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ANÁLISE DE MERCADO DE *WOOD-PLASTIC COMPOSITE* (WPC) NO BRASIL

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Botucatu, 13 de julho de 2020

*À minha amada família,
Antonio Carlos, Suelene e Henrique,
dedico*

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BÍBLIA SAGRADA. Traduzida em português por João Ferreira de Almeida. Revista e Atualizada no Brasil. 2. ed. Barueri, SP. Sociedade Bíblica do Brasil, 2011. p. 1664. Salmos 18:28.

RESUMO

Constantes preocupações com as fontes energéticas e com as mudanças climáticas tem gerado uma busca por novas descobertas e tecnologias nas cadeias produtivas. A quantidade de resíduo produzido no mundo e seu descarte se tornou assunto entre acordos comerciais e políticos entre os países. Soluções que retirem esses resíduos do meio ambiente são desejáveis pela sociedade, além de criar oportunidade de negócio para investidores. Produtos que sejam provenientes de fontes renováveis, com certificação e com possibilidade de voltar ao sistema produtivo após seu descarte tem ganhado espaço no mercado. Economia circular é a forma como esse novo modelo econômico pode ser definido, está desvinculado do uso de recursos finitos, através do uso eficiente dos recursos e da minimização de resíduos. Na economia circular o *Wood-Plastic Composites* (WPC) é um dos exemplos na produção de novos materiais, pois utiliza resíduos. O WPC utiliza em sua produção fibras naturais, resíduos agroflorestais, e polímero que pode ser virgem ou também reciclado. Algumas pesquisas já foram realizadas na área técnica do WPC no Brasil, porém poucos estudos de mercado encontram-se divulgados. No desenvolvimento de produtos mais tecnológicos e sustentáveis, como o WPC, informações são necessárias para que haja investimentos no setor, e então uma produção em escala dê maior acesso ao mercado. Dessa forma, o objetivo geral desse trabalho foi analisar o mercado de WPC no Brasil. Os objetivos específicos concentraram-se em entender o perfil de seus consumidores, influenciadores, pesquisadores e população geral através de questionários e uma análise econômica de um fabricante de WPC. A metodologia utilizada foi de revisão bibliográfica; elaboração de questionário para aplicação nos quatro segmentos; análise estatística dos resultados de questionários semiestruturado através da Análise de Correspondência Múltipla (MCA) pelo *software* R. A análise de viabilidade econômica foi realizada por meio da TIR e VPL, a partir de dados fornecidos de um fabricante de WPC, que demonstraram ser viável a produção de WPC. Como conclusão, o mercado brasileiro de WPC apresenta inúmeros desafios como: tornar o material WPC mais conhecido pela sociedade, e para isso investir mais em publicidade e marketing; proporcionar uma maior confiabilidade do produto aos engenheiros e arquitetos; aumentar o número de pesquisas e estudos de mercado no setor que suporte os investimentos, entre outros. Porém, existe uma enorme perspectiva de crescimento e muitas oportunidades nesse mercado, principalmente porque a população brasileira tem buscado novos produtos que possuam qualidade, bom preço e que sejam produzidos a partir de fontes renováveis de energia. E por fim, as empresas estão sendo cobradas a serem mais sustentáveis, executando uma economia circular e não linear.

Palavras-chave: Mercado de WPC. Compósito plástico-madeira. Economia circular. Fibras lignocelulósicas. Polímeros. Reciclagem.

ABSTRACT

The continuous concern about energy resources and climate changes has created a search for new developments and technologies in the productive chains. The amount of waste produced in the world and its disposal has become a political and commercial matters between the agreement of countries. Solutions which enable to remove this waste from environment are desirable from society, besides it can generate new business opportunities for investors. Products from renewable sources, certified and able to return to productive systems after their disposal have gained more space in the market. Circular economy defines this new economic model, it is disconnected from the use of finite resources, through an efficient use of the sources and waste minimizing. Wood-Plastic Composites (WPC) is an example of this new model, circular economy, about new materials production, using waste raw materials. WPC use in its production natural fibers, as agroforestry waste, and polymers that can be virgin or come from recycled via. Some researches about WPC have been done in the technical area in Brazil, but few studies about market can be found. When developing new products, more technological and more sustainable, as it is the WPC products, some information is necessary for attracting more investments, and then a larger scale production, improving the market access. Therefore, the main purpose of this study was to analyze the Brazilian WPC Market. Other objectives were focus on understand the profile of the consumers, influencers, researchers and general population, through a survey and an economic analysis of a WPC producer. The methodology used was bibliographic review; survey elaboration and application to four population; and a statistic analysis of the results using MCA from software R. The analysis of economic viability was realized in Excel, IRR and NPV, and the data was supplied by a WPC producer. The results of economic analysis showed that the WPC production is acceptable. In conclusion, the Brazilian WPC Market has some challenges to overcome, as: make the WPC well-known by society and for this, it is needed to invest in publicity and advertisement; also to obtain the confidence of engineering and architecture; to increase the market studies to support investors, *etc.* Although, there is a huge perspective of growth and many opportunities in this market, Brazilian people have looked for new products with high quality, good price and made from renewable sources. At last, the Brazilian government and companies have been requested to be more sustainable and change the linear economy to circular economy.

Keywords: WPC Market. Wood-Plastic Composites. Circular Economy. Lignocellulosic Fibers. Polymers. Recycling.

LISTA DE ABREVIATURAS E SIGLAS

CAPES	Coordenação de Aperfeiçoamento de Pessoal de Nível Superior
CEP	Comitê de Ética em Pesquisa
DIY	<i>Do it yourself</i>
EUA	Estados Unidos da América
IPCA	Índice Nacional de Preços ao Consumidor Amplo
MCA	Análise de Correspondência Múltipla
NFC	<i>Natural Fibres Composites</i>
ONG	Organização Não Governamental
PE	Polietileno
PEAD	Polietileno Alta Densidade
PEBD	Polietileno Baixa Densidade
PET	Polietileno Tereftalato
PNRS	Política Nacional de Resíduos Sólidos
PP	Polipropileno
PS	Poliestireno
PVC	Policloreto de Vinila
RSU	Resíduos Sólidos Urbanos
TIR	Taxa Interna de Retorno
TMA	Taxa Mínima de Atratividade
UE	União Europeia
VPL	Valor Presente Líquido
WPC	<i>Wood-Plastic Composites</i>

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INTRODUÇÃO GERAL

O mundo tem enfrentado sérios problemas ambientais decorrentes de ações ocorridas no passado após a Revolução Industrial. Constantes preocupações com as fontes energéticas e com as mudanças climáticas tem gerado uma busca por novas descobertas e tecnologias nas cadeias produtivas. A troca do uso de fontes energéticas fósseis por fontes renováveis, bem como a criação de leis e planos de ações para lidar com os resíduos resultantes dos processos industriais e agrícolas são bons exemplos (CESARINO et al., 2020).

A quantidade de resíduo produzido no mundo e a forma como é realizado seu descarte se tornou assunto importante entre os acordos comerciais e políticos entre os países. A cada ano toneladas de resíduos são descartados nos oceanos trazendo prejuízos imensuráveis para a sociedade e ao meio ambiente. Resíduos que, como o plástico, por exemplo, poderiam ser matéria-prima em novos processos produtivos (AWOYERA; ADESINA, 2020).

Uma grande quantidade de energia e recursos financeiros são desperdiçados após a colheita de produções agrícolas e florestais quando os restos culturais seguem para descarte de forma incorreta na natureza, ou queimados, ao invés de serem transformados e gerar assim, valor à sua cadeia. Soluções que retirem esses resíduos do meio ambiente são desejáveis pela sociedade, além de criar uma ótima oportunidade de negócio com retorno para investidores (SILLANPAA; NCIBI, 2019).

Uma forte demanda por produtos mais sustentáveis e inovadores, provenientes de sistemas produtivos eficientes tem ganhado espaço também entre os consumidores. Uma tendência de produtos que sejam provenientes de fontes renováveis, com certificação e com possibilidade da volta do material ao sistema produtivo após o descarte tem tido vantagem competitiva no mercado. Uma característica importante já que se espera um aumento populacional, e com ele um maior descarte de resíduos sólidos (SUZANNE; ABSI; BORODIN, 2020).

Um novo conceito, chamado economia circular, tem transformado os modelos de negócios nos últimos tempos. Segundo a Fundação Ellen MacArthur (2020) a economia circular traz uma ideia de crescimento onde favorece toda a população inserida na sociedade. Nela a atividade econômica é desvinculada do uso de recursos finitos e elimina a produção de resíduos do sistema.

A economia circular pode ser definida como um modelo econômico destinado ao uso eficiente dos recursos e da minimização de resíduos, redução de recursos primários e *loops* fechados de produtos, peças e materiais dentro dos limites da proteção ambiental, com benefícios socioeconômicos, entre outros (MORSELETTTO, 2020). Na economia circular, o *Wood-Plastic Composites* (WPC) é um exemplo de produto inovador, pois utiliza diferentes resíduos como matéria-prima em sua produção (KESKISAARI; KARKI, 2018).

O WPC é um produto com características esperadas por um mercado crescente de consumidor com perfil moderno e com consciência ambiental quanto ao seu consumo e com custo-benefício aceitável. O WPC é caracterizado pela adição de dois materiais diferentes que juntos formam um terceiro, também diferente dos outros dois, onde apresenta uma melhor qualidade. O WPC utiliza em sua produção fibras naturais, resíduos agroflorestais, e polímeros que podem ser virgens ou também vir da reciclagem (SOMMERHUBER et al., 2017).

Osburg, Strack e Toporowski (2016) concluíram em seu trabalho que o mercado de materiais eco-inovadores como o WPC seria maior do que o esperado no passado e incentivaram pesquisas sobre fatores detalhados sobre o consumidor e sua aceitação ao WPC e outros materiais eco-inovadores. Algumas pesquisas e publicações já foram realizadas quanto a parte técnica do WPC no Brasil, relacionadas à produção, porém poucos estudos encontram-se divulgados para compreender esse mercado e fomentar o desenvolvimento de produtos como este, mais tecnológicos, sustentáveis e circulares.

CHAPTER 1 – WOOD-PLASTIC COMPOSITES MARKET ANALYSIS IN BRAZIL

1.1 INTRODUCTION

The continuous concern about energy resources and climate changes has created a search for new developments and technologies in the productive chains. The amount of waste produced in the world and its disposal has become a political and commercial matters between the countries' agreement. There is an urgent need to balance population and industrial growth with the natural sources used. Solutions which enable to remove this waste from environment are desirable from society, besides it can generate new business opportunities for investors. Products from renewable sources, certified and able to return to productive systems after their disposal have gained more space in the market (AWOYERA; ADESINA, 2020; SILLANPAA; NCIBI, 2019; SUZANNE, ABSI; BORODIN, 2020).

Circular economy defines this new economic model, it is disconnected from the use of finite resources, through an efficient use of the sources and waste minimizing (MORSELETTTO, 2020). Wood-Plastic Composites (WPC) is an example, where new materials are highly encouraged to be produced using waste raw materials. WPC uses in its production natural fibers, as agroforestry waste, and polymers that can be virgin or come from recycled via (SOMMERHUBER, 2017).

