against the norm have strategies that advance issues, for example, foundation sharing which guarantee that such key framework is very much accommodated according to a planned perspective with the different players seeking administration conveyance not responsibility for. The specialists that is both the Ministries of ICT and Tourism inside the Zimbabwean setting ought to return to the drive on framework sharing where arms, for example, the POTRAZ become the foundation controllers where all the different specialist organizations contend on arrangement of genuine administrations and not on foundation abilities. These discoveries highlight the endeavours that different nations that have kept triumphs in reception and execution of IOT in medical care business have carried out consequently introducing a hole inside the setting of the Zimbabwe supporting the reasoning of the review.

9.3. Rewarding the employees through empowerment

Employee engagement rises when they are rewarded and recognised, which boosts retention and contributes to a more favourable workplace environment. Incorporating a rewards and recognition programme can assist boost employee engagement, which can lead to a variety of business benefits such

as greater productivity and retention. Employees at PSMI should be encouraged to express their thoughts. Others may be hesitant to break from the norms because they are fearful of introducing new thought processes to their staff. PSMI should recognise and promote innovative thinking because it provides a strong incentive for idea sharing and can help to stimulate the creative process.

9.4. Decentralisation

Lower levels gain more autonomy or independence as a result of decentralisation. This allows subordinates to do tasks in the most efficient manner possible for their department. When each department strives to be the best it can be, production rises and more revenue is generated, which can be used to expand the company. The delegation of authority at the intermediate and lower levels demonstrates the top level's trust and faith in their subordinates, and this trust and faith motivates employees at all levels because they are free to make decisions without seeking approval from superiors. Decentralization managers at the lower and middle levels are also taught how to make choices.

10. Feasibility and Justification of recommended strategy

The research and development center recommended as part of capacity building and training. This idea is justified because establishing a research development and training center will also help ensure that a preceding center of development for other industries will be set paving way for an inclusive adoption of the recommended conceptual model across the various facets of the economy of the country and thus will prove to be a springboard for adoption of strategic innovation developments. This argument has further been postulated by Tice J (2019) where she stipulated that an effective contemporary strategic innovation roadmap has to address issues of capacity development where emphasis was also placed on ensuring that necessary structures for enhancing strategic model is a key issue through training, research and development. Therefore, the establishment of a research and development center contribution to the initial conceptual model is a futuristic development thus the conceptual model becomes scalable.

In establishing the founding conceptual model, the researcher was of the idea that the concept be open for willing players but input from the findings of the study has pointed out this could be a potential area for an unsuccessful conceptual model. The basis of the argument was on the fact that voluntary infrastructure sharing option was previously attempted but could not yield any meaningful impact to the private hospital industry however, the contribution rationale was also to ensure that the various stakeholders within the industry have access to any infrastructure requirements without ownership costs associated and this could foster such players to adopt strategic initiatives by private hospitals. This argument was incorporated due to the fact that contribution from the key informants of the study was in sync with the assertions done by Kotonya et all (2017) who clearly pointed out that infrastructure complexities are a major drawback in terms of strategic innovation setups especially in developing countries, therefore inclusion of this perspective as proposed by key informants of this study would help plug a gap that had been already alluded to. This implies that by resolving this concern the conceptual model would have mitigated on the rising concerns of the strategic innovations by private industries.

The researcher’s recommendations emphasize the need to note that the engagement of service providers was essential but also highlighted that such an effort would best achieve intended results if various ministries such as the Ministry of ICT were to be roped in for ease of incorporation of such conceptual model considerations as well as for ease of incorporation of other government bodies such as POTRAZ for the regularization part of any policies within the conceptual model. This input was adopted as presented given the need to stir a sound buy in which calls for more inclusion of all key stakeholders. Exclusion of key stakeholders would enhance delays in implementation of any conceptual model to be designed from the research. Stakeholder engagement would be vital as thus initiative is at industry level hence the bearing of such a conceptual model would then be used as a stencil for cascading enabling conceptual models for other industries alike hence it is imperative to revisit the initial conceptual model to capture the input of some of the key informants of the study.

11. Implementation guide/model

The implement the conceptual model it is imperative to have perpetual study mechanism that entails continual service improvement of the conceptual model. The fact that this conceptual model is still a novel, there is a notable requirement for a study mechanism to ensure the model continues to improve and this is further buttressing the assertion of a control mechanism where the output from the control efforts should trigger a study of the conceptual model and this process is an iterative process that is applied to every stage of the conceptual model. This implies that every conceptual model stage is systematically studied for any possible improvement as well as an evaluation of the control environment also for improvement and mitigation of risks identified.

The idea of a self-regulating conceptual model that addresses issues of monitoring and control is proposed for implementation of the suggested conceptual model. The existence of a control conceptual model would aide in the improvement of risk mitigation strategies to alleviate the upcoming security challenges and the fact that these processes are iterative covering every stage or phase of the conceptual model, this implies that monitoring and controls are vigorously applied to the entire conceptual model to ensure that risks are identified and resolved timeously within the conceptual model.

12. Contributions

12.1. Theoretical Contributions

The study's findings will help future studies to build up for their respective studies in relation to the role of strategic innovation in private healthcare. Equally, the study findings assist with the understanding of the strategic innovation implementation challenges that are faced by private healthcare business. Equally, the study exposes some of the potential of the study that can be utilized by adopting the suggested conceptual model. The study also demonstrates the manner in which the recommended conceptual model has to be implemented to achieve optimal results.

12.2. Innovative Practical Innovations

The study also established the non-existence of a guiding conceptual model to regularize and promote adoption of the strategic innovation strategies as well as to help private healthcare industry players navigate through the noted concerns which these organizations or entities could not independently address due to incapacitation. As alluded to in the second chapter of this research, countries such as Malaysia which have started to realize improved adoption of IOTs within the private healthcare industry as well as China, guiding strategies and conceptual models have been designed to help improve these industries come up with strategic innovation initiatives but these conceptual models and strategies have been missing in the context of the Zimbabwean private healthcare industry and resultantly there has been a lagging behind in terms of the levels of adoption. Establishment of such strategies and conceptual model helps industries realize coordinated benefits across the entire industry thus helping all stakeholders within the industry come up with complementing efforts to realize the goal of enhancing adoption of strategic innovation strategies within the industry. As a result, the research through engagement of various identified key contributors drawn from various industries with a basis of strategic innovation experience and academic knowledge have helped come up with the recommended conceptual model that could be adopted to enhance the adoption of a guiding strategic innovation adoption within the private healthcare industry.

13. Limitations of proposed solutions

The research calls for coordinated efforts of private healthcare industry for infrastructure sharing to reduce potential costs of some of the strategic innovation initiatives but this depends on how the private health industry are willing to participate and self-organize. This is difficult for the researcher at this stage to predict how successful that will be hence the suggested solutions remain speculative and depended on how the respective private industry mobilize and crucially significant players with significant capacity to carry on financially worker private hospitals.

The researcher also calls for the government to support by assisting with co-coordinated policies which will create consistency and ultimately the ease of implementing the conceptual model at a higher level. Again, it is unclear whether the government is willing to invest itself into regulating private

healthcare business when the hospitals under its own guidance is failing indicating that the policy making efforts already may not be motivating.

The suggested conceptual framework has perpetual study mechanism which will require set aside budget for it to be feasible and robust. Considering how economic situation in Zimbabwe, this may be a limiting factor for most of the private health businesses in Zimbabwe.

14. Limitations of concept paper

The main alternative sources recommended were books and the internet. Recorded sources are restricted because explicit access is required, which the analyst lacks. Due to budget constraints, the analyst was unable to go on more extensive trips that would have been beneficial to the investigation. By completing the majority of the necessary obligations on the outings that were taken, the specialist had the choice of reducing the number of excursions taken while maintaining their productivity. There are a few local resources on important development in secret medical care offices. digitalization. This study looked at sources from unfortunate countries to better understand possible social consequences.

15.Further Research

Future studies can look at the role of strategic innovation in private healthcare business beyond just one country for instance a regional examination.

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Roma people and the Europeanization process. The status of European minority.

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Abstract: The paper: ‘’Roma people and the Europeanization process. The status of European minority’’ focuses on the Europeanization process for the Roma people and what are the main key moments in defining them as an European minority. Furthermore, it is important to present how the Europeanization process impacted the Roma community and what are the principal changes that have emerged through gaining the status of European minority.
Keywords: *Europeanization, European minority, Roma people*

1.Introduction

The process of "Europeanization" is an often used term that sometimes captures competing processes and sometimes staggered ones that specifically refer to institutional isomorphism and policy convergence. It is also suggestive of the movement, far from a purely intergovernmental organisation towards a European policy, or at least, a more integrated European political regime. Krasner suggests that regimes are "sets of principles, norms, rules and implicit or explicit decision-making procedures around which actors' expectations converge in a particular area of international relations’’[1]

The Institutions of the European Union have contributed to the development and building of a pan-European Roma identity. This new identity is primarily a political one because, linguistically and culturally, the Roma are still largely a heterogeneous group. Europeanisation has helped to develop a general human rights regime and a 'solution-oriented' human rights narrative. For its part, this has presented to minority groups, especially the Roma, a series of previously unknown political opportunities, both at European Union level and at the level of the other states in the European area.

As a consequence of Europeanisation, ethnic/minority groups realize and/or discover a more pronounced, consolidated national identity, or at least the shell of one. The expectations and assumptions of minority groups, in this case the Roma, and the ways of contention at their disposal, align themselves in such a way as to produce regularity and synergy between a previously dispersed community.

2.The Europeanization process

Europeanization is a somewhat amorphous process. However, it is suggestive of several contemporary developments, namely, the harmonization of institutional convergence policies, and normative reordering between (and within) European states. It has been identified both as a cause and as a consequence of European integration. Europeanisation is a concept closely linked to the accession and

[1] Stephen D. Krasner, „Structural causes and regime consequences: regimes as intervening variables,” in International Regimes, ed. S. D. Krasner, (Cornell: Cornell University Press, 1983), 2.

post-accession processes and encapsulates the 'merging' and 'bringing together of cultures' and political institutions in a broader European policy (or decision-making for a).

However, most may agree that Europeanisation is a multi-stage, complex and multi-level process. Radaelli stipulates that: "Europeanisation consists of processes of (a) construction, (b) diffusion and (c) institutionalisation of norms, procedures, political paradigms, styles, 'ways of doing things' and common beliefs and norms which are first defined and strengthened in the EU policy process and then incorporated into the logic of internal discourse (national and sub-national), political structures and public elections''[2]

This is a comprehensive definition of the Process of Europeanisation, which highlights the downward flow of regulatory standards and institutional practices from the Institutions of the European Union to the Member States and emphasises structure, discourse and public choice. There is both a deliberate and unintentional side to this process, with norms, ideas and expectations generated at European, civil society and Member State level (which also exist outside Europe).

The European Union, and in particular the Commission, has been instrumental in supporting Europeanisation and the development of an ethos or a 'European' programme throughout the Union. This is, after all, one of their main functions. However, other European institutions outside the EU, such as the Organisation for Security and Cooperation in Europe (OSCE), have done much to support the development and construction of a pan-European rights regime. In the field of Roma rights and integration, the OSCE has contributed to several comprehensive integration strategies and 'action plans'. Many of their recommendations are based on a particular conceptualisation of the Roma as a European minority (and, strangely, not a national minority) with a common cultural history and identity. The Council of Europe 1203 (1993) recommendations on Roma in Europe provide for:

1. One of the objectives of the Council of Europe is to promote the emergence of a genuine European cultural identity. Europe is home to many different cultures and all of them, including the many minority cultures, enrich and contribute to Europe's cultural diversity.
2. A special place among minorities is reserved for the Roma. Living scattered throughout Europe, not having a country to call their own, they are a real European minority, but one that does not fit into the definitions of national or linguistic minorities.
3. As a non-minority, the Roma contribute greatly to Europe's cultural diversity. In different parts of Europe, they contribute in different ways, whether through language and music, or through their crafts and crafts[3]

The first dating of Roma as an ethnic minority belonging to Europe was given by the Council of Europe in the late 1960s when it referred to "populations of nomadic origin" or "Gypsies and traveling groups"[4].

In its Recommendation 563 (1969) on the situation of the Roma and other nomads in Europe, as well as the numerous questions it put to the Committee of Ministers, the Parliamentary Assembly drew attention to the situation of Roma communities.

The Minority Rights Group (GDM) first published a report on the Roma (or 'Gypsies', as they are known in Western Europe) in 1973 and has since followed with great interest the developments affecting

[2] Adrian Favell and Virginie Guiraudon, eds. Sociology of the European Union (London: Palgrave Macmillan, 2011).

[3] The OSCE Office for Democratic Institutions and Human Rights has published several reports and 'action plans' summarising the difficult situation of the Roma and proposing a short- and long-term policy to help alleviate some of the institutionally generated prejudices that negatively affect Roma and Sinti. A report entitled, The implementation of the Action Plan on improving the situation of Roma and Sinti in the OSCE area, focuses on human security, police brutality and educational opportunities.

[4] Council of Europe, "The situation of Gypsies and other travellers in Europe," (Strasbourg: Council of Europe, 1969), "The role and responsibility of local and regional authorities in regard to the cultural and social problems of populations of nomadic origin," (Strasbourg: Council of Europe, 1981).

this minority. Following the collapse of the communist regimes in Eastern and Central Europe and the significant changes in the situation of Roma communities in Europe as a whole, the GDM commissioned a fully updated report on The Roma/Gypsies: a European minority, from two recognized experts in this field. This report is seen as an active method of supporting the work of the Group on minority rights, especially where the GDM has established practical training initiatives with Roma communities to encourage emancipation and also multicultural education projects to inform and educate 'mainstream' communities.

Resolution 125 (1981) of the Permanent Conference of Local and Regional Authorities in Europe (CPALRC) which had as its main theme "On the role and responsibility of local and regional authorities with regard to the cultural and social problems of populations of nomadic origin" addressed in detail the general situation of Roma communities and presented a series of recommendations. In direct response to the education-related section of this resolution, the Council for Cultural Cooperation (CDCC) decided in 1983 to organise an international seminar, the first of its kind and which was to pave the way for the next. The Council of Europe has also provided both the initial impetus and the continued support for a number of publications, most of them related to education[5].

It was not only the educational aspects that were taken into account. In 1983, the Committee of Ministers adopted Recommendation R(83)1 on stateless nomads and nomads of indefinite nationality. In 1986, the ad hoc committee of experts on the movement and identity documents of persons adopted the final activity report on the examination of legal issues relating to the movement of travellers. The Committee of Ministers highlighted some important points in response to members' questions. For example, at his meeting in April 1984, he gave an answer to question No. 271 "On the recognition of Roma as an ethnic minority".

The European Parliament adopted in March 1984 a resolution on the education of children with parents without a fixed home and another on the situation of Roma/Gypsies in which it recommended that the governments of the Member States coordinate their perspectives and called on the Commission to draw up Community-funded programmes aimed at improving the situation of the Roma without denying their cultural values[6]

3.The status of European minority

However, bringing the Roma into question as a 'truly European' minority and launching programmes to monitor and improve the situation of the Roma is rather a post-social phenomenon. In the early 1990s, both the Organization for Security and Cooperation in Europe (OSCE) and the Council of Europe began to support the publication of extensive reports on the situation of Roma[7].

The two institutions have also developed their own bodies that have been dedicated to Roma issues. The OSCE established a contact point for Roma and Sinti issues (the official name of the Roma minority in Germany) within the Office for Democratic Institutions and Human Rights in 1994 and formed the position of Adviser on Roma and Sinti issues in the OSCE area in 1998. The Council of Europe offered a place of coordinator on Roma issues in 1994 and set up a group of specialists on Roma, Gypsies and Nomads (also called travellers) in 1995, later called MS-S-Rom (Committee of Experts on Roma and Nomads) and initiated the European Forum for Roma and Nomads in 2004.

[5] Training of Teachers of Gypsy Children, report of the twentieth Council of Europe seminar, Donaueschingen, 20-25 June 1983, Council for Cultural Cooperation, Council of Europe, DECS/EGT(83)63 (English, French and German editions, Council of Europe, Strasbourg;*** Italian version, Lacio Drom, Roma; Spanish version, Presencia Gitana, Madrid).

[6] Martin Kováts, "Problems of Intellectual and Political Accountability in Respect of Emerging European Roma Policy," Paper presented at the Romani Studies Seminar, University of Greenwich, 11 Jan., 2001.

[7] Rachel Guglielmo și Timothy Waters, "Migrating Towards Minority Status: Shifting European Policy Towards Roma", Journal of Common Market Studies, 43, no., 4, (2005), Michael Merlingen, "Governmentality: Towards a Foucauldian Framework for the Study of IGOs", Cooperation and Conflict, 38, no., 4, (2003) 51 OSCE, "Implementation of the Action Plan on Improving the Situation of Roma and Sinti Within the OSCE Area," (Warsaw: OSCE/ODIHR, 2008)

For years, the EU has considered minority issues to be the internal affairs of the Member States. Later, although not as binding laws, but rather as a kind of 'common European standard', various policy principles of desirable minorities arose (European Convention on Human Rights, Copenhagen Document – 1990, Framework Convention for the Protection of National Minorities – 1995, Article 13 of the Treaty of Amsterdam – 1997, EU Charter of Fundamental Rights – 2000).

The Commission and the Roma Research Centre of the René Descartes University in Paris have produced a critical overview of the situation in terms of providing school services to Roma/Gypsy children in the Community. The European Commission organised meetings of Roma/Gypsy experts to guide and coordinate the study and subsequently to discuss the recommendations; the resulting report, School Provision for Gypsy and Traveller Children, was published in late 1986. Following a continuation of the study to cover the new Member States of Portugal and Spain, the exercise culminated on 22 May 1989 with the adoption by the Council and the Ministers of Education of a resolution on the provision of school services for Roma children.

At the beginning of the 1990s, a change in speeches and practices from the European institutions could be seen, the Roma would become partners in programmes aimed at improving their socio-economic situation.

The activities that led to the design of the first Council of Europe and OSCE documents attempted the 'transnational' option of an external symbolic homeland in the mid-1990s. These first specialised European programmes for the Roma used the language of human rights as a kind of international moral standard and gradually reached a transnational community approach, which could be called 'post-national citizenship'. This special status of Roma seems to have been strengthened by the Council of Europe Decision No. 1203, which refers to Roma as "a real European minority".[8]

More and more actions have been taken at both State and Union level, in particular the development of a multilingual newsletter and support for publications, inter-school exchanges, the organisation of regular meetings, the creation of networks of pilot projects, assistance to enable Roma/Gypsy organisations to organise meetings on school-related topics, etc.

At the end of the Copenhagen meeting of the Conference on the Human Dimension of the OSCE in June 1990, the participating states adopted a very important document. This last document says that these states have come together "to strengthen respect for and exercise all human rights and fundamental freedoms, develop human contacts and solve related humanitarian problems". Chapter IV is entirely dedicated to national minorities: Article 40 focuses on issues related to racism, and it is important to note that Roma/Gypsies are the only minority nominally mentioned in this context.

Following the Copenhagen meeting, an OSCE expert group on national minorities held a meeting in Geneva in July 1991. In Chapter VI of the final report of this meeting, the participating states expressed their concern about the spread of acts of violence on racial, ethnic or religious grounds. In this context:

'Participating States ... to reaffirm its recognition of the specific problems of roma (gypsies). They are ready to take effective measures to achieve full equality of opportunity between people belonging to Roma communities who habitually live in their state and the rest of the resident population. They also encourage research and studies on the Roma and the specific problems they face''[9].

Following a hearing in 1991, CALRE organised a meeting in Slovakia in 1992, bringing together local authorities, representatives of Roma communities and experts. This confirmed the results of the 1991 hearing. Its conclusions stressed both the need to update and reactivate the 1981 resolution and to present concrete working proposals. CALRE decided, on the basis of the combined conclusions of the hearing and the colloquium, to prepare a new text. Resolution 249(1993), entitled 'On the Gypsies of Europe: the role and responsibility of local and regional authorities', was adopted in March 1993.

[8] Soysal, "Changing Citizenship in Europe," pp. 17–29.
[9] Document of the Copenhagen meeting of the conference on the human dimension of the CSCE, 1990. https://www.osce.org/files/f/documents/9/c/14304.pdf.

One of the internationally recognized Roma activists, Nicolae Gheorghe together with Andrzej Mirga, launched in the mid-1990s in a policy document, the transnational identity project that can be used as a political strategy and as a political goal, remarked:"Why have we used the concept of 'transnational' from a wide range of concepts at our disposal to describe non-territorial or dispersed minorities? The idea is to indicate that we can evolve in a different way from the national minorities of nation-states [..] We can build an ethnic dynamic and a new image [..] by interacting with non-national or supra-national institutions''[10]

Recommendation 1203 of 1993 of the Council of Europe stated that "living scattered throughout Europe, without having a specific country of their own, gypsies are a real European minority [...] which contributes to Europe's cultural diversity"[11]

At an OSCE-organised seminar on minorities (Warsaw, 1993), in connection with the work of the subgroup on 'dispersed minorities', questions about the Roma were again highly discussed. In 1994, the OSCE, in cooperation with the Council of Europe, organised another seminar in Warsaw, this time focusing on the situation of Roma communities in particular. This seminar confirmed and strengthened the working guidelines and concepts developed over several years, and a significant willingness for inter-institutional cooperation has been demonstrated in connection with the development of a partnership involving Roma organisations. The Roma showed up again at the OSCE meeting in Budapest in the autumn of that year, when the OSCE Office for Democratic Institutions and Human Rights (ODIHR) was mandated to develop a "contact point" for Roma issues.

In June 2000, a general anti-discrimination programme called the 'EU Directives on Race and Occupation' was adopted. The deadline for implementation of the Directives in the Member States was July 2004. However, according to REIR (European Network against Racism), few Member States have complied with.

4.Conclusion

As a first conclusion after going through these data, we can see the road that the Roma population had to travel, a road that is part of their cultural identity. Through the years, their identity suffered many challenges and changes that have emerged into forming a new form of political status.

The Europeanization process marked a turning point in the evolution of the Roma people and its community by offering a series of opportunities that were never unlocked before. By undergoing this process, they managed to develop a new identity, which will shape their day to day lifestyle. Furthermore, the Roma people have acquired new skills that are required as an European member.

The European Union and especially, the Council of Europe played an essential role in shaping this new identity for the Roma people. Through their many Recommendations, they managed to secure a place for the Roma as an European minority.

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Job insecurity and organizational identification in the organizations: An empirical study

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Abstract. Job insecurity and organizational identification are significant constructs in an organization. This study aims to survey the relationship between these constructs. The researchers reached 233 employees and they could collect 220 usable questionnaires. SPSS V27 software was used to analyze the data. Factor analysis, reliability analysis, ANOVA test, and lineer regression analysis are applied to the data. The results suggested that job insecurity is a significant antecedent of organizational identificaiton and they have a negative relationship between each other. These results are useful for the scholars who study job insecurity and organizational identification. Moreover, the human resources departments and managers can use the results of this study to determine efficient organizational policies.

Keywords: *4-8 Job insecurity, organizational identification, organizational policy, organization.*

Introduction

The organizations aim to prepare the best teams fort he best performance. But better employees request higher wages and higher wages mean higher expectations. Among the other motivatiors, higher wages are the leading ones (Morris et al., 2016), but higher wages do not always provide job security.