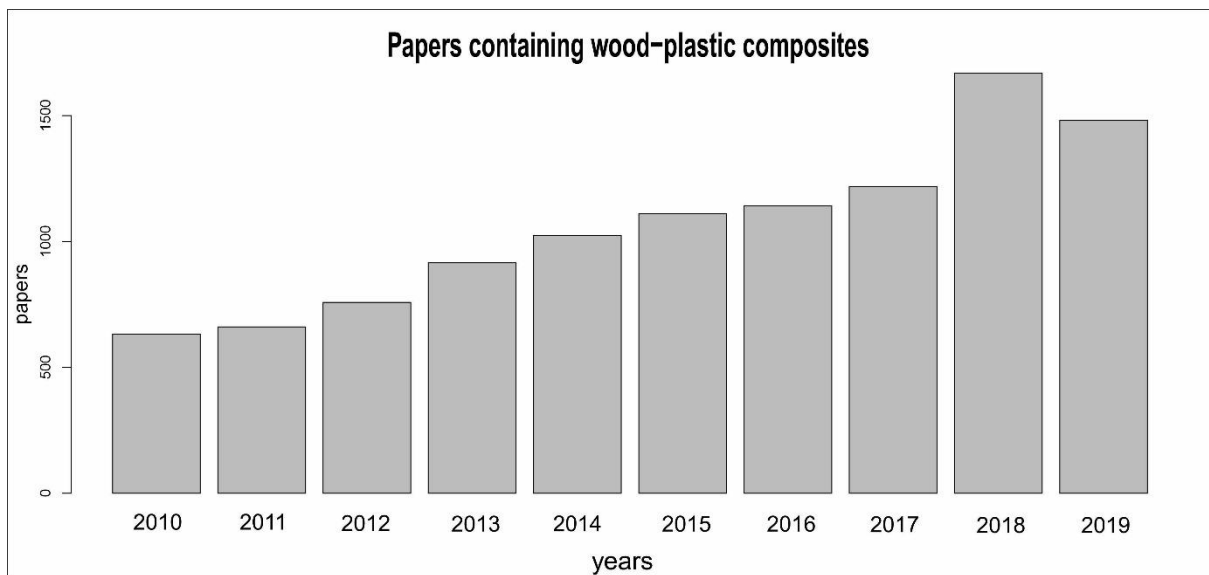
According to Ellen MacArthur Foundation (2020) the circular economy is an economy based on the principles of designing out waste and pollution, keeping in use the products and the materials, also regenerating natural systems. This Foundation also works in a project called "New Plastic Economy", where the vision is eliminate the plastics we don't need from the system; innovate to ensure that the plastics we do need are reusable, recyclable, or compostable and circulate all plastic items we use to keep them in the economy and out of the environment. This project encourages solutions to remove plastics from environment.

The European Union has the strategic and priority to change its economy into a circular economy, through the efficiency of resources. This can allow the countries to reduce the environment pressure, increase their competitiveness and innovativeness of economy and creates new Jobs as well (TURKU; KARKI; PUURTINEN, 2018). According to the Brazilian National Confederation of Industry, CNI (2018), the circular

economy represents a great opportunity to expand the manufacturing potential in the country, contributing to business resilience and competitiveness with sustainability.

For this reason, universities and researchers around the world are currently looking for studying more about WPC due to its importance in the development of new materials (PRITCHARD, 2004; ARRUDA, 2007; KESKISAARI; KARKI, 2018; MALVIYA et al., 2020). Graphic 1 is noncumulative and demonstrate the number of articles published in CAPES Periodic between the year of 2010 and 2019, where it is possible to note the grow of researches containing the word “wood-plastic composites”.

Graphic 1 – Publication in CAPES Periodic about “Wood-Plastic Composites”



Then, in accord to the importance of finding solutions to environmental problems and motivated by the circular economy, this study was carried out to disclose the market potential of WPC in Brazil, to make information available to potential consumers and investors in the sector. The main purpose of this study was to analyze the Brazilian WPC Market. Other objectives were focus on understand the profile of the consumers, influencers, general population, and researchers through surveys. The selection of these segments was in accordance with:

- ✓ General Population: they are the potential consumers. Important to understand what they want;
- ✓ Consumers: people who have already bought something produced from WPC;

- ✓ Influencers: civil engineer and architect who can recommend the product and influence the purchase;
- ✓ Researchers: professionals who work in the search area (biomass, natural fibers, composites, material engineering and circular economy).

1.1.1 WPC Concepts

The history of WPC is ancient, but has been dated with greater importance in 1916, through Rolls-Royce that used the material in the automotive industry, and it was popularized in the USA during the 90's. Nowadays it is well-known in many countries as USA, Europe and Asia, mainly in China (PRITCHARD, 2004; CLEMONS, 2000)

The concept of WPC is a mixture of polymer resin (matrix) and natural fiber, in this case, wood fiber. According to ASTM D-3878 (2019) composite is a substance consisting of two or more materials, which are combined to form a useful engineering material the sum of two or more different materials, insoluble in one another, different from each other resulting in an useful engineering product with different characteristics compared to the constituents. WPC is the sum of the matrix - polymers, known as plastics, and the natural fibers, called lignocellulosic reinforcements, resulting in a material with better attributes than wood or plastic (RODOLFO JR; JOHN, 2006; AYRILMIS; KAYMAKCI; GULEÇ, 2015).

Lignocellulosic fibers are good alternatives to use as reinforcement and loads in material development, because of their low cost. The application of lignocellulosic fibers in polymeric materials brings advantages such as good appearance of the new material and superior mechanical properties than when using other fibers (YAMAJI, 2004; HYVARINEN; RONKANEN; KARKI, 2019).

Natural wood is considered as a polymeric composite consisting of cellulose, hemicellulose and lignin (SAKA, 2001). The efficiency of natural fiber reinforcement is according to cellulose presence and the degree of crystallinity in its chemical composition (CARASCHI; LEÃO, 2002). According to Chollakup et al. (2011) the integration of natural fiber in the matrix of composites can be poor because of the strong hydrogen bridges that keep them merged. Thus, it is necessary to leave the cellulose free to join the polymeric matrix. To achieve this, some treatments may be necessary to separate hemicellulose and lignin from this fiber. One of the methods most utilized nowadays is the chemical treatment. This treatment increases the

adhesion between the hydrophilic part from fiber and the hydrophobic part of the polymer (VEDRTNAM; KUMAR; CHATURVEDI, 2019). The treatment with sodium hydroxy (NaOH) is an example. Marcon et al. (2009) reported that the alkaline treatment breaks the hydrogen bridges and roughen up the fiber surface, may resulting in better mechanical properties of this composite.

Regarding to the disadvantages, Zini and Scandola (2011), reported that the natural fibers brings a mechanical properties variability in composites, varying with the age of the plants, geographical area and harvesting methods. And, also, the maximum temperature that the cellulose can be processed without burning, which is around 200°C, influencing the choice of the polymer (BURGSTALLER, 2007).

However, Zah *et al.* (2007) declared that the main advantage of using fiber in composites, in their study with the *curauá* fiber, is the low cost that can be two or three times cheaper than glass fibers. Chandramohan and Marimuthu (2011), reported that natural fiber composites, such as WPC, can be about 30%-40% lighter, even than aluminum structures when designed for the same functional purposes, for example. Contributes to a 30% weight reduction and a 20% cost reduction during the manufacture of a vehicle (CESARINO et al., 2020).

According to Caraschi, Yamaji and Leão (2005), the blending of wood sawdust and plastics offers better mechanical properties for these materials, reduces costs and decreases the generation of effluents and polluting residues. Vedrtnam, Kumar and Chatuverdi (2019) also quoted several advantages for the use of natural fibers in the production of composites, among them: such resources come from renewable sources of energy, low cost; low density; they are not toxic; easier to recycle and compost at the end of the WPC's useful life. The use of agriculture waste is an economic advantage, besides also being more ecologically efficient (KESKISAARI; KARKI, 2018). Ganguly et al. (2010) cited that in all regions of the USA, participants cited the use of recycled materials as the main attribute to the deck needs.

WPC is a material with the possibility to be inserted in the wood and plastic markets. Figure 1 shows a WPC deck with a similar appearance to a natural wooden deck. Comparing WPC with products made only with wood, Arruda (2007) presents WPC with several competitive advantages, such as: more resistant to UV rays, color maintenance even in external areas; lower maintenance cost; recyclable product; easy to install; greater resistance to termites, fungi and the attack of other microorganisms.

Figure 1 – WPC deck



Source: Ecowood, 2020

The production of WPC starts with important choices, the matrix itself and later on the fibers. A choice of which fiber and polymer to use, and the ratio between them. This selection will depend on the production process and the desired material properties. That means, it can vary according to the use that the product will have, where usually the greater the need for stiffness, the greater the amount of fiber and the more flexibility required, the less the fiber ratio. The choice of polymers can also be between virgin and recycled polymer (HYVARINEN; RONKANEN; KARKI, 2019). Sommerhuber et al. (2017) reported in their study that the potential environmental impacts for most of the environmental parameters in the production of WPC from recycled materials by the Life Cycle Analysis (LCA) study are lower compared to the WPC produced from virgin materials. The meaning of LCA according to ISO 14040 and ISO 14044 is the compilation and evaluation of inputs, energy outputs and the possible environmental impacts of a product system throughout its life cycle.

The most used fibers in the composites are sawdust, rice husk and agroforestry waste in general. Thermoplastics are commonly used as a matrix (MARTINS et al. 2017; CRESPELL; VIDAL, 2008). Among the most common polymers in composites are polypropylene (PP), polystyrene (PS), polyethylene (PE), low density polyethylene (LDPE), high density polyethylene (HDPE), polyethylene terephthalate (PET) and polyvinyl chloride (PVC) (PANTHAPULAKKAL; ZERESHKIAN; SAIN, 2006). Such information is important to note since the raw materials used can result in products with better characteristics and different price in the market. Products having PVC as a matrix, for example, are more expensive due to their attributes and advantages over

other polymers used in composites. PVC does not depend as much as other polymers of crude oil or natural gas, which means that PVC has a smaller carbon footprint than PP, PE and HDPE. The WPC produced in PVC matrix maintains the color for a long time compared to others, being resistant to UV rays and self-extinguishing by fire (CESARINO et al., 2020).

According to Migneault et al. (2009), the production of WPC can be obtained by mixing wood and plastic through heating and melting. Injection is increasing worldwide, but it is still lower than extrusion. So, the most common process of WPC production is extrusion, in the main manufacturing countries, also in Brazil. Dammer et al. (2013) reported that in Europe the production process of the WPC deck is extrusion, based on the polymeric matrices of PVC and PE.

1.1.2 WPC Market

WPC is a material that can be inserted where natural wood and plastic are already used (SOMMERHUBER et al., 2017; JIANG; FU; HE, 2020). The WPC deck, used on balconies, around swimming pools, piers, is one of the products which has the greatest acceptance and commercialization in the world and in Brazil, being the flagship in the main producers around the world. But WPC is also widely used in internal parts of automobiles, pergolas, dumpsters, benches, sleepers, culvert mouths, toys, among other applications, as shown in figure 2 (CHAN et al., 2018). WPC is a great material for outdoor applications, with expectations for greater applications in structural functions, once its efficiency has been proven.

Figure 2 – Facade, Pergola and e Playgrounds



Source: Ecowood, 2020

Among the advantages for the WPC deck are the product's resistance, safety, practicality in maintenance, does not fade, does not loose splinters, resistant to attack by pests, fungi and its durability. It is recyclable and has low energy consumption in its production. In addition to reducing the use of natural wood and felled trees, contributing to non-deforestation, it can also collaborate by removing the plastics that make up a large part of Municipal Solid Waste (MSW) from the environment (SOMMERHUBER; WELLING; KRAUSE, 2015). Composites made from natural fibers usually have applications in automobiles because they have greater resistance than polymers, in addition to reducing the total weight by 10 to 30%, which also leads to savings in fuel costs. Well-known brands like Audi, BMW, Mercedes Benz, Volvo, Fiat, Renault, Ford, Peugeot and Volkswagen have already used or use WPC in some automotive parts (ASHORI, 2008).

According to Carus et al. (2015), in Europe, the deck market represented 67% of the application and use of WPC. Followed by automotive parts with 24% of market share. Comparing to wood market, in the USA, WPC's market share in the deck and fence market was 15% in 2004, with 79% for wood, and 2% plastic (estimated market at US \$ 5.7 billion), according to Wolcott and Smith (2005). In 2013, in Europe, the WPC market share in the deck market grew and varied between 2% to 15% depending on the region in Europe (DAMMER et al., 2013).