Job insecurity affects the performance of employees. This variable also increases the anxiety and it causes a dilemma. This dilemma is about the decision between taking the risk for self-actualization and avoiding the risk of making mistakes.

Organizational identification is a significant construct for the employees. Organizational identification is tendency of accepting the performance and the success of the organization as his/her own performance and success. This study aims survey the relationship between job insecurity and organizational identification.

1. Concepts and their Relationships

Job insecurity is the perceiving that the job of an employee is at risk (Sverke et al., 2002). Job insecurity is the difference between expected and actualized levels of employement security (Bentzen et al., 2020). The fear of losing the job increases the job insecurity. Uncertainty of the future and job increases anxiety (Emberland, & Rundmo, 2010).

Organizational identification refers to accepting the norms of an organization and feeling as a part of that organization. Employees working with high organizational identification identify themselves together with the organization. They accept the objectives of their organization as their own objectives.

The researches showed that job insecurity has a significant impact on organizational identification (Chirumbolo, 2016; Chirumbolo et al., 2017). Job insecurity is an antecedent of organizational identification (Piccoli et al., 2017), meta-analysis of Jiang and Lavaysse (2018) confirmed this finding.

H1: Job insecurity has a significant effect on organizational identification.

The research design is prepared according to these conceptual relationships. It is shown in figure 1. Kim (2019) related job insecurity, organizational trust, and organizational identification with each other by suggesting that job insecurity is an antecedent of organizational trust, and organizational identification is an outcome of organizational trust. The research model of this study improved the research design of Kim (2019) according to the results of other studies suggesting the direct effect of job insecurity on organizational identification (Asif et al., 2019; Piccoli et al., 2017; Chirumbolo et al., 2017).

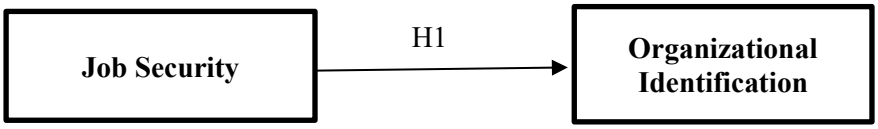

Figure 1. Research Model

2. Methodology

2.1. Sample and Measuring

The authors used snow-ball sampling method to collect the data of this study from various organizations. The author could reach the e-mails of 233 employees. All these employees did not answer, and all the ones who sent a reply did not provide usable answers. 220 of the collected questionnaires were usable and these 220 interviews formed the data of this study.

5 item scale of job insecurity was used to measure job insecurity (Hellgren et al., 1999). This scale was translated into Turkish by Seker (2011). 6-item scale of Mael and Ashforth (1992) measured the organizational identification. It was translated into Turkish by Tüzün (2006). Each scale used 5 point Likert scale.The title is set 17 point Times Bold, flush left, unjustified. The first letter of the title should be capitalized with the rest in lower case. It should not be indented. Leave 28 mm of space above the title and 10 mm after the title.

2.2. Measurement Assessment

The analyses of this study were performed by using SPSS v27. According to the results of KMO analysis, the items were appropriate for confirmatory factor analysis. After the confirmatory factor analysis, two items of job insecurity are removed to determine the dimensionality of each construct. The factor loadings are indicated in table 1. The factor loading of each question was over 0.6, which is the recommended threshold value (Hair et al., 2006).

Table 1. Factor Loadings of Constructs

	Component	
	1	2
JIS1		0.771
JIS2		0.732
JIS3		0.647
JIS4		0.711
JIS5		0.714
OID1	0.601	
OID2	0.745	
OID3	0.848	
OID4	0.854	
OID5	0.809	
OID6	0.718	

JIS: Job insecurity
OID: Organizational identification

2.3. Findings

Table 2 indicates the reliability analysis results, standard deviation and mean values of the chosen constructs. The threshold for Cronbach Alpha values is 0.70, and they are over this threshold (Nunnaly, 1967).

Table 2. Reliability Analysis Results

		MEAN	**SD**	**CR**
1	JIS	2.0472	0.7607	0.904
2	OID	3.4347	0.8014	0.813

SD: Standard deviation
CR: Cronbach Alpha

Table 3 indicated the descriptive statistics: age and term of contract. The effect of age and term of contract on the scores of job insecurity and organizational identification is analysed by using one way ANOVA technique. ANOVA test results showed that age and term of contract has no significant effect on these constructs at the level of .05.

Table 3. Comparison of the Constructs According to Descriptive Statistics

			JIS	**OID**
Variable	**Groups**	**n**	**Mean-Standard Deviation**	**Mean-Standard Deviation**
Age	18-22	70	2.01-0.78	2.92-0.89
	23-27	64	2.07-0.61	3.31-0.77
	28-32	63	2.08-0.70	3.41-1.01
	32-36	23	2.03-0.61	3.40-0.72
Term of contract	6 months or less	56	2.01-0.70	3.02-0.84

Variable	Groups	n	JIS	OID
			Mean-Standard Deviation	Mean-Standard Deviation
	1 year	64	2.04-0.75	3.08-0.91
	2 year	87	2.18-0.71	3.22-0.77
	3 or more	13	1.88-0.91	3.31-1.03

The regression analysis results of the relationships between job insecurity and organizational identification are indicated in table 4. Job insecurity has a positive and significant effect on the organizational identification at a .01 level of significance. H1 is supported.

Table 4. Regression Analysis Results of the Relationship between Job Insecurity and Organizational Identification

Independent Variable	Dependent Variable	Beta	t	R^2	*F*	*Sig*
Job Insecurity	Organizational Identification	-0.502	-9.017	0.301	81.089	0.000

3. Discussion and Conclusions

3.1. Discussion

The surveyed relationship of this study is rarely studied. The results shows that job insecurity is an antecedent of organizational identification, and there is a negative significant relationship between these constructs. The hypothesis of this study is confirmed.

The results of this study is in line with the results of previous studies (Piccoli et al., 2017; Chirumbolo et al., 2017). Such studies provided a scientific and theoretical base to this study. The confirmed model of this study has no conntradiction with the existing literature.

3.2. Theoretical and Practical Implications

The literature lacks the results of the surveyed relationships. There is a limited number of such studies and the results of this study can guide the academicians who study these constructs. Furthermore, the results of this study can be used by the managers who determine policies regarding job insecurity.

3.3. Conclusion and Future Research

The results of this study has various contributions to the literature. First, this study showed that job insecurity of employees has significant effect on their organizational identification. Second, the findings showed that job insecurity of the employees has a negative effect on organizational identification.

The number of the studies surveying the relationship between job insecurity and organizational identification can be increased in time. The increasing number of such studies will provide an ability to make a review or meta-analysis by using the aforementioned variables.

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Suistanable and durable development of Romanian road transport, în the context of european requirements of the European Union

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Abstract. The scientific work presents a concrete research carried out by the authors in order to implement some concepts of a technical and economic nature so that the readers can become aware of a certain way of presenting the problems regarding the durability development and sustainability of the road transport system. It proposes a study, carried out from a managerial point of view with engineering nuances, so that the concept of sustainable development in the addressed field can be viewed in a global context. The work as a whole is intended to be a theoretical approach with correlations in the field of engineering and management, essentially aiming at the sustainable development of the road transport. Finally, are presented some conclusions and further research directions in this way.

Keywords: *durable development, sustainability, road transport, milestones, targets, strategy.*

1. Introduction

Sustainable development brings to the fore a new set of values that will direct the future model of the economic-social development of the humanity, with its present and future needs, the protection of the natural environment and its conservation, mitigation and stopping the destruction of ecosystems. Until recently, industrial activities bore the entire blame for the pollution of our planet.

The rapid development of all branches of transport, especially the road sector, the increase in the production of automobiles worldwide, the frequent use of cars that are not friendly to the environment, have caused the balance of the sources of noxes and harmful effects to tilt in the opposite direction, towards the minus, making that transport activities become today the main source of environmental pollution, becoming a real danger to the human health.

At the present time, specialists say that 72% of the polluting substances emitted into the atmosphere result from transport activities. As previously presented, sustainability in transport derives from a complex system that aims to ensure the mobility needs of today's generation, without contaminating or damaging environmental factors or human health. Applying now a maximum efficiency of the consumption of raw materials and energy, the transport system must satisfy in optimal conditions the economic, ecological and social perspectives of the mobility needs of the generations to come [1].

The vast majority of researchers have come to the conclusion that the current road transport system is not sustainable and will not have durability because everything that has been achieved so far is based on an exaggerated consumption of resources that has led to the destruction of the environment and human health.

Consequently, the sustainable road transport is a fundamental element for prosperity ensuring, but creates a true compromise between obtaining major benefits and certain constraints related to the cumulative effect of environmental and social costs. Sustainable development and durability in road transport implies a balanced economic growth in terms of economic, social and environmental dimensions. They are directly dependent on the production and energy sectors, which ensure the social development of a nation.

1. The concept of durable development

The word *development* becomes more and more often used in the last decades, having more meanings. Many authors believe that the term development has several meanings, being a polysemic concept, sometimes causing great confusion. The word has several meanings, however, the most important ones are those of growth, evolution, progress.

The other term, *durable*, *durability*, is defined as something that includes a long period of time, that lasts a long time, durable, solid, viable. Therefore, to develop durable means to grow, to progress, to evolve permanently, certain things that last over time.

The concept of ***durable development*** has as its genesis the world economic crisis that took place between the years 1929-1933 and subsequently evolved to include all economic, social and human spheres, and currently it defines the new path of the humanity. At that time, the strong industrial exploitation of resources harmed the environment, and the durable development was thought of as a saving solution to the ecological decline that would follow. Through the measures taken, an agreement was established between the economic and social progress, without degrading the environment. The idea behind the concept represents a higher quality of life for the current generations, but also for those that will follow.

Some authors place the origin of durable development in the *Wealth of Nations* written by Adam Smith in 1776 [2]. The author is a classic who wrote one of the best political economy books ever written, trailblazing, with a masterful purpose unsurpassed to this day. He is a pioneer of the modern economic thinking. His theory regarding development was based on the division of labor that allows the increase in productivity and which, together with the increase in investments, leads to an increase in total production and production per capita.

A concrete definition of the durable development is presented by [3], în in the report *Our Common Future*, which became a reference document, being the first to use the term global development (durable development), also known as the *Brundtland Report*, which said: durable development is the development that aims to meet the needs of the present, without compromising the ability of future generations to meet their own needs.

In our view, the durable development does not only represent those actions taken to protect the environment. Durable development means all those actions, taken as a whole, to build, permanently develop, viable, the things and objectives necessary to carry out the daily activities. For example, the humanity's need for mobility led to the development of the automobile and communication ways, objectives that continue to this day, through technology, but also the network of modern roads and highways. Without the automobile and a lasting, durable network of communication routes, the humanity would not have been able to move from one place to another and would not have been able to secure the goods and food necessary for the daily living.

All these things, however, must also be seen through the lens of environmental protection. Let's not forget that cars consume resources and emit pollutants into the atmosphere. A motor vehicle pollutes from the extraction of the ore from which it is made, until it is scrapped. Also, the construction of the road infrastructure (roads, highways) pollutes with noise, chemically, affects and destroys natural ecosystems.

However, the road infrastructure, since ancient times, has facilitated the free movement of people and consumer goods. Subsequently, they developed much later in isolated areas and regions, only after the infrastructure was paved and automobiles appeared. With the appearance of highways, high-speed roads and the development of the automobile industry, the road transport had a remarkable evolution, becoming one of the most accessible and important ways through which the humanity expressed its desire for mobility. Considering the fact that it is one of the most unsafe transport systems and pollutes the environment a lot, the road transport has become and is the most important in the economy of all the states of the world.

It was found that the underdeveloped countries or regions, as well as the developing ones that have insufficiently developed transport systems and infrastructure, or have inefficient transport services, are difficult to develop from this point of view, and those that invest in this field do remarkable progress, developing durably. If these aspects are neglected, the economic, social and ecological costs increase.