According to Carus, Eder and Koter (2014), the world production of WPC in 2012 was 2.43 million tons and the world forecast for WPC production for 2015 would be 3.83 million tons. USA, China, Europe and Japan are in the lead (GUIMARÃES, 2013). As shown in table 1 below, it is possible to observe the world production of WPC, with significant quantity for North America, most USA, China and Europe with Germany. Table 1 also shows the number of producers. It is important to note that in South America the production doubled in two years and showed 10 producers. Relevant information since in this study it could be observed that only in Brazil was found twenty-three (23) WPC manufacturers in 2020. Another relevant data is the position of China, which together with India tripled their productivity. China is even among the main exporters. It is known that Brazil imports WPC from China, but the quantity information is not disclosed. According to Dammer et al. (2013) Germany's representativeness in the WPC market was the result of greater knowledge about production, the greater concentration of manufacturers of machinery for production and

research and development institutes for this product. In addition, the same author pointed out that in Germany, consumers were more aware than the average of Europeans regarding the use of WPC. He also mentioned that in Germany there was an association of WPC manufacturers as part of the wood workers association. Such success could be connected even to the support of the government and to the conferences that usually happen there and take great knowledge.

Table 1 –Global WPC Production

GLOBAL WPC PRODUCTION			
Region	Tons in 2010	Tons in 2012	Number of producers in 2012
North America	900.000	1.100.000	56
China	300.000	900.000	422
Europe	220.000	260.000	62
Japan	40.000	65.000	25
Southeast Asia	30.000	40.000	45
South America	10.000	20.000	10
India	5.000	25.000	21

Source: Dammer *et al.* adapted by author, 2013

Regarding the demand for products made with WPC, North America and Asia were the two largest consumers of WPC in the world (USA and China as the largest consumers) in 2015. And according to the same study, the China, India and Brazil would also be increasing their demand for WPC products very fast (REINFORCED PLASTICS, 2015). The main distribution channel in Europe are distributors and wholesalers, because they are at the center of the distribution system. Europe imports WPC decks estimated between 20% and 50% of the market demand. Most of them come from China due to their low cost, or from USA, because their better quality (DAMMER *et al.*, 2013). They reported that a lot of technical research was carried out, however, the WPC was still not well known by European consumers.

Studies developed with general population and consumer about WPC products, as a survey in the USA, WPC was classified as a material with the longest useful life, the most easily maintained material and the most sustainable by respondents (GANGULY *et al.*, 2010). Osburg, Strack and Toporowski (2016) studied the acceptance of WPC consumption in the German market and concluded that the greater the environmental and innovation concern of consumers, the greater the acceptance

of WPC in the market. Wolcott (2005) highlighted that the main points for acceptance of the WPC in the USA were the approval of the use by the manufacturer, the cost-benefit ratio, and an effective marketing communication about the product. In the study of Panda et al. (2020) it was reported that consumers' sustainability and socio-environmental awareness had a positive impact on their purchase intention.

According to the searches found in the review, there is not much data about WPC market in Brazil. Few publications provided some information in this sector. According to Sebrae (2013), product markets that combine a good cost-benefit ratio with environmental awareness have a competitive advantage and are expanding in Brazil. In the same study, it is still reported that according to the Green Building Council Brazil, a Non-Governmental Organization (NGO), which works with sustainable buildings, Brazil ranked fifth in the ranking of countries that have invested the most in green buildings.

Trigueiro and Bocardi (2012) reported that WPC producers in Brazil believe that even the WPC price - around 30% higher - on average than natural wood, this could change if the production increased. Guimarães (2013) after naming numerous advantages of the product, also presented the impasse of higher initial cost comparing to natural wood.

Sebrae (2014) described that the WPC Brazilian market was still unknown by general population, despite being in a growth stage, and propose to the public sector to start making more sustainable purchases, adhering to the product and contributing to the sector's sales increase. That is the case of the *Balneário* of Rio Bonito, belonging to Botucatu city, located in São Paulo State, that used WPC in public works, a WPC deck in figure 3. Also, Fernando de Noronha Archipelago in Pernambuco State, figure 4, inserted WPC deck in Sancho's Beach, and in other locations in the archipelago. A tourist place where sustainability is extremely necessary and encouraged.

Figure 3 – WPC deck in Rio Bonito, Botucatu/SP - Brazil

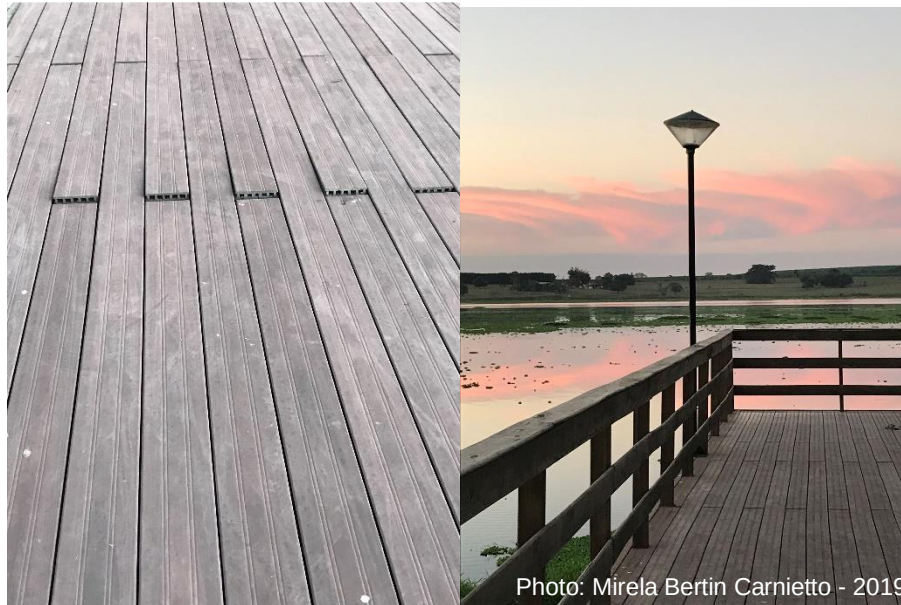


Figure 4 –WPC deck photos in Fernando de Noronha/PE - Brazil



Source: G1, 2020

1.2 MATERIAL AND METHODS

The bibliographic review was realized through searches about relevant information of WPC and the updated publication on this market. The review was carried out by searching for the subjects of this work in books, magazines, journals,

dissertations, theses, online sites, and other sources of publication. The review contributed to a greater basis on the topic for this research.

1.2.1 Surveys

The surveys were applied to four different segments: general population, consumers, influencers (civil engineering and architect), and researchers. The general population was chosen because it represents the potential consumer, to understand its socioeconomic characteristics; the degree of knowledge of the product; which attributes are important to the product; among others. The consumer segment also was selected to understand the socioeconomic aspects; how they knew the product; the reason of purchase; and their degree of satisfaction with the WPC product. The influencers were inserted because they are responsible for recommending the WPC product to potential consumer and the construction workers. Some people get the first contact with this material when they are building. Researches were chosen because they are ahead looking for innovation. So, it is important to understand if they believe in the WPC future. The project was approved by the Ethical Committee in Scientific Research, before being applied, and all the information about the approval is in “Appendices” at the end of the dissertation.

The questions in the surveys were based on specific objectives to obtain the market knowledge, with information determined by competent institution, such as, the sociodemographic questions, designed by Sebrae (2013). The attributes asked in the questionnaires, such as durability, appearance, low maintenance, cost, ecological, for example, were attributes mentioned by researchers in the bibliographic review, which have also been used in a consumer perception questionnaire applied in Austria by Weinfurter and Eder (2009).

The surveys are available in the “Appendices”, containing all the questions asked. For a better understanding and application of the statistics, the questions were closed, with the possibility of inserting a personalized answer in “other”. The surveys were formulated through the Google Forms online platform due to the easy usage, because it is free and has no limit on the number of responses. Such forms were sent through social networks, WhatsApp, Facebook and Instagram, and e-mail to the different segments. The period for receiving responses to the questionnaires was from March 2019 to June 2020.

1.2.2 Statistical analysis of survey responses

The purpose of applying the questionnaires was to know the profile of consumers, and potential consumers, their aspects, their behavior patterns and their preferences. Identify how the influencer, civil engineer or architect, behave regarding the knowledge and recommendation of WPC products, and the opinion of researchers about WPC. Therefore, for a better understanding and usage of the data obtained by the questionnaires, a statistical analysis was applied.

The statistical analysis used to process the results was the Multiple Correspondence Analysis (MCA), through software R, version 3.5.3, year 2019. The study between the relationship of two qualitative variables is called simple correspondence analysis. In this search, the questionnaires, the relationship was between more than two variables, thereby the multiple correspondence analysis was applied. This analysis is a technique used in multivariate statistical analysis made for categorical data.

Such a tool allows a graphic evaluation of the existing relationships between variables and their categories (PRADO, 2012). This analysis presents in a space with two dimensions the correspondence between the categories. Multiple correspondence analysis reduces the size of associations and thus allows a graphic representation with a reduced number of factors (BLISKA, 2018). According to Prado (2012), this analysis presents a representation of columns and rows of the matrix in a geometric way with reduced dimension, where it is possible to observe the relationships between variables and categories. Therefore, this analysis allowed the questionnaires to be evaluated in order to relate the responses of individuals, forming clusters and signaling trends. Also, making better use of the questionnaires results, percentage graphics were obtained using the software R.

For a good interpretation of the MCA results, Bliska (2018) used some rules that were also taken into account in the present work, they are: i) they present a similar distribution to the categories when appear next in the graphic, then, they are associated with each other; ii) in the same way, when the categories, two or more, of the same variable are far from each other, they have different distribution and are inversely associated; iii) there can be grouping and similarity when the categories of

the same variable are close; iv) finally, if there is proximity to the categories of different variables it is because the factor can be explained.

1.3 RESULTS AND DISCUSSIONS

Table 2 shows the number of questionnaires answered, according to the segments established in this study. Therefore, for all subsequent analysis shown in the results, they refer to this answer table.

Table 2 – Questionnaires responses

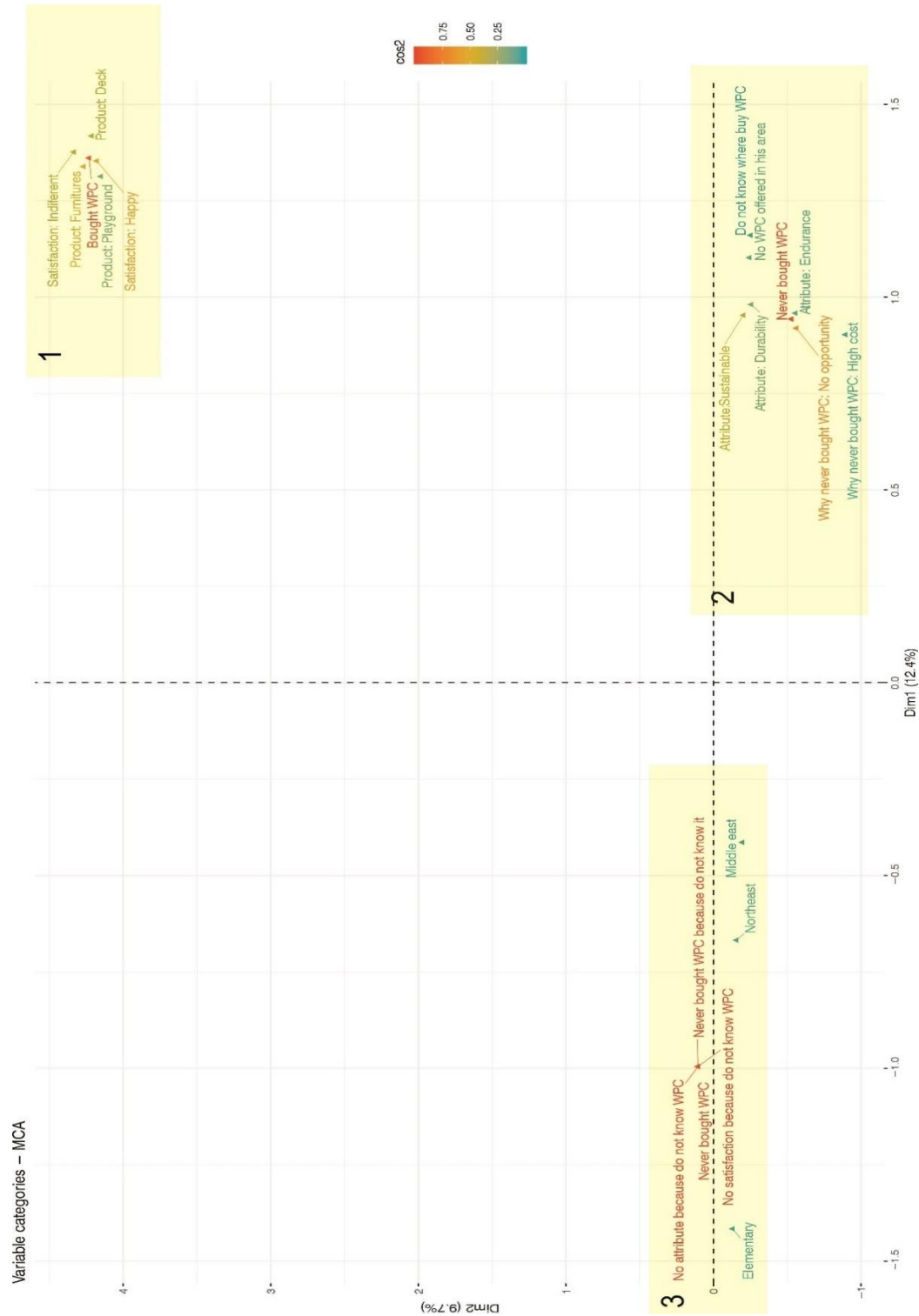
Number of responses for each questionnaire	
General Population	133
Influencers	48
Consumers	44
Researchers	18

1.3.1 General Population

The MCA result obtained by using the R software, when treating the data from the 133 general population responses, is portrayed in graphic 1 with two dimensions. The associations between the categories can be understood according to the proximity of the answers, where those that are closer have a greater correspondence than those that are more distant from each other. The categories that are close to the origin of the axes have low significance among themselves. Thus, the categories in the graphic within the same quadrant have characteristics that are common to each other. (BLISKA, 2018). And based on the points in graphic 1, with the location close to the direction and region of origin in the space, we have the formation of 3 homogeneous clusters, the clusters that were addressed in the following figures.

In the graphic, on the X and Y axes, there is a contribution value of the axis for the variance of each category, that is, the value of how much each variable was explained by the axes considered in the analysis. In graphic 2, the axes account for 22.1% (12.4% + 9.7%) of the total variance. It is also possible to note that the categories that have more reddish color in the graph have greater significance than those with blue color.

Graphic 2 – General Population MCA



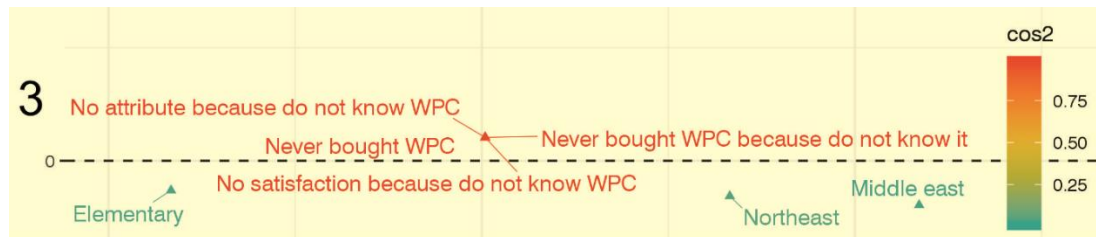
The figure 5 shows cluster 1 formed in the MCA of the general population. Cluster 1 is formed by a profile of people who have already purchased a WPC product. The products purchased were deck, furniture and children's playground and are indifferent or satisfied with the products.

Figure 5 – Clusters 1: General Population

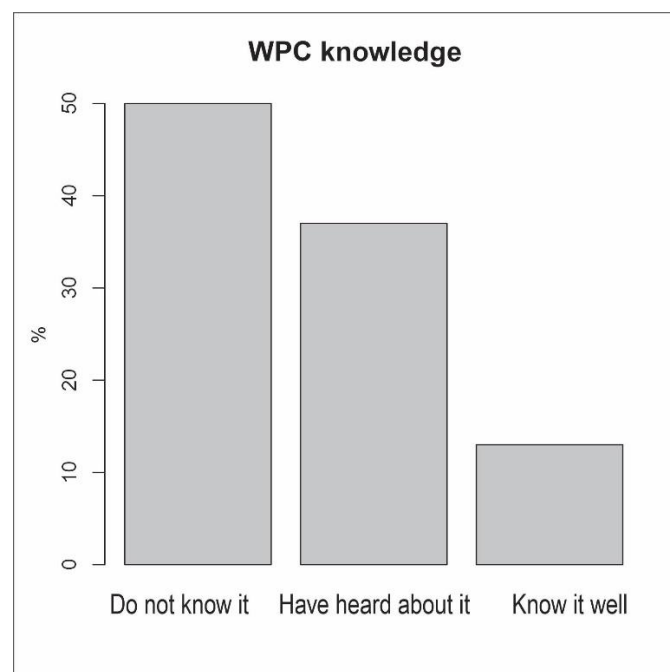
In figure 6, cluster 2 is presented, which is formed by a profile of people who have never purchased a WPC product. The reasons for having never bought is because they have never had the opportunity. They also do not know where they sell this product; there is no product offer in the region or because the product has a high cost. About the attributes, sustainable product was the main one, followed by durability, endurance.

Figure 6 – Clusters 2: General Population

Finally, in figure 7, cluster 3 is made up of a profile of people who have never purchased WPC. A tendency of never buying is because they do not know what it is WPC. For this reason, they could not answer about its attributes or the satisfaction with the product. In this profile, the tendency is to be from the Northeast and Midwest region and have only elementary education.

Figure 7 – Clusters 3: General Population

In addition to MCA, percentage analysis was performed. Thus, when analyzing the population's knowledge about the WPC product, it can be noted that 49.62% of the population does not know the material yet, another 37.60% replied that “have heard about it, but do not know it well”, that means, a value of 87.22% who does not know the material about to have an opinion over WPC. In this case, only a low percentage of the population, 12.78%, knows what WPC is, as it can be seen in graphic 3 below. This result meets the Sebrae study (2014) that the WPC market is still unknown by the general population in Brazil.

Graphic 3 – General Population knowledge about WPC

In graphic 4 below there are also an important information. It shows that most of the population, 47.76%, knew the WPC material through media (internet/social networks) and advertising (magazines/newspapers/television). Followed, respectively,

by the indication of friends and family; and indication of influencer - civil engineer or architect, with 16.42% and 14.93%.

Graphic 4 – How have hear about WPC

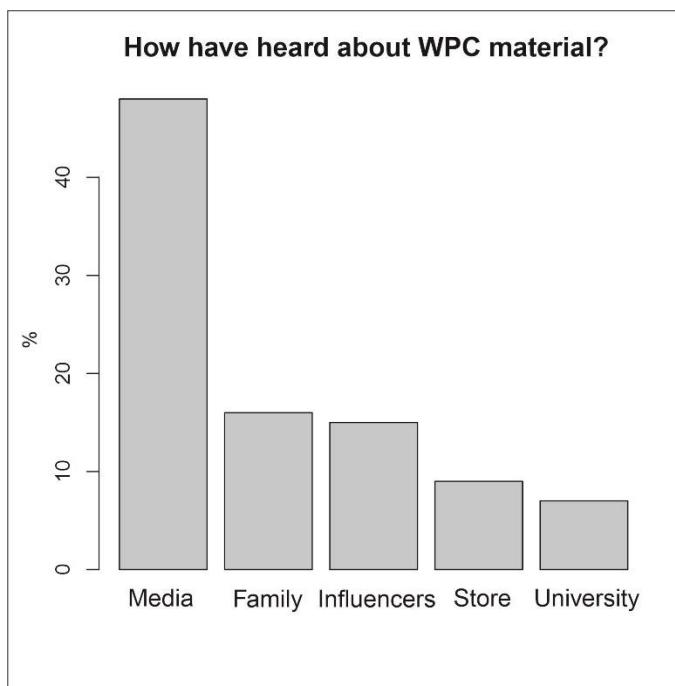


Table 3 shows the main WPC brands in Brazil by social network, it is possible to notice that even brand A with the largest number of followers, still has a low value compared to the comprehensive population in its state of location, which is São Paulo. At the present time, the social networks Instagram and Facebook present themselves as an excellent marketing tool for companies to get closer to their consumers. Whether to promote their or to make direct sales through e-commerce on these platforms.

Table 3 – Followers number by producers in social media

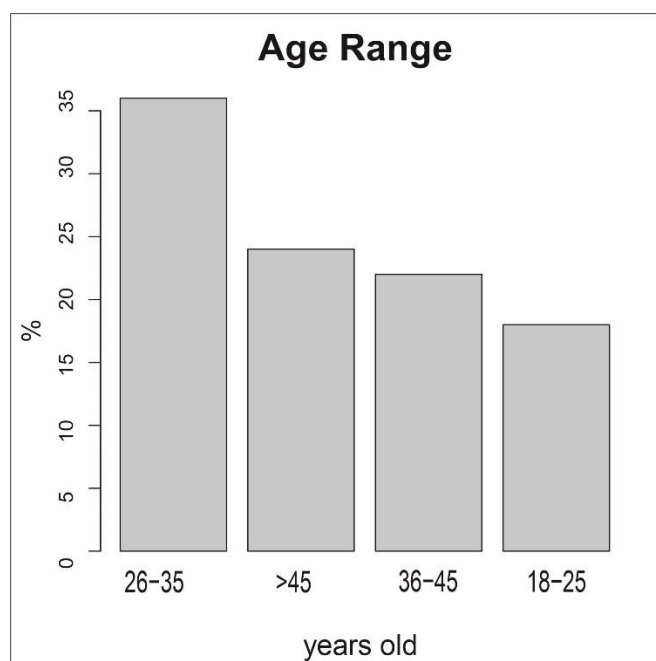
Producer	Instagram	Facebook	Total Followers
Brand A	9.900	24.000	33.900
Brand B	18.000	4.800	22.800
Brand C	12.400	3.600	16.000
Brand D	1.700	2.100	3.800
Brand E	1.400	300	1.700

Source: Prepared by the author. Data from 02/06/2020.

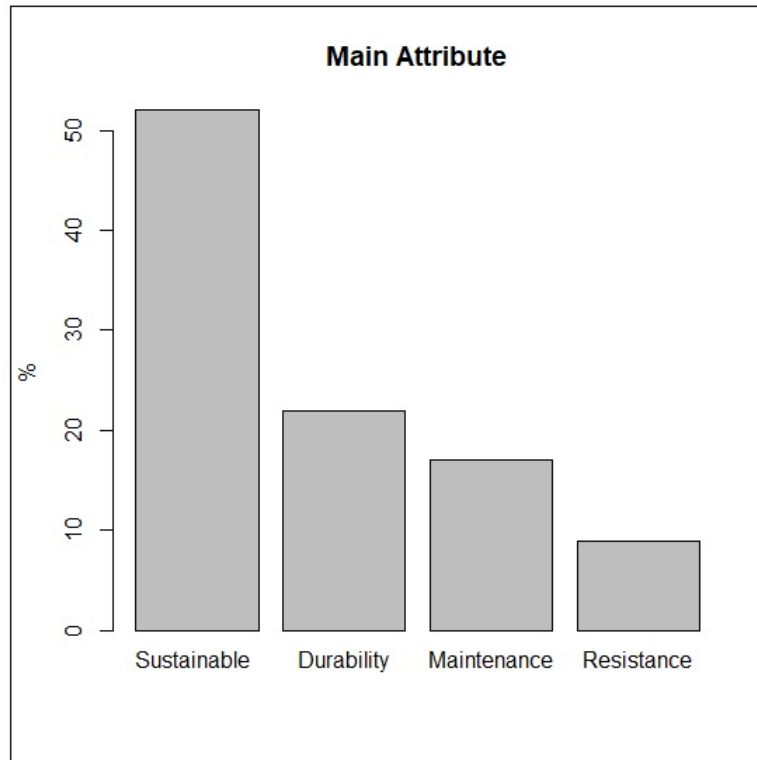
The population that “knows well WPC” and “have heard about it” is mostly between 26 and 35 years, as shown in graphic 5. This fact may be associated with

young people at the moment presenting a greater environmental concern (ROSA; LEONIDIO; JESUS, 2015). Such young people with a profile to buy "green" products, present a greater search for innovations, according to Radons, Battistella and Grohmann (2016). In addition, they have in the media the main way to acquire knowledge, as already shown how they knew about the WPC.