Over time, the durable development has been interpreted according to the approaches of the fields in which this term is used, and history has shown that the first people who approached this term in the field of transport were the profile organizations, regardless of the field of transport in which they operated.

In antiquity, the highly developed civilizations were those that knew how to capitalize on the advantages offered by nature, namely, inland waterways and openings to the seas or oceans. The Roman Empire, China, Egypt and Greece prospered very quickly when they developed their river and sea transport routes. In this way, countries like Japan, Spain, Great Britain, Germany, France and the United States of America developed their state economies very quickly too. With the advent of the railways, the infrastructure in this area developed and allowed the development of areas and regions that had wealth in raw materials, but were landlocked.

2. The concept of sustainability

The sustainability derives from the term *to support something*, *to provide support*. It is defined by the quality of the human actions, to take place without exhausting the available resources, and like durability, it ensures that balance between economic-social growth and environmental protection.

So, sustainability is the ability to exist and develop without depleting natural resources for the future [4]**.**

With the emergence of the term sustainability, the notion of suistainable development has been permanently developed in the opinion of specialists. It is the foundation of the human needs that improves the quality of life.

Thus, the need to integrate qualitative aspects in the measurement of the development is emphasized, and the suistainable development is a central concept that refers to a new way of understanding the world, but also to a method of solving global problems [5, pp. 241-242].

The foundations of this concept were laid for the first time in 1992, at the National Conference in Rio de Janeiro, Brazil. The concept of sustainability focuses on the conservation of material resources and their efficient use, in order to facilitate and guarantee future generations access to an uncompromised natural and economic environment. More specifically, the extent to which the present needs are met without compromising the ability of future generations to meet their own needs. This is about intergenerational equity. In this sense, the current generation benefits from the basic resources of the environment without preserving or replacing them. What remains for future generations from these resources are only the debts they have to pay.

Hartwich, was the one who identified a theoretical interconnection between resource rent and economic sustainability in the case of exhaustible resources [6].

His rule shows us that a nation will invest the rent collected from the present use of the exhaustible resource, in the case of a use that maximizes the owner's benefit [6].

Personally, I agree with the specialists who claim that in its essence, the concept of *sustainability* shows us the connection between the responsible consumption of resources and the environment from which they come, in order to increase the economic efficiency in the medium and long term.

A durable economic growth requires sustainability, and the durable development presupposes superiority over economic growth.

3. Durable development in road transport

The durability in road transport derives from a complex system that is destined to ensure the mobility needs of today's generation without contaminating or damaging environmental factors or the human health.

In other words, the specialists and researchers have the mission of finding current transport options that do not pollute the environment and that do not affect the human health, and this can be achieved by increasing the energy efficiency of the fuels burned in the thermal engines of the means of transport, the use of more efficient vehicles in terms of fuel consumption, the use of alternative energies for travel and last but not least, the permanent reduction of waste of any kind resulting from the production or decommissioning the means of transport.

The means through which action can be taken to achieve these desired goals are the economic-legislative ones, through which action is taken on fees, authorizations and taxes [1].

The effect of these constraints can lead to the reduction of the use of the polluting vehicles with advanced physical or moral wear, with technical defects, the reduction of energy consumption, the efficiency and effectiveness of transport activities, the equal redistribution of income between the transport organizations and society, but also the reorientation of the way in which transport activities are carried out. Those aspects through which the transport o rganizations cause damage or loss, without being held responsible, will have to be analyzed very well.

These represent the external costs or externalities [1], and are defined by the noxious pollution of the earth's atmosphere. If some policies specific to the concept of durable transport are adopted, this does not mean that the style in which we live is immediately or totally changed, taking radical measures to reduce the need to travel or to restrict the purchase of motor vehicles, but it is necessary to act where there is the genesis of evil, namely, through the design and construction of non-polluting means of transport, friendly to the environment.

In the figure 1, presents mobility pyramid showing the order of priority for the different modes of transport in achieving a sustainable transport system.

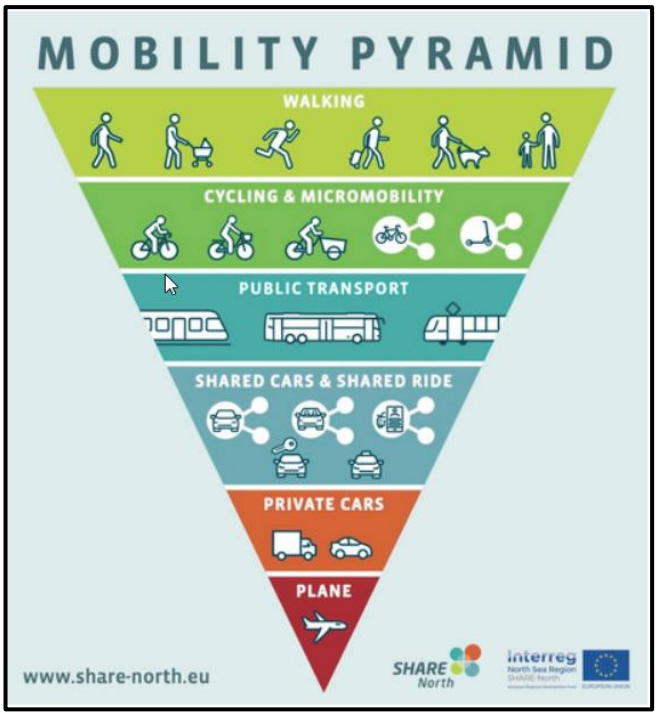

Figure 1 The mobility pyramid for different modes of transport to achieve a sustainable transport system [14]**.**

The measures that will be taken in this regard must be taken in the long term and not in the medium or short term, by applying new strategies of a political nature that determine the three main factors that contribute to the durable development of transport, namely [1]:

1. The political factor, at a high level, through the decisions it takes;
2. Teams of specialists, in factories and plants, to value their training and knowledge in the field of automobile construction;
3. The involvement of the society through the activities it carries out daily.

According to the same author, from the point of view of sustainable development, transport has four important economic functions, namely [1]:

It increases the possibility of movement and makes the transfer of the production factors, especially the labor force, to those places where they can be used efficiently;

It modifies the productive functions as a result of progress in transport, reducing costs, introducing investments into the production process;

Feeds the production process, which allows goods and people to be transferred between them and in the centers of production and consumption;

It ensures cohesion, social security, increases the standard of living of the population by expanding some facilities and providing consumer goods.

It was found that underdeveloped countries or developing countries that have insufficiently developed transport systems and infrastructure, or have inefficient transport services, develop with difficulty or hardly at all from a social, economic and cultural point of view, and those that invest in this field they make remarkable progress in this field by developing durably. If these aspects are neglected, the economic, social and ecological costs increase.

The impact that transport has on the population must be analyzed in a broader perspective, as follows:

Realized the need for an agreement between the economic environment and the environment, on the new path of development that supports the progress of humanity for the whole planet and for a distant future;

The desire for mobility that has negative effects on the environment and human health must be satisfied at the same time as taking measures to reduce these effects.

The concept of comprehensive durability implies a balanced economic growth in terms of economic, social and environmental dimensions, it depends directly on the production and energy sectors, which ensure a major social prosperity but, in a more advantageous direction, durable transport can be created as an adjustment of transport services to meet other objectives.

The first more important research in the field of durable development of transport was presented at the OECD Conference in Vancouver in 1996 [7], where the principles of durable transport were stipulated, then they were continued at the Workshop on durable transport in the period 20-21. 10. 1998, in the capital of Canada, Ottawa, and in the capital of Austria in Vienna during the period 04-06.10. 2000, the results of the EST project - *durable environmental transport* were presented, where on the occasion of these events the social dimension of the transport durability was clearly revealed [1].

Initially these concerns regarding durable transport were of the engineers, applying the principle that any reduction of polluting emissions by means of transport represents durable development, so that later new definitions and practical interpretations of durability are introduced, reaching that comprehensive durability deduced from the combination of several dimensions of durable development, initially the environment, then the environment and the economy, and finally the environment, the economy and the social. *Benefit-cost* analysis was used as an analytical work tool [1].

4. Sustainability of road transport in Romania

The proposed objective is to increase the sustainability of all national transport systems, thus supporting the transition to electromobility and digitalisation, through the development of a sustainable and ecological transport infrastructure, which determines and at the same time contributes to the completion of the trans-European transport networks (TEN-T), which resulted in the decongestion of the urban nodes.

In this sense, targeted actions are aimed at developing environmentally friendly measures, which will target high-speed transport infrastructure (highways, expressways and national roads), the development of Intelligent Transport Systems, measures regarding road safety and security and the protection of the environment.

In this sense, in order for the proposed objective to produce its expected effect, for the development of road networks at the national level, certain reforms and investments will have to be made for implementation and development, in the component: sustainable transport, the pillar: the transition to a green community. Tables 1 present the main reforms that Romania has proposed, as well as the financial funds necessary for the development of the road transport system, through the PNRR.

Table 1 Reforms established by the objective of developing the road transport system within PNRR [8]

Reforms	**Allocated budget (mil. euros)**	**Milestones/Targets**
R1. Sustainable transport, decarbonisation and road safety/Road decarbonisation in accordance whit the ”polluter pays” principle.	10	1. Entry into force of the law for the implementation of a new charging system based on distance traveled for heavy goods vehicles (trucks) and higher property taxes for the most polluting passenger vehicles (cars / buses / coaches), on the basis of the “polluter pays” principle and the principle of environmental taxation.
		2. Entry into force of the law to encourage the use of clean vehicles and fleet renewal programs by domestic users, private companies and public institutions.
		3. New clean vehicles purchased by public bodies, at least 3% above the thresholds of Directive (EU) 2019/1161 of the European Parliament and of the Council of 20 June 2019 amending Directive 2009/33 / EC, in the period 2021- 2025.
		4. Scrapped polluting vehicles (EURO 3 or less). At least 250,000 polluting vehicles (with EURO emission standards 3 or less) older than 15 years will be scrapped between 2022 and mid-2026.
		5. Increasing the number of zero-emission vehicles by 2026 (29,500 units).
		6. Charging stations for electric vehicles installed nationwide. Completion of the network of recharging power stations with a number of 52 stations that will have 264 charging points by 2026, located on the 4 proposed highways.
		7. Adopt the national road safety strategy. The National Road Safety Strategy for 2021-2030 will implement EU rules and guidelines as set out in the EU Road Safety Policy Framework 2021-2030 and the “zero vision”, which aims to reduce deaths by 2050 in road accidents to near zero.
		8. Entry into force of road safety legislation - legislation on monitoring, enforcement and sanctions applicable to road safety infringements.
		9. Installed and functional equipment to improve compliance with

Reforms	Allocated budget (mil. euros)	Milestones/Targets
		speed limits and road safety regulations.
		10. Reducing the number of road accident victims (seriously injured and killed) by 25% compared to the 2019 reference level.
R2. High – performance management for quality transport – Improving institutional management and corporate governance capabilities.	19	1. The entry into force of Law no. 50/2021 for the approval of the Government Emergency Ordinance no. 55/2016 on the reorganization of the National Company of National Highways and Roads in Romania - S.A. (C.N.A.I.R.) and the establishment of the National Road Investment Company - S.A. (C.N.I.R.).

The latest report at the level of the European Union on the state of the road transport infrastructure (European Transport and Infrastructure Board) from 2019, shows that our country is the worst in this area, ranking in last place, with a score of 2, 96 [9, pp. 25-34].

In this sense, in order for the proposed objective to produce its expected effect, for the development of road networks at the national level, certain reforms and investments will have to be made for implementation and development, in the component: sustainable transport, the pillar: the transition to a green community.

Table 2 shows the main investments that Romania has proposed, as well as the financial funds needed for the development of the road transport system, through the PNRR.