Graphic 5 – Age range of the population that “knows well” and “have heard about”

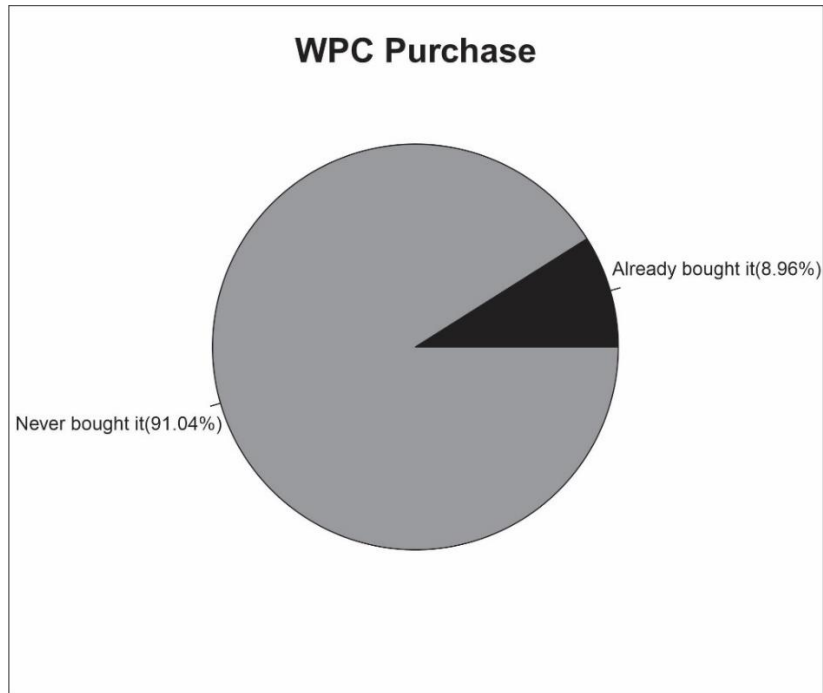


In graphic 6, the general population who answered “know well” or “have heard of it” reports the WPC attribute most important, and "greener" was the most cited. Remembering that in this case, the answer is not associated with WPC product purchased. Even so, it is worth mentioning that this aspect calls the attention of potential consumers. Such attribute can be a differential used in advertising and marketing. Also, the most quoted were the durability of the material, better cost-benefit in maintenance and greater resistance, respectively.

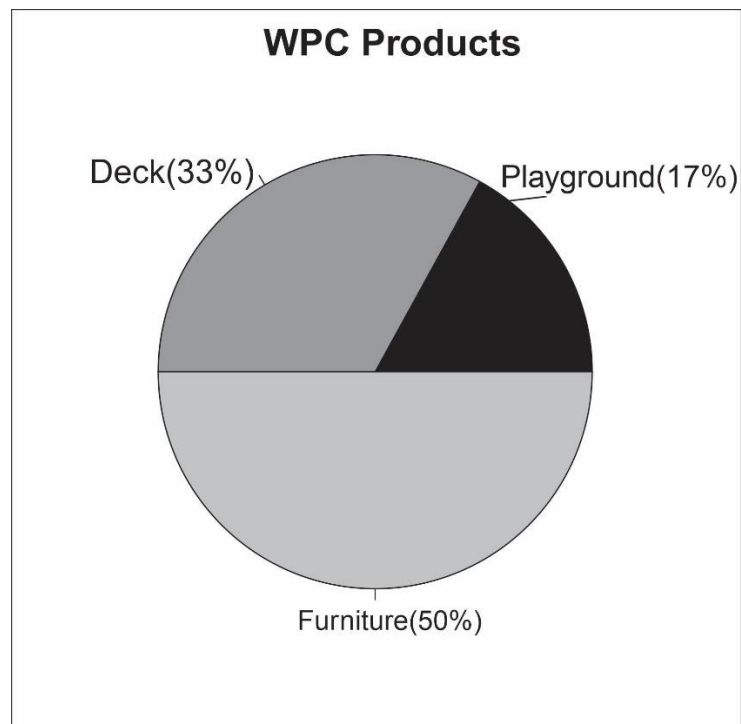
Graphic 6 – Most important WPC attribute

In graphic 7, the data show how many between of the population that answered, “know well” or “have heard about it”, have already bought something produced with WPC. In this case, the graphic informs that the minority 8.96% of the population has already purchased WPC products. That is, 91.04% of those who know WPC, never bought anything from WPC. It may be due to the Brazilian population still does not have the culture of making buildings with decks and pergolas in their homes. From those who said they had already bought, they replied that they bought furniture (benches, trash cans) with 50% and deck, adding 83.33% as observed in graphic 8. The situation is optimistic regarding the market opportunity for WPC products.

Graphic 7 – Percentage of those who have already bought something from WPC among those who answered that they "know it well" or "have heard about it"

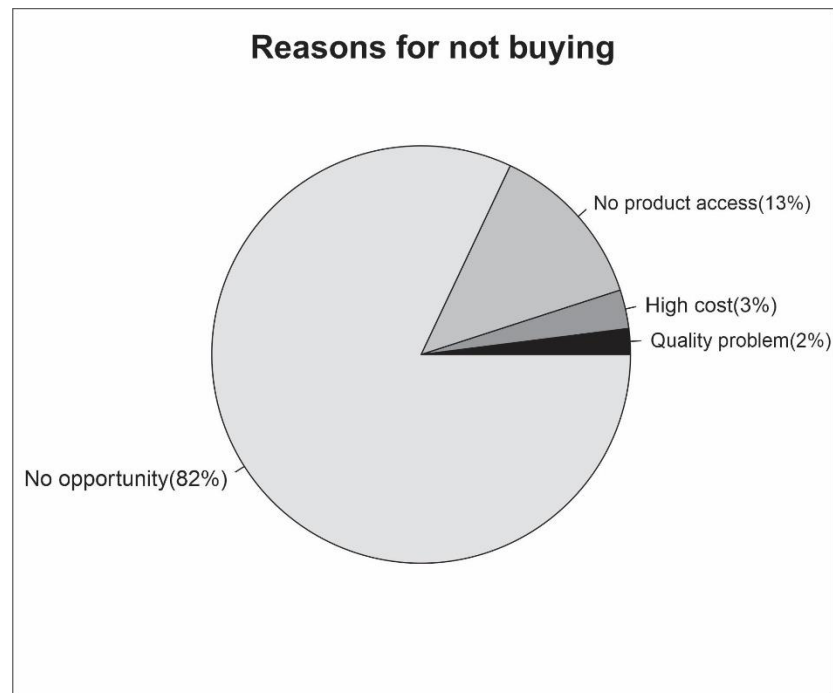


Graphic 8 – Most purchased WPC product



Although many have never bought as seen before, 81.97% have not yet bought because they have not had the opportunity, shown in graphic 9 below. Few mentioned that they have not because of the lack of product supply in the region, because of the price or even because of the lack of quality. It can be highlighted the fact that the deck is not an item yet frequently placed in engineering and architecture projects in Brazil.

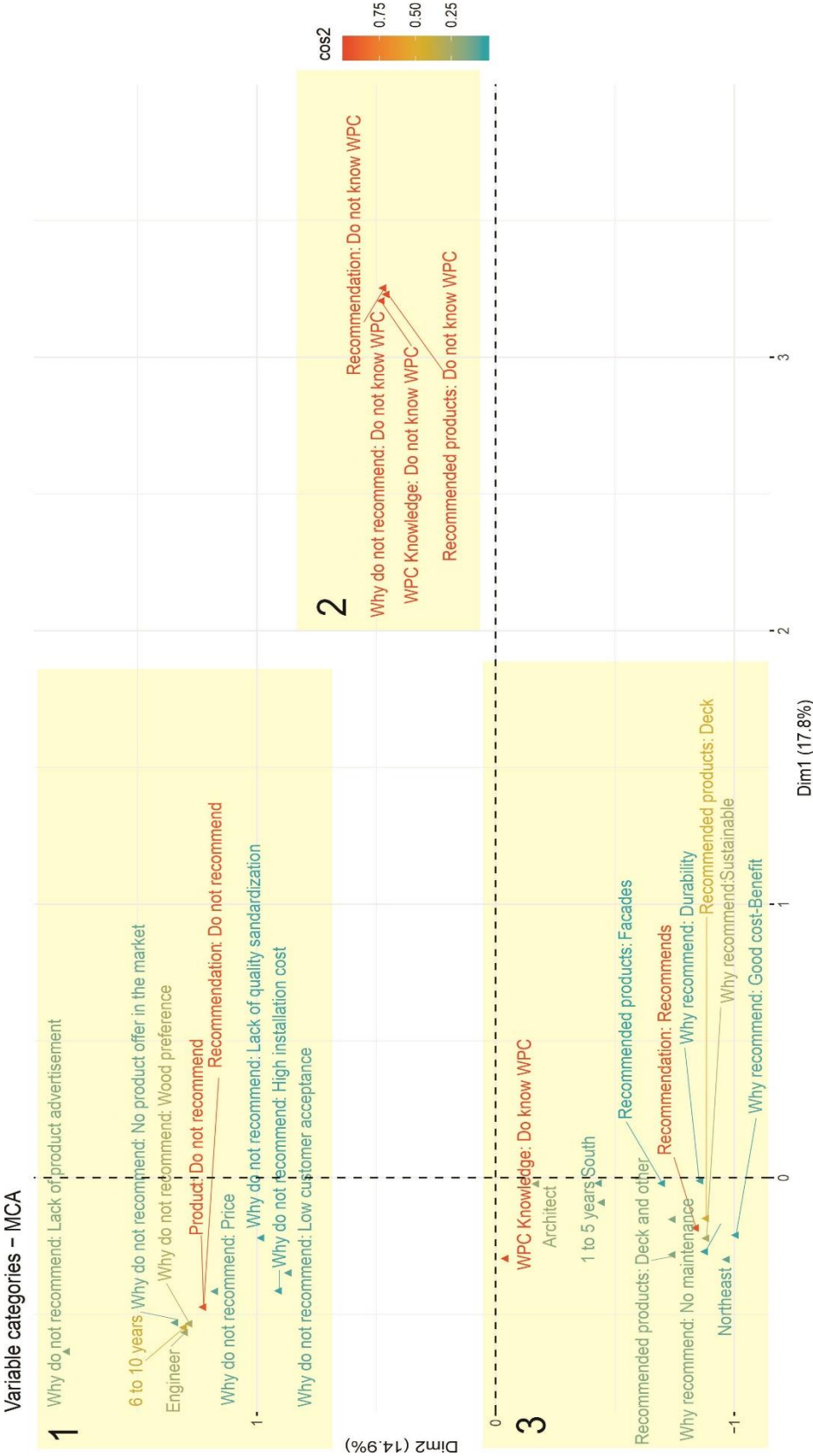
Graphic 9 – Reason about “have never bought a WPC product”



1.3.2 Influencers

The questionnaire was also applied to influencers, professionals in Civil Engineering or Architecture, obtaining 48 responses. Based on these responses, the multiple correspondence analysis was processed and graphic 10 was obtained below. The total variance in the axes account was 32.7% (17.8% + 14.9%). It was also obtained 3 clusters among the influencers that will be discussed in the following graphics.

Graphic 10 – Influencers MCA



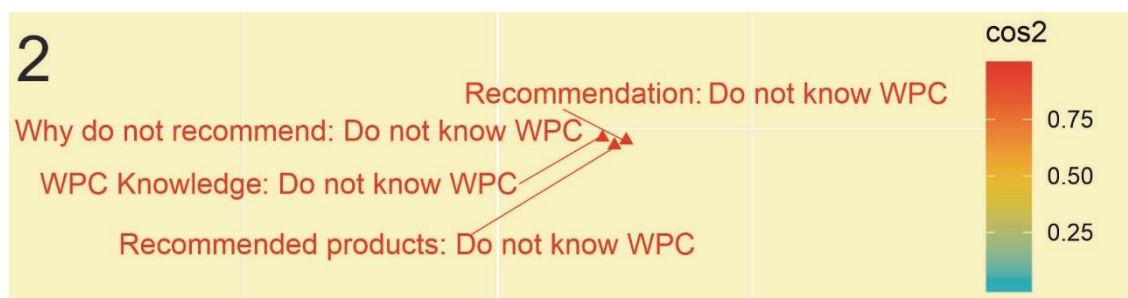
In figure 8, cluster 1 of the influencers is presented, formed by a profile of people who are mostly civil engineers and do not recommend WPC products, so they do not have a specific recommendation product, and tend to have between 6 to 10 years of experience in the construction market. The main reasons cited for not recommending are, in the first place, that they prefer wood instead of WPC; low product offer on the market; price; lack of product standardization and low customer acceptance.

Figure 8 – Cluster 1: Influencers



In the case of cluster 2 of influencers, as shown in figure 9, the group is made up of a people profile who do not know what WPC is and therefore do not recommend any product. A significant cluster because it is red in color and located on the chart far from the center of the axes.

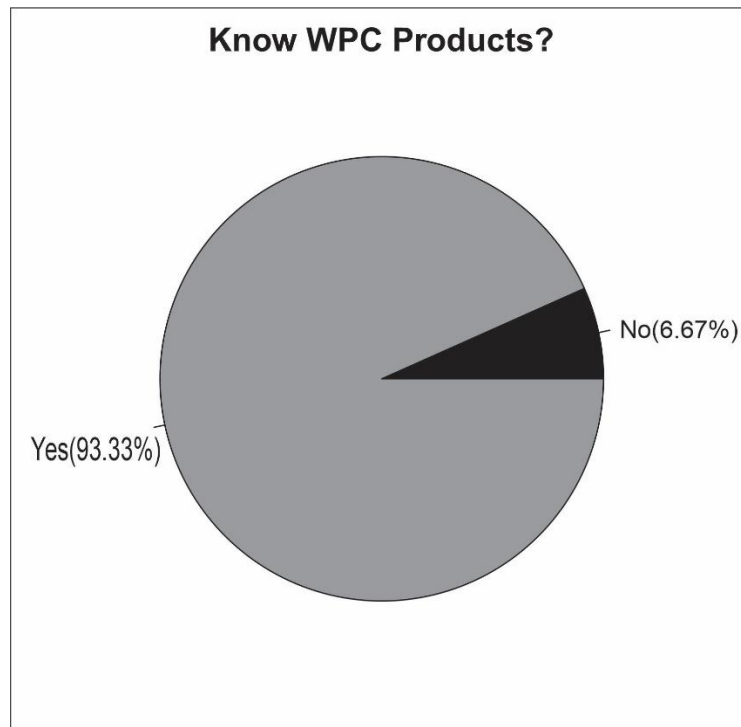
Figure 9 – Cluster 2: Influencers



The last cluster of influencers is the number 3, shown in figure 10 below, formed by a profile of people who know what WPC is, mostly architects, and who recommend the WPC product. The most recommended products by them were deck, followed by facades and others. Reasons for their recommendation are low maintenance, durability, good cost-benefit and sustainable product was more relevant.

Figure 10 – Cluster 3: Influencers

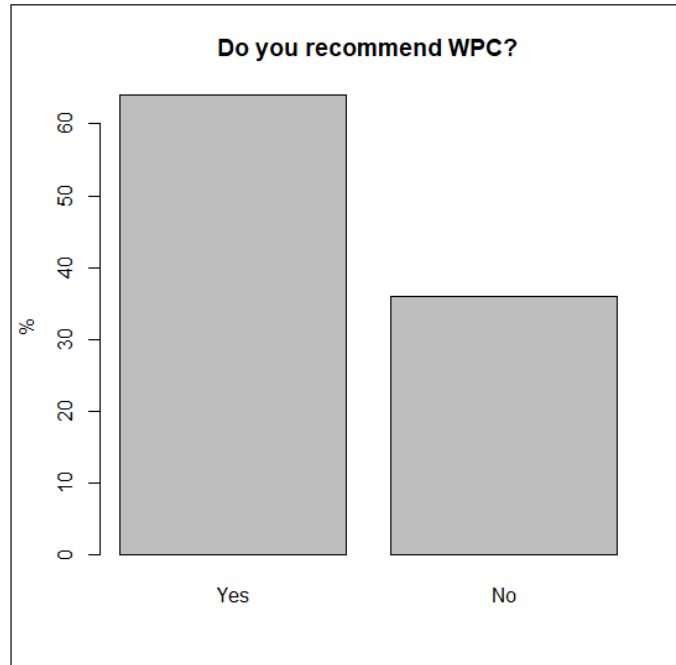
In addition to the MCA, analysis of percentage of responses were also important to enrich this work. It can be observed that in this influencers group, the knowledge of WPC products is higher and greater than the general population; 93.33% of the influencers answered that they knew WPC, and only 6.67% answered that did not have any knowledge, as shown in Graph 11.

Graphic 11 – Knowledge about WPC

In the case of knowledge of the material, the question was if they recommended in their projects the WPC products (deck, pergola, facade, benches). As shown in

graphic 12, it is possible to note that 35.71% of those who know the material, do not recommend WPC products.

Graphic 12 – WPC product recommendation

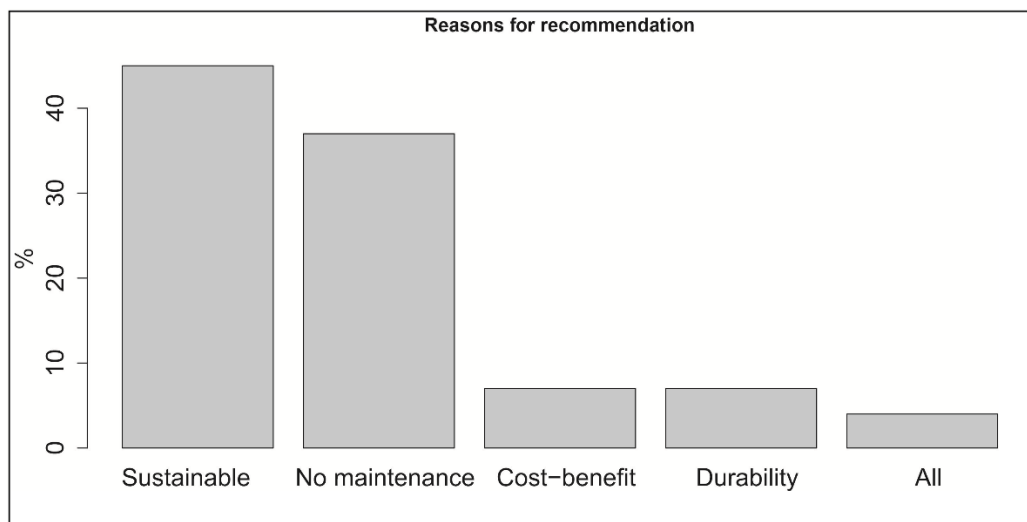


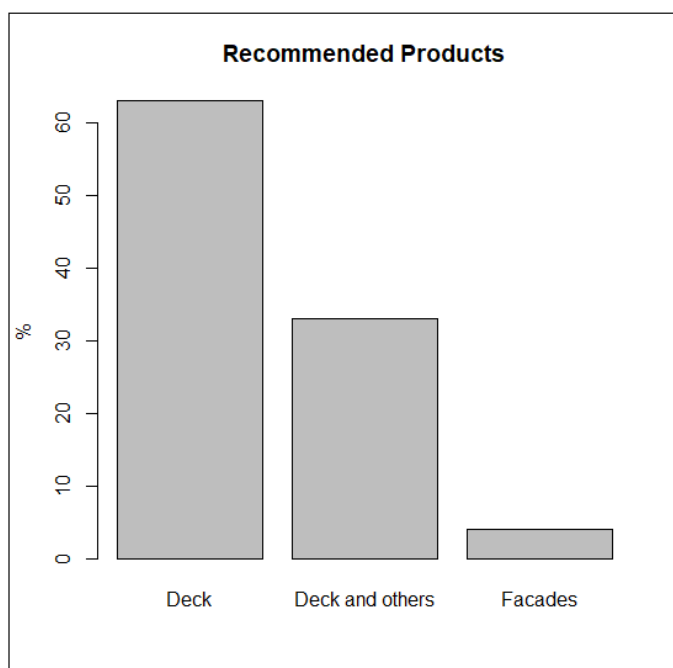
It is also noteworthy that among the Influencers, the ones who most recommend WPC products are the architects, with chances of this answer being since the WPC is not yet technically proven to be effective in structures in the construction area. In Table 4, the χ -square statistical analysis was generated between the answers of architects and engineers regarding the recommendation of WPC products and the result was obtained: χ -squared = 48.505, df = 1, p-value = 3.294e- 12. As the p-value is <0.05, it indicates that there is a difference between the observed and expected values. Therefore, the results between architect and engineer regarding the recommendation are significantly different.

Table 4 – Contingency table: Influencers x Recommendation

Surveys	Do not recommend	Recommend	General Total
Architect	29,73%	70,27%	100,00%
Civil Engineering	80,00%	20,00%	100,00%
General Total	35,71%	64,29%	100,00%

In graphic 13, it found the main reason for influencers to recommend WPC products. They answered that it is because WPC is a sustainable product. Followed by the low maintenance, good cost-benefit and durability. The low maintenance has an impact on the cost because the wooden deck needs more maintenance. In graphic 14, influencers said that the main recommended WPC product was the deck.

Graphic 13 – Main reason for WPC recommendation

Graphic 14 – Products most recommended by Influencers

Influencers were also asked to answer about the WPC brands on the market. Most of them did not know any brandy to quote or do not indicate any specific brand for customers. Of those who cited some, the main brands were Santa Luzia, Rewood, Ecoblock, InBrasil and Ecowood, among others, as shown in table 5.

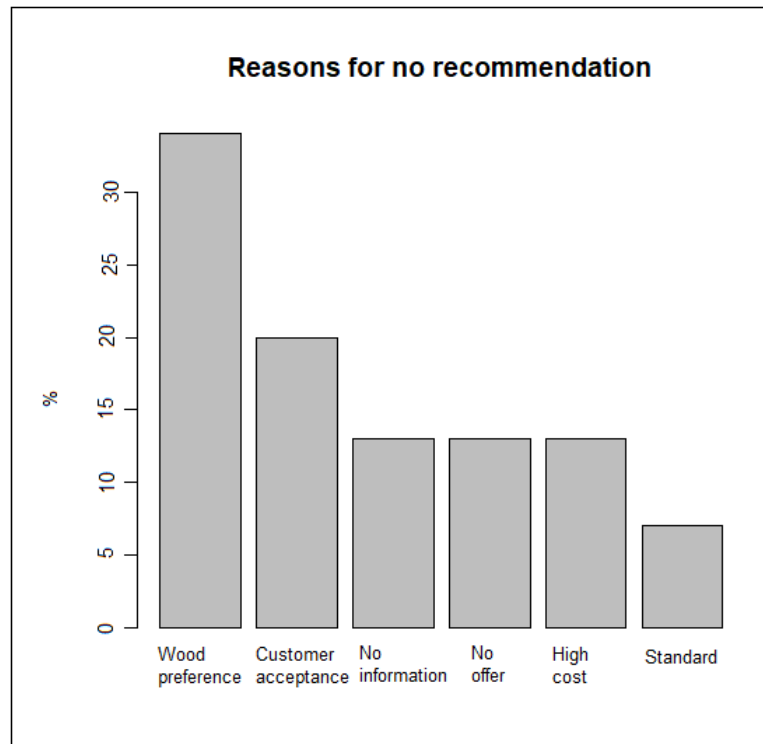
Table 5 – Brands named by Influencers

Brand	%
Do not know any brand	62,96%
Do not indicate any specific brand	7,41%
Santa Luzia	7,41%
Rewood	3,70%
Uniflex	3,70%
Arkowood - Arkos Brasil	3,70%
Ecoblock	3,70%
In Brasil	3,70%
Ecowood	3,70%

For a better understanding, the influencers who answered do not recommend WPC products, explained the reason for not recommending; graphic 15 shows the main reasons. As the graphic points out, the main reason is because they prefer wood products. Followed by the low acceptance of customers, which can be explained to the fact of the low knowledge about WPC products by general population. Lack of

information and product disclosure comes in third place along with low product offerings on the market and high product cost. Finally, they cited the lack of standardization in the product.