Table 2 Investments established by the objective of developing the road transport system within PNRR [8].

Investment	Allocated budget (mil. euros)	Milestones/Targets
I1. Dvelopment of sustainable road infrastructure related to the TEN-T network, tolling, traffic management and road safety.	3.095	1. Signing of contracts for 100% of works, following open and competitive tenders and relevant permits obtained, with opinions from the environmental impact assessment and the corresponding assessment (part of the Habitats Directive) issued and incorporated since the investment design phase.
		2. Entry into force of the law to encourage the use of clean vehicles and fleet renewal programs by domestic users, private companies and public institutions.
		3. New clean vehicles purchased by public bodies, at least 3% above the thresholds of the Clean Vehicles Directive (Directive (EU) 2019/1161 of the European Parliament and of the Council of 20 June 2019 amending Directive 2009/33 / EC] for the period 2021- 2025. For clarity, this would mean a target of at least 21.7% for light vehicles, 9% for heavy vehicles and 27% for buses, given

Investment	Allocated budget (mil. euros)	Milestones/Targets
		that the minimum targets for public procurement set for Romania in the Clean Vehicles Directive are: 18.7% for light vehicles, 6% for heavy vehicles and 24% for buses.
		4. Construction of new roads, 50% of the works completed.
		5. Construction of new completed roads (TEN¬-T standards).
		6. Elimination of black spots / hotspots on road safety. The 267 road safety hotspots / hotspots in 2021 will be reduced by 129.

In september 2021, Romania is not among the more than half of the EU member state whose recovery plans have been approved by the European Commission [10]. The figure 2 shows the share of investments in transport infrastructure through the National Recovery and Resilience Plan (PNRR), submitted to the EC, in 2021, by the Roamanian Government.

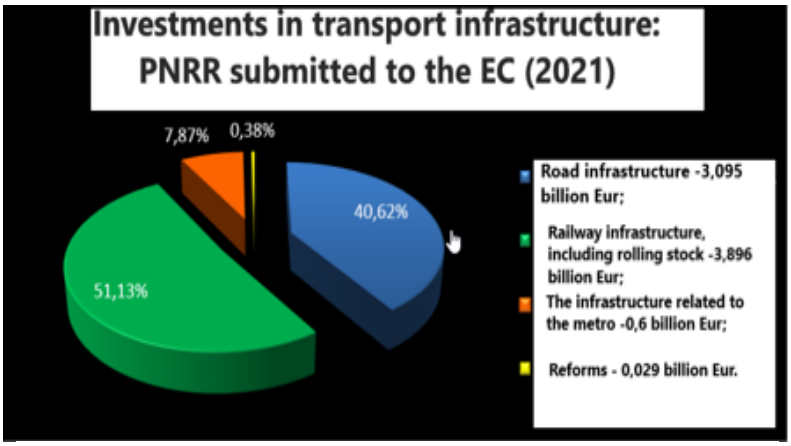

Figure 2 Share of the investments in transport infrastructure (PNRR transmitted by the EC (2021) [15].

According to the data specified by the Romanian Government, both reforms and investments will be made in reciprocity with:

- ***Climate policies at European level*** [10]. According to the authors, these policies consist in the development and use of renewable energies; the development of energy efficiency in all European industries; reducing pollution by reducing CO2 emissions in new motor vehicles; urgent measures to reduce pollution by manufacturing industries and reduce pollution from landfi lls;
- ***The European Green Pact*** [11]. In our opinion, this pact has as its main purpose the transformation of the economies of the European Union countries into an efficient, modern and competitive economy in terms of resources. From this point of view, Europe aims to achieve the following objectives by 2050: zero greenhouse gas emissions; economic growth to be delimited by the use of resources; the development of human beings and the habitats in which they live;
- ***The EU's 2030 climate goals plan*** [12]. In the opinion of the authors, this plan brings new measures to reduce greenhouse gases by a percentage of 40%, below the level of the year 1990; the renewal of some political ambitions to increase the energy efficiency; bold targets for the renewable energy; a new governance strategy and new indicators to guarantee a developed, secure and competitive energy system;
- ***The European strategy on durable and intelligent mobility***, which provides sets of measures established by the European policies for long-term durable and sustainable development, as follows [13, p. 3]:

a) By 2030: at least 30 million vehicles with zero-emission will be in operation on the European roads; 100 European cities will be climate neutral; high-speed railway traffic will double; the

scheduled collective journeys of less than 500 km will have to be carbon neutral within the EU; the automated mobility will be widely implemented; zero emission ships will be ready for market launch.

b) **By 2035:** high-capacity zero-emission aircraft will be ready for market launch;
c) **By 2050:** almost all the cars, vans, buses and heavy vehicles will have zero-emission; the railway freight traffic will double; the high-speed railway traffic will triple; the multimodal trans-European transport network (TEN-T), equipped for a sustainable and intelligent transport with high-speed connectivity, will be operational for the global network.

5. Conclusions

Through the durable development of the urban transport, the efficiency of sales markets and the population's access to leisure activities and entertainment increases, and through the development of the rural one, the same is developed and ensured in these markets, production costs decrease and the rural economy develops rapidly, which is not related to agriculture.

The interurban and international transport develops the domestic and foreign trade through a faster movement of goods and passengers.

By making transport services more efficient, a region develops faster from a social, economic and cultural point of view, constituting a very complex process of capitalizing on the skills and talent of the population, but also of natural resources.

By protecting the environment and through a responsible use of all resources, us, as the current generation, will ensure the durable and sustainable development of everything we will leave as wealth to our descendants.

By improving the transport activities, we develop economically and increase the mobility, but it is necessary to find that state of concordance between the three factors, the ecological factor, the social factor and the economic factor, on which the lasting and durable development of transport systems depends. The durable development of transport is the main pillar of the economic development, and its growth reduces poverty and the access to the free market for goods and passengers, offers the opportunity to enter the labor market, services, education and having a decent house.

Despite all the efforts undertaken by the authorities in our country in the last 30 years, to modernize and restore the domestic transport systems, according to the previously analyzed data, it turns out that a large part of the public road network is in a mediocre or completely damaged state, insufficiently prepared to take over and cope with a high flow of vehicles.

At the national level, we have an outdated and aging motor vehicle fleet, whose means of transport have advanced physical and moral wear, have technical defects that endanger the lives and health of people and road users, and the road safety is defective, with all the efforts made for efficient and operative road traffic management.

Due to these reasons, the Government of Romania, the Ministry of Transport, the National Road Infrastructure Administration Company and the Local Administrations, through their decision-making position, must take into account and adopt new development strategies in this field, in order to ensure a high technical and quality level, to integrate the road transport system in Romania to EU requirements.

Such a strategy consists in the creation of sustainable road structures, so that the road transport system in our country becomes more efficient, safer, with a reduced economic, environmental and social impact. Only in such a situation can the Romanian road transport be considered sustainable. This desired can be achieved if, in addition to reaching the technical and engineering targets specific to the road transport activity, the entire system has the ability to protect and repair the damage caused to the ecosystems within which it evolves, to use material, financial, human and natural, and finally to cover all the important human tasks and needs such as: the satisfaction and comfort, health, safety and the provision of jobs for mankind.

Durable road transport cannot be set aside from the economic issues, because it is an integral part of this system. Currently, the transport specialists and those with environmental protection

responsibilities must urgently solve the major problems in this sector, in order to meet the reduction of pollution, but also to find ecological and economically viable transport solutions. All of the above are the primary objective of a durable and sustainable auto transport system.

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A Meta-Analytic Review on The Relationship Between The Variables Regarding Group Participation and Turnover Intention

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Abstract: This study aimed to survey the effect of the variables regarding the group participation such as ethnicity, discrimination and organizational diversity on turnover intention. This study used a meta-analytical perspective. 26 studies were used for the meta-analysis. Comprehensive Meta-Analysis Software (CMA) is used. Heterogeneity analysis and publication bias test are applied. The results showed that ethnic diversity has a small effect on turnover intention and diversity climate has a medium effect on turnover intention. Three relationships were listed in the review part of this study. The results of this study can be used by future researchers who will study similar variables surveyed in this study. Moreover, the managers who determine organizational policies for ethnically diverse organizations can use the information provided by this study.

Keywords: *Ethnicity, diversity climate, organizational diversity, discrimination, turnover intention.*

1. Introduction

The group participation of the behaviors determine the performance of an organization and it is a good indicator of their motivation. They indirectly affect various variables such as knowledge sharing that are vital for an organization. Group identification can be shown as a good example of a variable affecting the group particiation. It is the tendency of an employee to define himself together with a group and accepting their failures and problems as their own. Such employees also feel pride with the success of such groups.

Ethnicity is a negative attitute regarding group participation and it may affect the relationships in an enterprise. The employee can be ostracized due to his/her ethnicity. This situation can increase the turnover intention of the employee. But the reason for such an increase on turnover intention can be the perception of the employee or the attitudes of the employees.

Discrimination is another negative attitude. Even though it is a crime, such attitudes exist, but in a socially acceptable level. Therefore ethnicity is neglected. But the people may react to a person from a different ethnicity by legally accepted behaviors. Ostracism can be shown as an example. Ethinicity can start various mistreatments. Thus, the importance of ethinicity cannot be underestimated.

Mistreatment is not the only effect of ethnicity. Employees can easily avoid mistreatment by hiding their ethnicity. Providing privilege or support can be another effect of ethnicity. The owner of the enterprise may tend to protect and support certain employees due to their ethnicity. Such a discrimination is also difficult to prove.

The main objective of this study is to investigate the effect of the variables affecting the group participation of the employees on the turnover intention. A meta-analytic review is used to survey these relationships.

2. Conceptual Relationships

The study of Buttner et al (2012) determined the effect of ethnic diversity on turnover intention. The direction of this relationships was positive. Self et al. (2020) confirmed this effect. But this study determined a negative relationship.

Jolly et al. (2020) emphasized the effect of diversity climate and showed that it has a negative effect on turnover intention. The organizations with high ethnic diversity can decrease turnover intention. Levin (2003) focused on the perceptions of the employees and suggested that diversity perceptions affected turnover intention negatively.

Hosoda (2016) suggested that accent can also be a reason for discrimination. He made a research on 256 expatriates living in the United States and found that perceived accent discrimination has a significant effect on turnover intention. There was a positive relationship between these two variables. Thus, the hypothesis of this study is prepared as below:

H1: Ethnic diversity/diversity perceptions/discrimination has a significant effect on turnover intention.

In an organization, there are various processes and various work-groups. The performance of these work-groups determine the performance of such processes. Consequently work-groups are important and the performance of the employees in such groups has a strict connections with the work-group identification. The hypothesis shown below can be derived according to the information given here:

H2: Work-group identification has a significant effect on turnover intention.

3. Methodology

This study used a meta-analysis technique and PRISMA (Moher et al., 2009). These generally accepted guidelines are followed. GoogleScholar, Web of Science, Scopus, and Proquest databases are searched to reach the eligible studies. 20 eligible studies were used fort his meta-analysis.

The author searched the databases on december, 2020. He screened a total of 2,745 abstracts. The keywords used for this research were “turnover intention”, “ethnicity”,”diversity”, and “discrimination”. The studies providing correlation values regarding such relationships were chosen.

The collected studies were analyzed by using Comprehensive Meta Analysis Software (CMA). Heterogeneity analysis and publication bias tests were carried out. The data sets including less than 4 studies were not suitable for publication test and they were excluded.

The studies were coded according to their distinctive characteristics. The author also coded the studies to determine possible moderating variables. The quality of each study was tested by using Zangaro and Soeken (2007). None of the collected studies were coded as medium or low quality, all of them were scored as high.

4. Findings

4.1. Meta-Analysis Findings

The first step of meta-analysis was heterogeneity analysis. This analysis showed that all the data sets are heterogeneous. The results are in table 1. The data set regarding the relationship between ethnicity and turnover intention included 14 studies, the data set regarding the relationship between diversity climate and turnover intention included 3 studies, and the data set regarding the relationship between perceived organizational diversity and turnover intention included 2 studies.

Table 1. Results of Heterogeneity Analysis.

Surveyed Relationship	**I^2**	**P value**	**k**	**r**
Ethnicity-turnover intention	90.147	0	14	.089*
Diversity climate-turnover intention	83.174	0	3	-.41*
Perceived organizational diversity-turnover intention	88.782	0	2	.02
Work-group identification	83.214	0	2	-.33*

*: significance at .01 level

The effect size of these relationships are also indicated in table 1. The effect size of ethnicity on turnover intention is .089 and the effect size of the diversity climate on turnover intention is -.41. The effect size of the relationship between perceived organizational diversity and turnover intention is nonsignificant.

The publication bias is known as a tendency of publishing some certain results and rejecting the others that are in a range. In fact, it is a kind of consistency determined by publication bias tests. This inconsistency can be corrected by artifact correction.

The publication bias tests were applied to the first set and they are not applied to the other data sets as the number of studies was not high enough to provide significant results. The publication bias tests of the first data set regarding the relationship between ethnic diversity (ethinicity) and turnover intention did not indicate any sign of publication bias. The observed and adjusted values were equal to each other in Duval and Tweedie's trim and fill test, therefore it was not necessary to trim any studies. The Egger's regression test results did not exceed the threshold that was .033 (Egger et al., 1997).

4.2. Review Findings

Some of the surveyed relationships were investigated by just one study, therefore they are not added into meta-analysis. Hence, they are listed in the review part of this study. These relationships and the studies confirming these relationships are shown in table 2.

Table 2. The Other Relationships

Antecedent	**Sample size**	**Correlation**	**Confirming study**	**Sector**	**Country**
Racial dissimilarity	197	.23	Richard et al.,2019	various	USA
Perceived accent discrimination	256	.17	Hosoda,2016	various	USA-expat
Perceived discrimination	310	.723	Qablan & Farmanesh, 2019	hospitality	North Cyprus

Antecedent	Sample size	Correlation	Confirming study	Sector	Country
Change oriented organizational citizenship behavior	480	-.267	Campbell,& Im,2016	public	South Korea
Involuntary citizenship behavior	152	.358	Chae&Hahm, 2018	various	South Korea

Racial dissimilarity refers to low ethnic diversity, it can also be accepted as a reverse scale of ethnic diversity scale. Perceived accent discrimination is the discrimination occuring due to the accent of an employee. Perceived discrimination is the overall discrimination perceived by the employee.

5. Discussion

Work-group participation can be accepted as a dimension of organizational identification as this construct uses work-groups instead of the whole organization. Our study showed that work-group participation is a significant antecedent of turnover intention and it has a negative effect on turnover intention.

Discrimination is a concern for the organizations as it can trigger mistreatment (Qablan & Farmanesh, 2019). It is also a significant antecedent of turnover intention. The variables related to ethnicity and discrimination are important for the ethnically diverse organizations.

The results of this study suggested that ethnicity (ethnic diversity) has a significant effect size on turnover intention. The direction of this relationship is positive. This results indicated that increasing ethnic diversity increases turnover intention. 13 of the 14 studies was conducted in the United States and 1 study was conducted in South Africa. 5 of these studies found a negative relationship between these two variables, 1 of them found the correlation value as zero and the others found a positive relationship between these variables.

The effect of perceived organizational diversity on turnover intention was nonsignificant. Hsiao et al. (2020) found the direction of this relationship as positive and Levin (2003) found the direction of this relationship as negative. These contradicting results affected the significance of the finding.

The review part of this study listed 3 antecedents of turnover intention. Perceived discrimination has a high correlation value between turnover intention and this value is close to .8 which is close to the threshold of multicollinearity (Cohen, 1988). Qablan and Farmanesh (2019) provided the correlation value for this relationship, but they did not test the multicollinearity.

6. Limitations and Future Study

Some relationships were not added into meta-analysis and it was not possible to test the publicatipn bias of some studies taking place in the meta-analysis. But the number of studies surveying these relationships can increase in time and future meta-analysis studies may provide more valid and reliable results.

7. Conclusion and Implications

The effect size of the relationship between ethnicity (ethnic diversity) and turnover intention is *small* (Cohen, 1988). The effect size of the relationship between ethnic diversity and turnover

intention is *medium.* The effect size of perceived organizational diversity on turnover intention is not significant.

This study was the first meta-analysis study surveying the effects of aforementioned variables on turnover intention. Previous meta-analysis studies investigating the antecedents of turnover intention did not list these variables (Park & Min, 2020; Tett & Meyer, 1993; Choi & Kim, 2016; Kim and Kao, 2014).

The findings of this study can be used to determine human resources management policies or the organizational policies of the managers aiming to decrease turnover intention. Especially, the managers of ethnically diverse organizations can use the results of this meta-analysis. They will be useful to determine the factors affecting turnover intention.

The findings of this study can be used by the future researchers. This study will guide the researchers. Moreover, future researchers can use the studies used in the review part of this study for their meta-analysis.

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Developing a crypto currency regulatory model: The case of Zimbabwe

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Abstract. The rise of crypto currency has prompted numerous calls for financial regulation. The study's objective was to identify regulatory concerns and their impact on regulation of crypto currency usage in Zimbabwe. A probability sampling method was used to pick 450 respondents from banks and regulatory institutions. Structured questionnaires were used to obtain data from the selected respondents. The primary elements impacting crypto currency regulation were identified using an ordinal logistic regression modelling technique. Money laundering, financial stability, consumer protection, monetary policy and tax evasion were found to be regulatory concerns that influences regulation of crypto currency usage in Zimbabwe. Based on these findings the author presented proposals such as incorporating Central Bank Digital Currency (CBDC) into applicable legislation and reaping the benefits of crypto currency through the issuance of CBDC.

Key words: *Crypto Currency, regulation, Central Bank Digital Currency (CBDC), Reserve Bank of Zimbabwe (RBZ)*

Introduction

In our daily lives, currency acts as an important medium of exchange for goods and services. The concept of currency has progressed from bartering through the use of coins, notes and now digital payment systems. The use of block chain to allow payments through the use of crypto currency is the most recent development. The most popular crypto currency is bit coin and it was used for the purpose of this research. Zimbabwe has faced financial crisis over the past two decades which has seen cash problems, particularly the choice of an appropriate money regime and periods of extraordinary money instability (Cipolla, 2013). Following this crises, the government has tried a number strategies which include replacing the ZWN by the third Zimbabwean dollar and suspending the Zimbabwean dollar with multi-currency regime (Exchangerates247.com, 2022). Despite the fact that these techniques have been adopted, Zimbabwe is still experiencing currency problems.

The use of virtual currencies also known as crypto currencies is growing both locally and globally. There are numerous virtual currencies in use, with Bitcoin being one of the most prominent (Mangudya, 2017). Crypto currency is growing more and more comparable to traditional currencies in general, however its applications is still limited (Langer, 2021). Different researchers such as (Austin Hill, 2018); (Joa Silva Piedadge, 2018); (Jacobs, 2018); (Schmidt, 2018); (Sansonetti, 2014) and (Pich et al, 2020) highlighted that crypto currency serves as a medium of exchange, digital means of payment and digital store of value. Countries such as Elsavado and Central African Republic uses crypto currency as an official currency (Al-Jazeera, 2022). As a result it is against this background that crypto currency can certainly be used as an alternative in the payment system.

Crypto currency however is well associated with a number of risks such as tax evasion, money laundering and wallet vulnerability (Arthur R. Bos, 2018). The Central bank of Zimbabwe cited risks caused by crypto currency trading such as theft, terrorism financing, tax avoidance and fraud (Techzim, 2018). As a result Zimbabwe prohibited the trading of all virtual currencies and have instructed private banks to shut the bank accounts of people exchanging in virtual currencies (Mangudya, 2018).

However, the Zimbabwe minister of finance Mthuli Ncube seems to have some positive perceptions when it comes to crypto currencies. Ncube urged the Reserve Bank of Zimbabwe to take up knowledgeable people in the sector and create regulation for crypto currencies (Mudzingwa, 2018). As a result, the focus of this research will be on filling this gap. The legal aspects of regulating crypto currencies from a central banking viewpoint are generally understudied in Zimbabwe and this research aims to close that gap.

Literature review

Theoretical perspectives of regulation

The concept of crypto currency

Crypto currency is a decentralized digital currency that was created in 2008 to facilitate peer-to-peer transactions without the participation of a bank (Cao, 2019). The term regulation has no clear definition. In this research, regulation will be defined as the utilization of legal tools to obtain social and economic policy objectives.

Public Interest Theory

The public interest hypothesis focuses on the ability of the general public to observe regulatory decision-makers. On the other hand, when key decision makers work without scrutiny, they are more likely to provide regulatory benefits to well-organized interest groups at the expense of the general public. The assumptions of the public interest theory are as follows: 1. the existence of a market failure 2. the assumption of a benevolent regulator or alternately, an efficient political process 3. the selection of effective regulatory institutions (Nhavira, 2014).

Private Interest Theory of Regulation

Private interest theories were created to explain the regulatory ineffectiveness and inefficiency. This theory was created mostly by political scientists after the public interest theory was discredited by empirical and theoretical studies. This idea assumes that regulation will eventually suit the interests of the industry in question. The empirical research began with the foundational contribution by (Stigler; Friedland, 1962), who demonstrated that regulation did not cut rates and price discrimination. Despite the fact that this research was eventually proven to be incorrect about the scale of the influence of regulation (Peltzman, 1993), it nonetheless provided an entirely new perspective on government regulation. The analysis should have revealed that regulation reduced prices by around a fourth, causing output to increase by more than half.

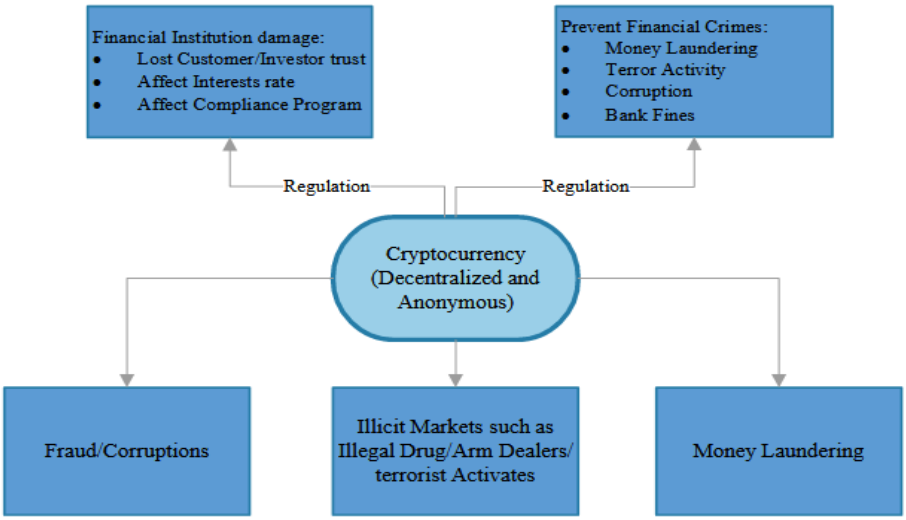
Buru's Theory of Regulation

Money laundering, corruption, the illicit market, illegal drug and arms dealings are among the financial crimes cited by Burrus (2018) as being facilitated by the decentralized and anonymous nature of crypto currency. As a result, it is used to pay transactions related with criminals wanting to conceal their unlawful cash and earnings. Furthermore, according to Burrus (2018), money laundering occurs as a result of drug and arms trafficking, allowing criminals to profit. Financial crimes are caused by a lack of suitable legislation, according to Burrus (2018).