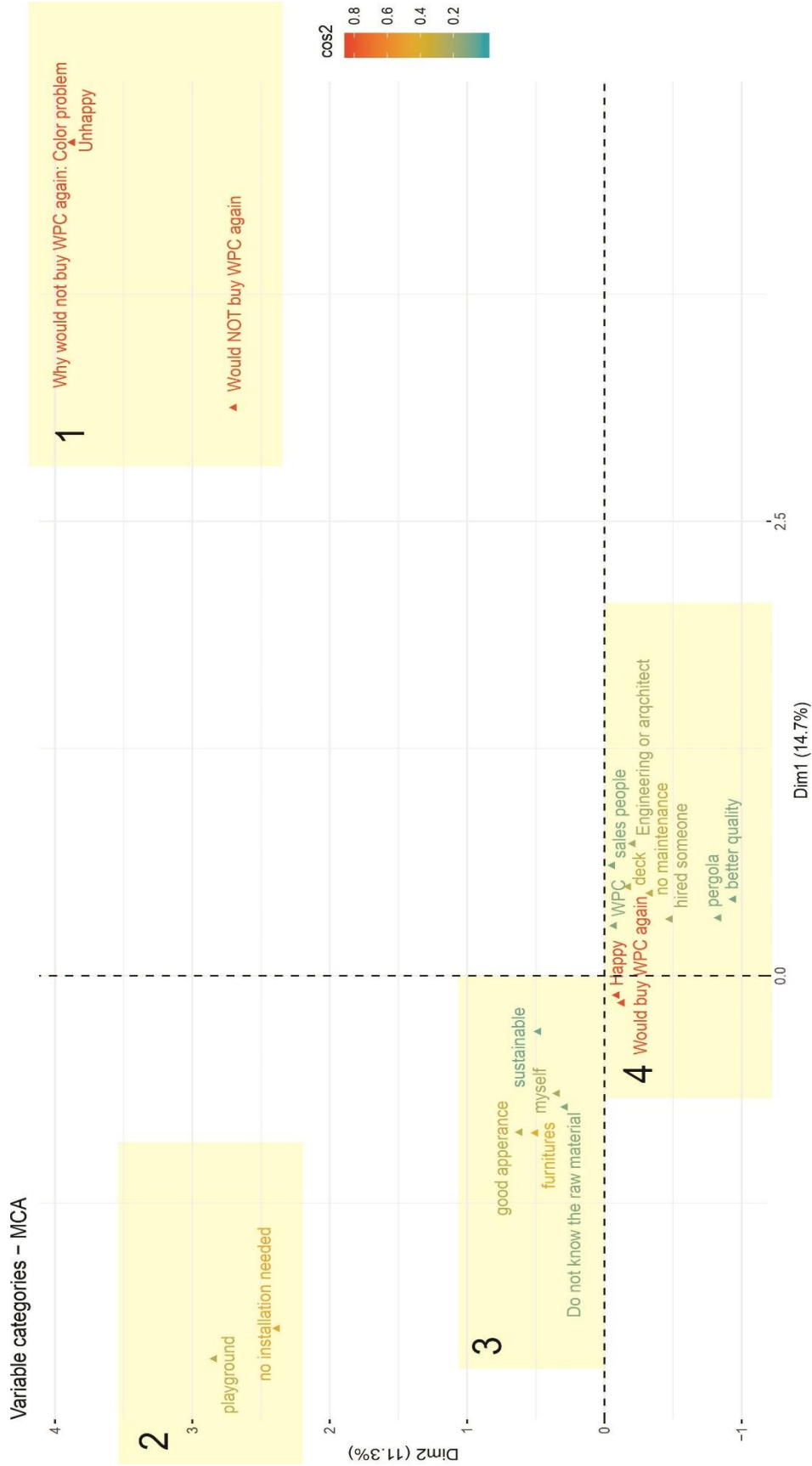
Graphic 15 – Reasons why influencers do not recommend WPC



1.3.3 Consumers

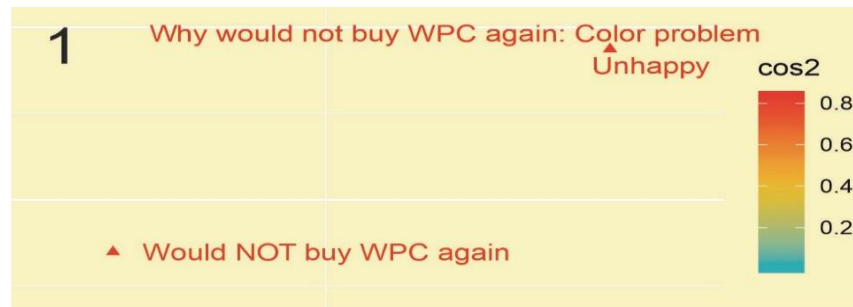
The responses obtained for the consumer questionnaire were 44 responses. Based on these responses, the MCA was performed and the graphic 16 below was obtained. The total variance in the axes account was 26% (14.7% + 11.3%). It was also obtained 4 clusters among the consumers that will be discussed in the following graphics.

Graphic 16 – Consumers MCA



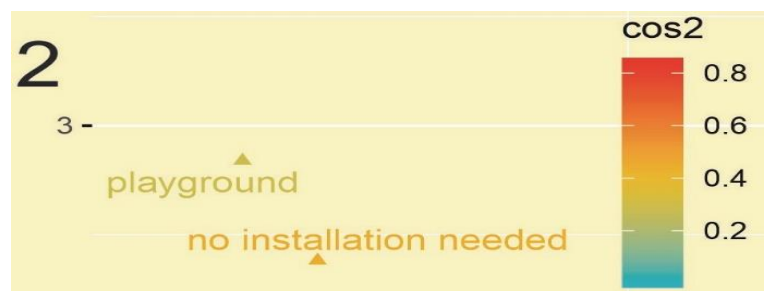
In figure 11 it is possible to observe the Cluster 1 of consumer segment. They are formed by people who bought WPC product but would not buy WPC again. They are unhappy about the product, because of color problems.

Figure 11 – Cluster 1: Consumer



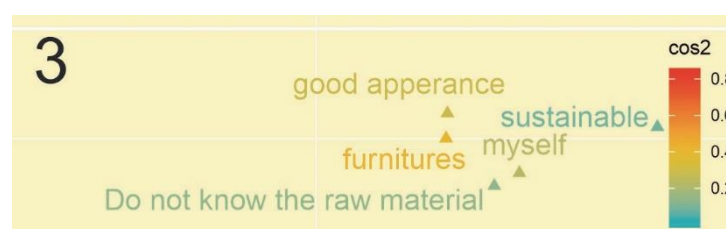
Cluster 2 is shown in figure 12. These consumers bought playground and it was not necessary to install the product.

Figure 12 – Cluster 2: Consumer



Cluster 3 is at figure 13, consumers who are happy with the products answered that bought furniture. The good appearance and sustainable were the attributes most quoted to this cluster. They installed the product their own, and they do not know the raw material of the product, if it was WPC, or just plastic.

Figure 13 – Cluster 3: Consumer



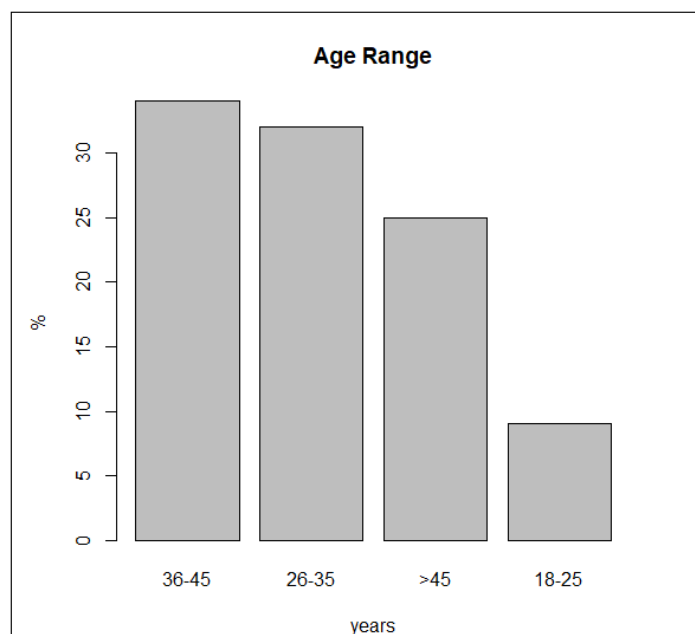
Cluster 4 in figure 14 is about consumers who are happy about the product. They bought WPC products, as deck and pergola. No maintenance and better quality are the most important attributes for them. The installation of the product was made through salespeople or they hired someone to do it. Influencers, engineering and architect were responsible for them to buy WPC product.

Figure 14 – Cluster 4: Consumer



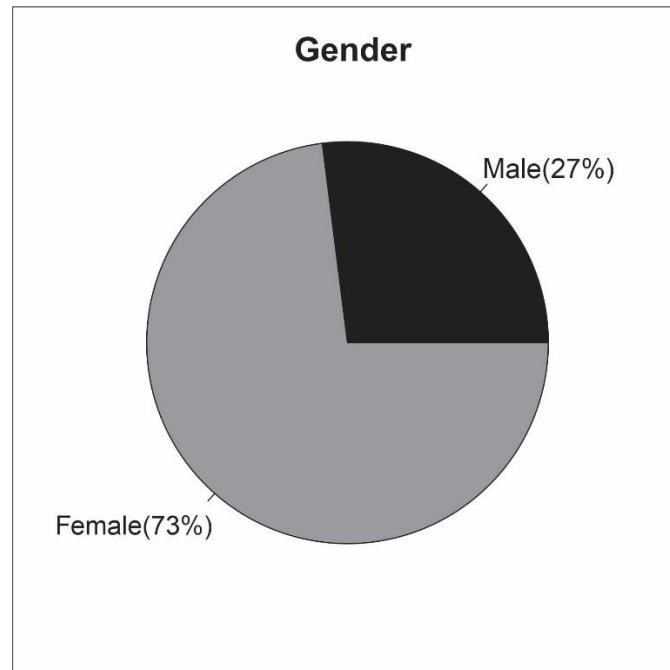
In addition to the MCA, analysis of percentage of responses were also important to enrich this consumers study too. It can be observed that in this segment, the age range of the most of consumers are between 36 to 45 years old and 26 to 35 years old, as shown in graphic 17. That can be explained once this age is usually the time of life where people used to build or reform houses, or buy furniture, once these are the products that this segment quoted in the survey.