Marian's Theory of Regulation

Marian's research has become increasingly interested in crypto currency regulation, stating that the high level of anonymity and decentralized nature of crypto currency has prompted illicit transfers, particularly money laundering, which has made it difficult for financial institutions to identify criminal activity. Because the "Know Your Customer" laws have hindered financial institutions ability to reduce fraudulent transaction there is need for a better and new intermediary regulation for crypto currency exchanges in banks. Marian (2015) went on to say that new legislation can help reduce crypto currency-related money laundering financial crimes since criminals will find it difficult to get around them.

Relationships between Cryptocurrency, Financial Crime, and Regulation



Note. Relationships between Cryptocurrency and Regulations

Figure 1. Relationships between Crypto currency and Regulation

The figure 1 above shows the relationship between crypto currency and regulations.

Empirical Review

Shirakawa (2019) employs a cross-sectional ordered probit model with institutional and macroeconomic data from multiple sources to examine how efficient regulatory institutions and de jure financial openness impact policymaker's mentalities toward pursuing further financial development through the use of crypto currency. The findings demonstrate that better governance institutions are linked to a less restrictive regulatory position on crypto currency, but that financial openness has no bearing. The findings also show that before new types of financial technology may be adopted, a certain degree of institutional quality may be necessary.

Furthermore, according to a study by Arner (2020), crypto currency stable coins offer greater threats to financial stability, monetary policy transmission, monetary sovereignty, consumer protection and investor protection. Furthermore, it was stated that foreign regulators are concerned about market manipulation, fraud and abusive consumer behaviour (IOSCO, 2020).According to a research by Feinstein (2012), regulation and legal compliance have been important challenges for crypto currencies from the outset. He claims that governments are still concerned about crypto currencies because they are mostly used for illicit purposes. Money laundering, terrorism financing, cyber security, consumer protection, investor protection and market manipulation are all serious problems with crypto currencies.

There has not been much investigation into how crypto-currencies are governed globally. In 2012, the ECB conducted a crypto-currency investigation and highlighted that the projected rise of digital currencies will need international cooperation in developing a common regulatory framework. (Bank,

2015). The study also found that while digital currencies offer a modest danger to price stability, it also proffers risks associated with criminal activity for the users. The French Virtual Currencies Working Group produced a document in 2014 that outlined the risks connected with the unregulated nature of digital currencies, as well as ideas for addressing these concerns (Currencies, Group, 2014). Three sources of risk were identified: the presence of unregulated participants, a lack of transparency and extraterritoriality. The Currencies and Group (2014) proposed that the use of crypto-currencies be controlled, regulation and cooperation be created and that industry knowledge be developed to better manage risk in order to mitigate these dangers.

Conceptual Framework

The research was guided by the Marian theory of regulation. Marian highlighted components that affects crypto currency regulation include corruption, consumer protection technology risk, market risk, liquidity risk and money laundering. The model hypothesized also include regulatory concerns highlighted by the Zimbabwean authorities such as fraud, theft, monetary protection and tax evasion.

The model proposed for the realization of this research is represented in Figure 2.

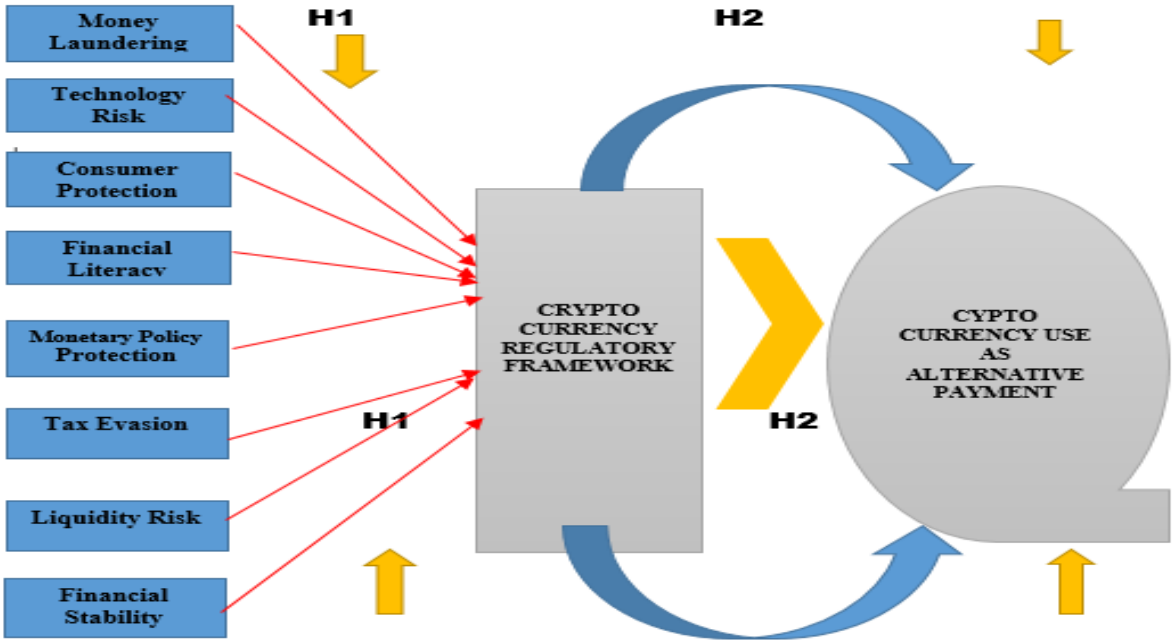


***Figure 2*: Proposed Model**

Figure 2 above shows a conceptual framework with hypothesis as follows:

H_0: Regulatory concerns are key in crafting a model which regulates crypto currency usage as an alternative payment system in Zimbabwe

H_1: Regulatory concerns are not key in crafting a model which regulates crypto currency usage as an alternative payment system in Zimbabwe

H_0: A model can be developed which efficiently regulate crypto currency as an alternative payment system.

H_2: A model cannot be developed which efficiently regulates crypto currency as an alternative payment system.

Methodology and Instruments

The research took a quantitative approach in assessing the regulatory concerns that impact regulation of crypto currency usage as an alternative payment system in Zimbabwe. The elements that influence crypto currency regulation were modeled using an ordinal regression model. To analyze how regulatory concerns influence crypto currency regulation, a structured questionnaire was used to collect data. 1500 people were considered for participation. A probability sampling method was used to pick 450 respondents from banks and regulatory institutions including CBZ Bank, Stewart Bank, FBC Bank, POSB Bank, Reserve Bank of Zimbabwe, Ministry of Finance and the Securities Exchange Commission. 450 questionnaires were distributed, with 400 legitimate questionnaires responded and 50 spoiled and so ineffective for the study.

The Ordinal Logistic Regression Model was used to conduct the research. Ordinal logistic regression is a regression approach in which the dependent variable is measured at the ordinal level and one or more explanatory variables are provided which might be ordinal, continuous or categorical (Winship, 1994). The relationship that the researcher is attempting to establish is the impact of regulatory concerns on the regulation crypto currency usage as an alternative payment system in Zimbabwe.

Ordinal logistic regression Model

$$\text{logit P}\big((\text{Y} \leq \text{j})\big) = \beta\text{j} - \beta\text{jX1} + \cdots + \beta\text{j} = \text{pXp} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

This model makes use of cumulative probability up to a point, representing the whole range of ordinal categories.

Therefore, The cumulative probability of a response less than and equal to j is given as:

$$\text{P(Yi} \geq \text{j} + 1 = \frac{\exp(\alpha\text{j} + \beta\text{1jXil} + \cdots + \beta\text{KjXik})}{1 + \exp(\alpha j + \beta 1 jXij + \cdots + \beta kjXik)} \ldots\ldots\ldots\ldots (2)$$

Where:

Y	is a variable that has not been seen.
$P(Y \geq j+1)$	The cumulative probability of an occurrence is defined as (Y≥ yj);
αj	is the constant term/intercepts in question
B_k	is the (p by 1)-dimensional vector of regression coefficients that corresponds to the xi covariates.
Xij	is the parameter that describes how the independent variable X affects the dependent variable Y.

Dependent Variable

The crypto currency regulation is the dependent variable in this research because it assesses the level to which regulation of crypto currency usage is influenced by regulatory concerns, it is the result of regulatory concerns. In other words, let Y stand for the crypto currency regulation. Also, let Y be a categorical response, with higher values suggesting greater importance of a crypto currency regulation regime.

Then:

Y = Crypto Currency Regulation
1 = low (1 -2 points)
2= medium (3 points)
3 – High (score 4-5 point)

Table 1: Dependent Variable Categories

CRYPTO CURRENCY REGULATION		
Not Important	Not Important or Slightly Important	Not Important, Slightly important or very important or extremely important
$log\frac{\mathrm{P1}}{\mathrm{p2}+\mathrm{p3}+\mathrm{p4}};1$	$log\frac{\mathrm{P1}+\mathrm{p2}}{\mathrm{p3}+\mathrm{p4}};2$	$log\frac{\mathrm{P1}+\mathrm{p2}+\mathrm{p3}}{\mathrm{p4}};3$

The table above shows the dependent variable and its categorical odds.

Table 2. Dependent and independent variables

Variable Name	Valid Range	Variable Type
Crypto currency regulation	Low Medium High	Ordinal
Money laundering	not at all important Slightly important Important Extremely important	Categorical
Liquidity risk	not at all important Slightly important Important Extremely important	Categorical
Financial literacy	not at all important Slightly important Important Extremely important	Categorical
Consumer protection	not at all important Slightly important Important Extremely important	Categorical
Monetary policy protection	not at all important Slightly important Important Extremely important	Categorical
Technology risk	not at all important Slightly important Important Extremely important	Categorical
Tax evasion	not at all important Slightly important Important Extremely important	Categorical

Results

Goodness of Fit Test

Table 3: Goodness of Fit Test

Model	-2 log Likelihood	Chi-Square	df	Sig
Intercept Only	610,785			
Final	525,876	56,222	12	.0000

The likelihood ratio chi-square test was used to verify if there is no significance difference between the base line models to the final model of the substantial chi-square result (p.0005). The table above shows that money laundering, financial stability, consumer protection, monetary policy protection, tax evasion, liquidity risk, technology risk, market risk and financial literacy were significant. They fits better than the intercept only model. The p value is less than 0.05 therefore the null hypothesis was rejected in favor of the alternative hypothesis.

Pseudo R-Square Statistics

Table 4: Pseudo R-Square Statistics

Pseudo R-Square	
Cox and Snell	.766
Nagelkerke	.812
McFadden	.594

In the ordinal logistic regression model, the Cox and Snell, Nagelkerke and McFadden pseudo-R2 statistics were employed to quantify the variance explained by the independent variables. The current R2 values (Negelkerke=.0.8123, Cox and Snell= 0.766, McFadden=0.594) suggest that the proportional variance explained by the independent variables on the dependent variable in the regression model are significant. Therefore money laundering, financial stability, consumer protection, monetary policy protection, tax evasion, liquidity risk, technology risk, market risk and financial literacy are most likely to be good indicators of crypto currency regulation.

Parameter Estimates of the Ordinal Logistic Regression Model

Figure 3: Parameter Estimates of the Ordinal Logistic Regression Model

		Value	Std.Error	t-value	p-value
Mon_Laund		1.9198	0.76191	4.7393	0.00
Liq_Ris		-1.3989	0.33404	0.1879	0.800
Fin_Stab		1.3062	0.25916	4.6990	0.000
Con_Prot		0.6156	0.12571	3.9623	0.000
Mon_Pol		0.0581	0.24647	0.2498	0.000
Tech_Ris		-1.3063	0.27894	4.8375	0.600
Tax_Eva		1.8304	0.53941	3.3734	0.000
Fin_Lit		-1.2069	0.1567	5.7455	0.700
1	2	1.7404	0.55954	3.4967	0.000
2	3	3.6874	0.58188	6.3088	0.000
3	4	5.2102	0.61365	8.7534	0.000

The figure 3 above shows that the most significant influence factor is the variable with the greatest coefficient that is less than the specified significance level of 0.05. Variables with p <0.05 were found not to be significant and variables with p >0.05, on the other hand, were determined to have no influence

on crypto currency regulation since p>0.05. Mon_Laund (money laundering) is the first significant independent variable, with a coefficient of 1.9198 and a p-value of 0.0000 which is less than 0.05. Given that all other factors in the model remain constant, we may predict a 1.9198 rise in the ordered log probabilities of money laundering regulation for every unit increase in crypto currency trading. With a coefficient of 0.6156 and a p-value of 0.00 which less than 0.05 for Con Prot (consumer protection) was found to be significant. Financial stability, tax evasion and monetary policy protection were also revealed to be significant variables. Liquidity risk, technology risk and financial Literacy were shown to be insignificant variables with p-value s 0.800, 0.600 and 0.700 respectively.

Odd Ratios and Confidence Intervals.

Table 5: Odd Ratios and Confidence Intervals

Variable	Odd Ratio	Confidence Interval	
		2.5%	97.5%
Mon-Lau	4.1176871	2.1155767	7.859797972
Liq_Ris	0.2708420	0.1556667	0.4663431
Fin Stab	1.0598649	0.6672596	1.6878900
Con_Prot	3.678740	1.23673673	1.6826783
Tech_Ris	0.2208420	0.14363678	0.4663431
Tax_Eva	3.0598649	0.32675677	4.6878900
Fin_Lit	0.5138640	1.2321852	1.8660740

The table above shows the coefficient parameters converted to proportional odds ratios and associated 95 percent confidence intervals. The odds ratios were computed by exponentiation the coefficient parameters. The odds ratio for money laundering is 4.11 times higher than other variables moving from lower, medium to higher categories of regulation holding other variables constant. Furthermore, the odd ratio for tax evasion is 3.05 times higher than other variables moving from lower, medium to higher categories of regulation holding other variables constant. More so, the odd ratio for consumer protection is 3.67. This means that for one unit increase in crypto currency use, the chances of consumer protection odds to moves from the lower and middle categories to the high category are 3.67 times higher given that all of the other variables in the model are held constant. Lastly, the odd ratio for liquidity risk is less than one with a coefficient of 0.271. This moves in line with the parameter table coefficient which is negative . This means that odd ratio is 0.27 times lower going from the lower and middle categories to the high category assuming that all of the other variables in the model are held constant. Similarly, financial literacy and technology risk have odds ratios less than 1 and have the same implication

Discussion

The primary regulatory concerns affecting regulation of crypto currency usage were investigated using an ordinal logistic regression analysis. Crypto currency regulation was characterized in order of magnitude relevance, from not important to extremely important, as the dependent variable. The results of the ordinal logistic regression analysis revealed that the primary regulatory concerns affecting crypto currency regulation is a model containing money laundering, financial stability, consumer protection, monetary policy protection and tax evasion.

Money laundering, consumer protection and tax evasion are the factors with were found with the most explanatory power for crypto currency regulation. According to the findings, liquidity risk, technological risk and financial literacy had no discernible impact because they had coefficients with (p>0.05). The findings are consistent with other studies that have shown these characteristics to be a source of concern in crypto currency regulation such as a study by (IOSCO, 2020); (Feinstein, 2021); (Madeng, 2019) and (Arner, 2020). They highlighted that money laundering, consumer protection, tax evasion and monetary policy protection affects crypto currency regulation. However , the findings also contradicts with a study by Kumar's (2012), particularly on the money laundering variable which

concluded that crypto currency money laundering has a negative impact on banks and the economy. These may be owing to the fact that money laundering has an impact on a variety of economic variables, including income loss, social costs, currency exchange rates, capital flows, interest rates, and economic instability and privatization risks. Furthermore, these results are consistence with a research conducted by Sadhaseevan (2019) who presented risks crypto currencies present to end-users and the financial system as a whole, he highlighted that crypto currency is affected by financial crimes such as money laundering.

In addition, the research found out that financial stability affects crypto currency regulation, however these results contradicts with that of Sadhaseevan (2019) who concluded that crypto currencies do not present any substantial risk to the payment system and financial stability. Furthermore, consumer protection was also found to be a significant. This could be because the majority of traditional financial investment market participants are institutional investors and individual investors and they cannot compete with institutional investors in terms of capital size, information consulting resources and information analytical capability. If crypto currency exchangers are not regulated, investors are left unprotected. As a result, there are no specific restrictions that protect them against financial injury or loss.

Some elements were not significant, particularly the risk of technology, liquidity risk and financial literacy. Technological risk was not considerable because the popularity of crypto-currencies has increased dramatically in recent years and more tools and knowledge resources have become available. Trading platforms may have provided operation interfaces comparable to conventional stock exchanges and performed extensive online and offline education and trainings for potential consumers. Liquidity risk was not significant because crypto currency may enable access to new capital and liquidity pools through tokenized old assets and new asset classes. Certain alternatives are accessible with crypto currency that are just not possible with fiat currency. Crypto currency for example, can enable real-time and accurate revenue sharing while increasing transparency to assist back-office reconciliation. In addition, the research discovered that financial knowledge does not affect crypto currency regulation. This is consistent with other researches such as (Lam, 2017) who states that those who are financially literate are less prone to make rash investments.

Conclusion

This study has taken a comprehensive look at regulators' concerns on the usage of crypto currency in Zimbabwe. The risks associated with crypto currencies are manifested in the regulatory dilemma, in which policymakers and lawmakers are wary of crypto currencies due to perceived risks. Money laundering, liquidity risk, financial stability, consumer protection, monetary policy protection, technology risk and tax evasion are the top risks cited by authorities in Zimbabwe. The researcher's goal was to evaluate the regulatory concerns that influence regulation of crypto currency usage in Zimbabwe. Structured questionnaires were used to obtain data from 400 respondents using probability sample procedure. Because the dependent variable is ordinal, an ordinal logistic regression was used in this research. The analyses' ordinal logistic regression model met all of the relevant assumptions. Initially, several criteria were regarded as possible predictors of crypto currency regulation. Money laundering, financial stability, consumer protection, monetary policy protection and tax evasion were shown to be the most significant variables which affect crypto currency usage regulation in Zimbabwe.

Recommendations

The recommendations made in this research were subjected to two basic premises. Specifically 1. not to obstruct the development or innovation of crypto currencies and block chain technology and 2. to remove hazards to the greatest extent practicable. Zimbabwean regulators worry about crypto currency risk therefore the author suggest they implement the Central Bank Digital Currency (CBDC) model. Central bank digital currencies are digital tokens issued by a central bank that are comparable to crypto money. They are pegged to the value of that country's fiat currency (Seth, 2022). They use the same underlying distributed ledger technology of crypto currencies. The CBDC will be the best solution for

the Zimbabwean scenario because its components and technology can regulate money laundering, financial stability, consumer protection, monetary policy protection and tax evasion. Zimbabwe through the Reserve Bank of Zimbabwe should issue Central Bank Digital Currencies (CBDC) because it uses the crypto currency innovation yet also eliminating regulators risk concerns.

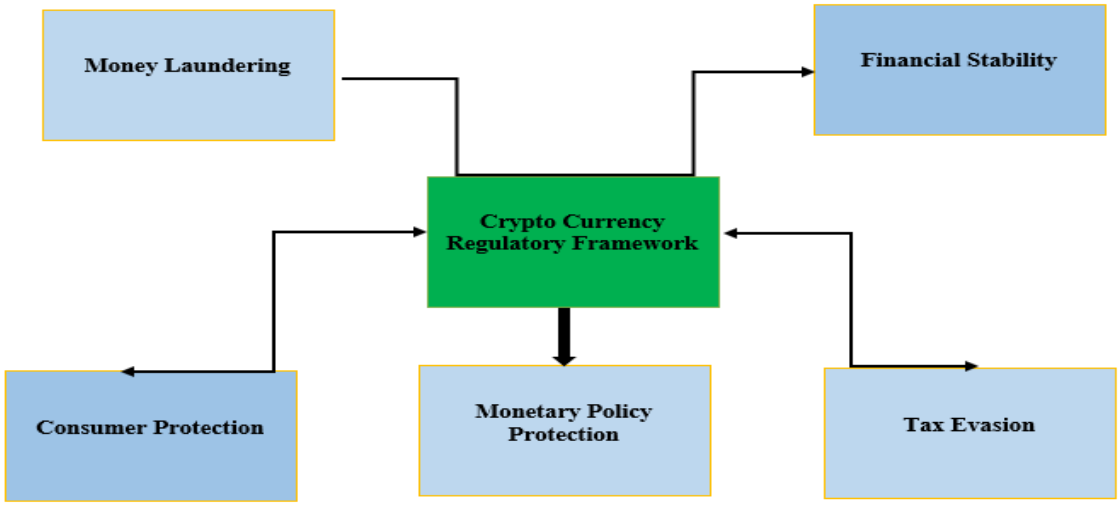


Figure 4: Crypto Currency Regulatory Framework for Zimbabwe

The figure above shows that primary regulatory concerns affecting crypto currency regulation in Zimbabwe is a model containing money laundering, financial stability, consumer protection, monetary policy protection and tax evasion. As a result, the research has provided foundations of regulatory model by identifying areas mostly regulators are concerned about. Therefore overall, the null hypothesis is not rejected and the researcher concluded that regulatory concerns are key in developing a regulatory framework and thus it is possible to develop a regulatory model.

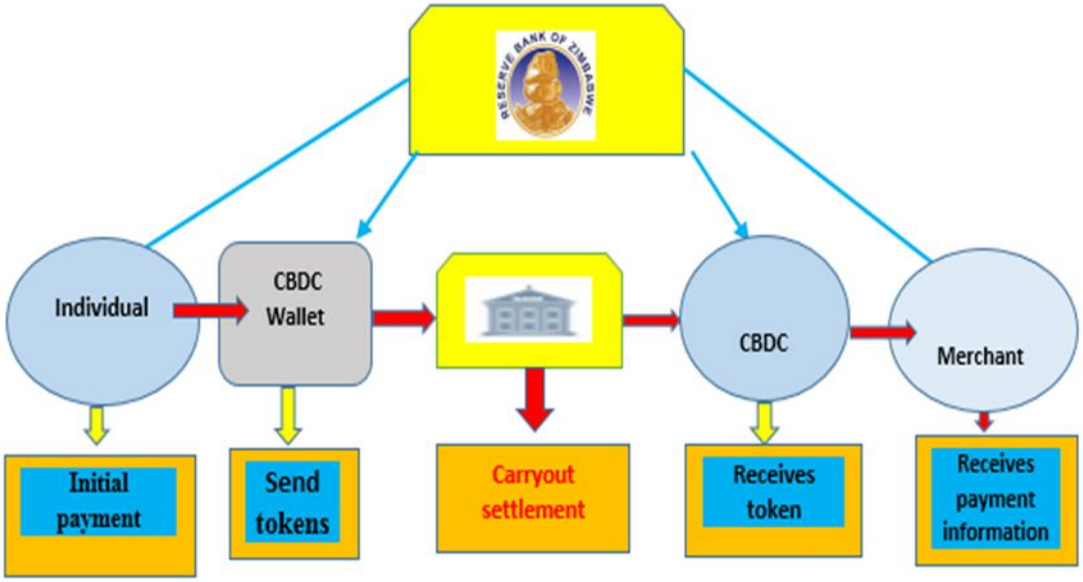


Figure 5: Central Bank Digital Currency: A model regulating Crypto Currency risk concerns

The figure above shows a model which regulates crypto currency risks such as Money laundering, financial stability, consumer protection, monetary policy protection and tax evasion.

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