Graphic 17 – Age range of consumers

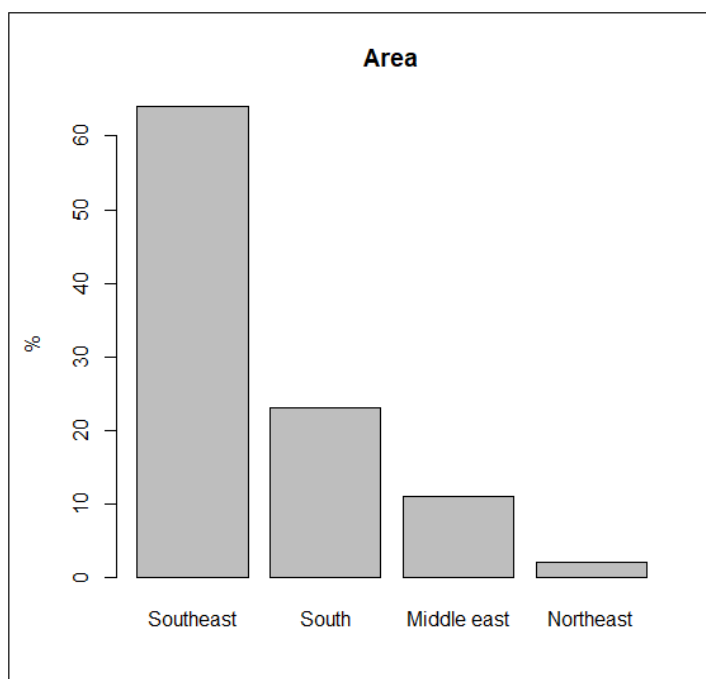


About the gender of the consumers, the graphic 18 demonstrate that women are the main consumers of WPC products, with 73% of the survey participants. Weinfurter and Eder (2009) also concluded in their study that women were the most important clients of green products.

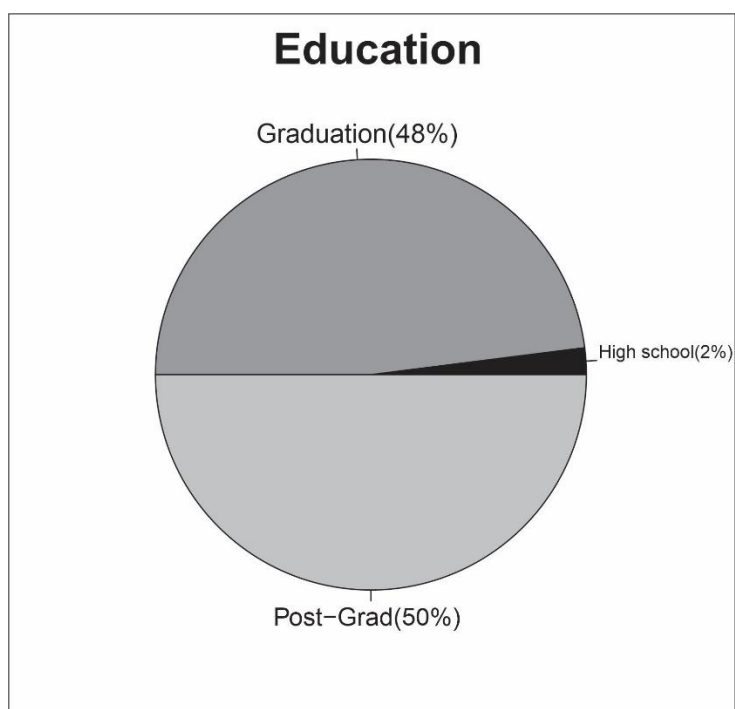
Graphic 18 – Gender of consumers



The consumers of WPC products are located at southeast and south area of Brazil, in a total of 87%, graphic 19. This can be explained because the WPC producers are also located in the same area. Consumers at this Brazilian location may be opener to try new technologies and products than others.

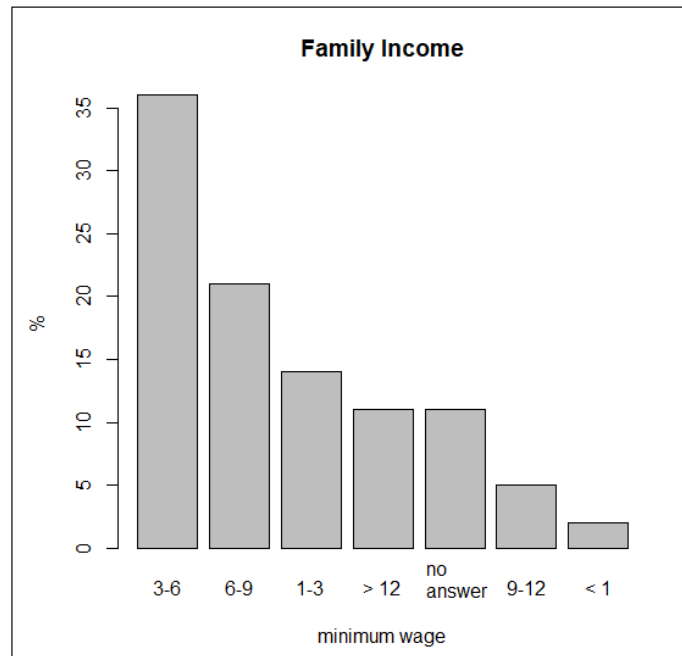
Graphic 19 – Location of consumers in Brazil area

The graphic 20 shows the WPC consumers education. According to the responses, consumers have a high level of education. This may be due to greater access to information and knowledge of the material's benefits. Half of consumers presented a post-graduation.

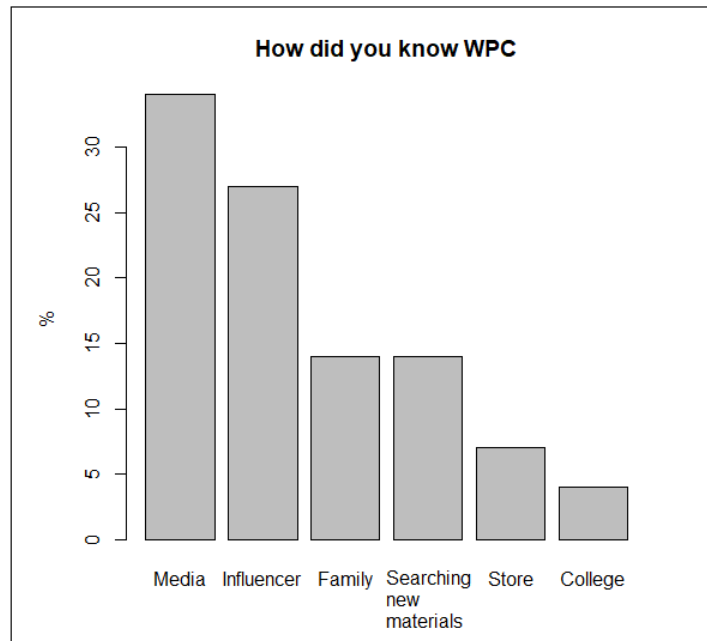
Graphic 20 – Consumers education

In graphic 21 it is noted the family income of WPC consumers. Between 3 – 6 and 6 – 9 minimum wage were the main quoted.

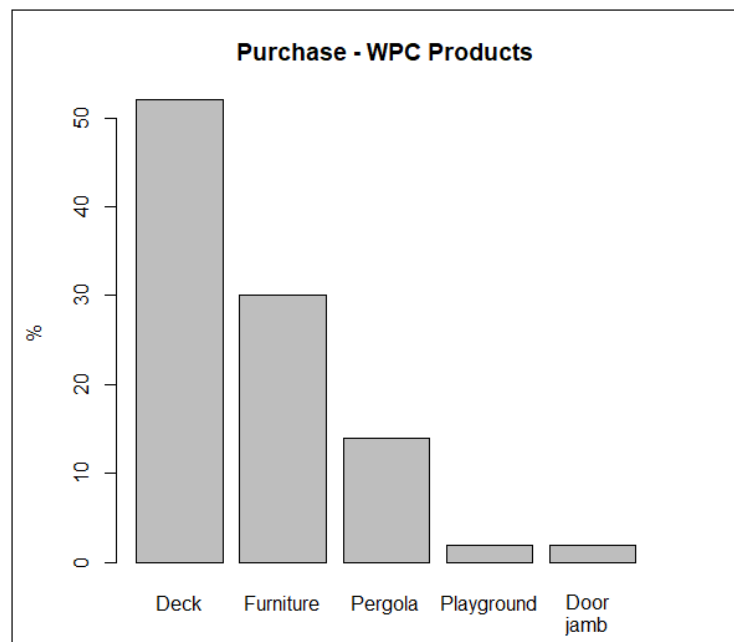
Graphic 21 – Consumers family income



Consumers answered about how they knew the WPC product and as shown in graphic 22, media and influencers (engineering and architect) were the ways most quoted, with 61%. Media as general population was the main way. That means this is a good alternative to producers to divulgate the WPC products. Influencers are an important segment that these WPC producers can work together. Engineering and architects can really influence this market.

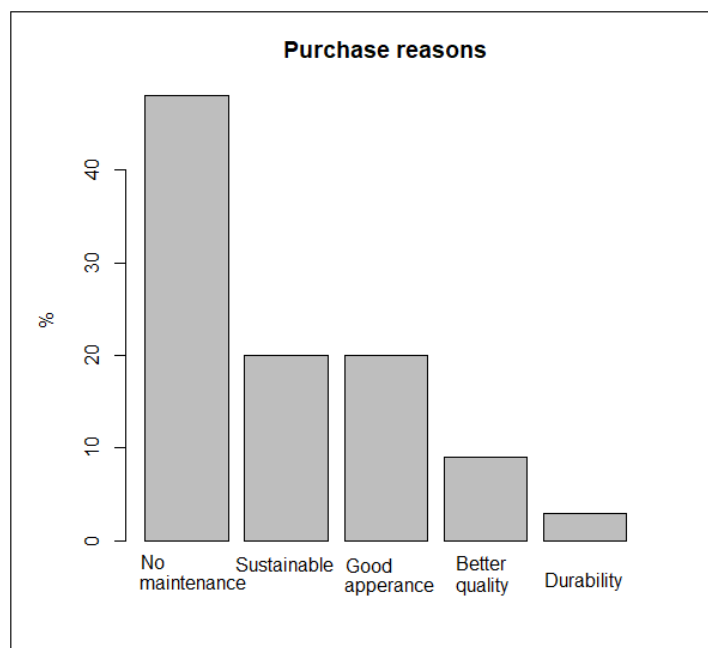
Graphic 22 – How did you know about WPC product?

Deck was the product most bought by consumers, followed by furniture, that means 82%, as possible to read in graphic 23. Furniture, as trash, bench, etc. are products that can become a good market for WPC material. It is cheaper than deck and more people can buy, once the deck, only those who are building house can do it.

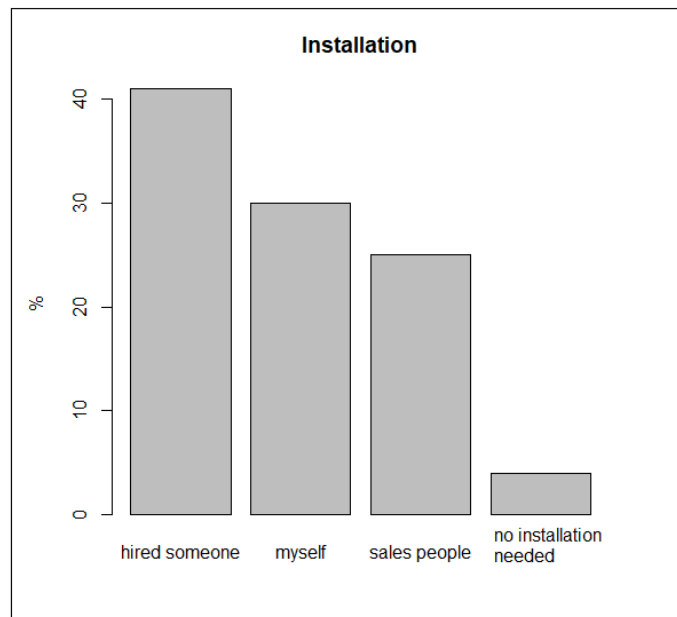
Graphic 23 – Product that bought

Graphic 24 shows the attributes that were the reasons for the WPC purchase. About that, no maintenance was the main attribute, followed by sustainable and good appearance. Better quality and durability were also answered. No maintenance is a reason that WPC can be cost-effective compared to natural wood products.

Graphic 24 – Why did you buy WPC?



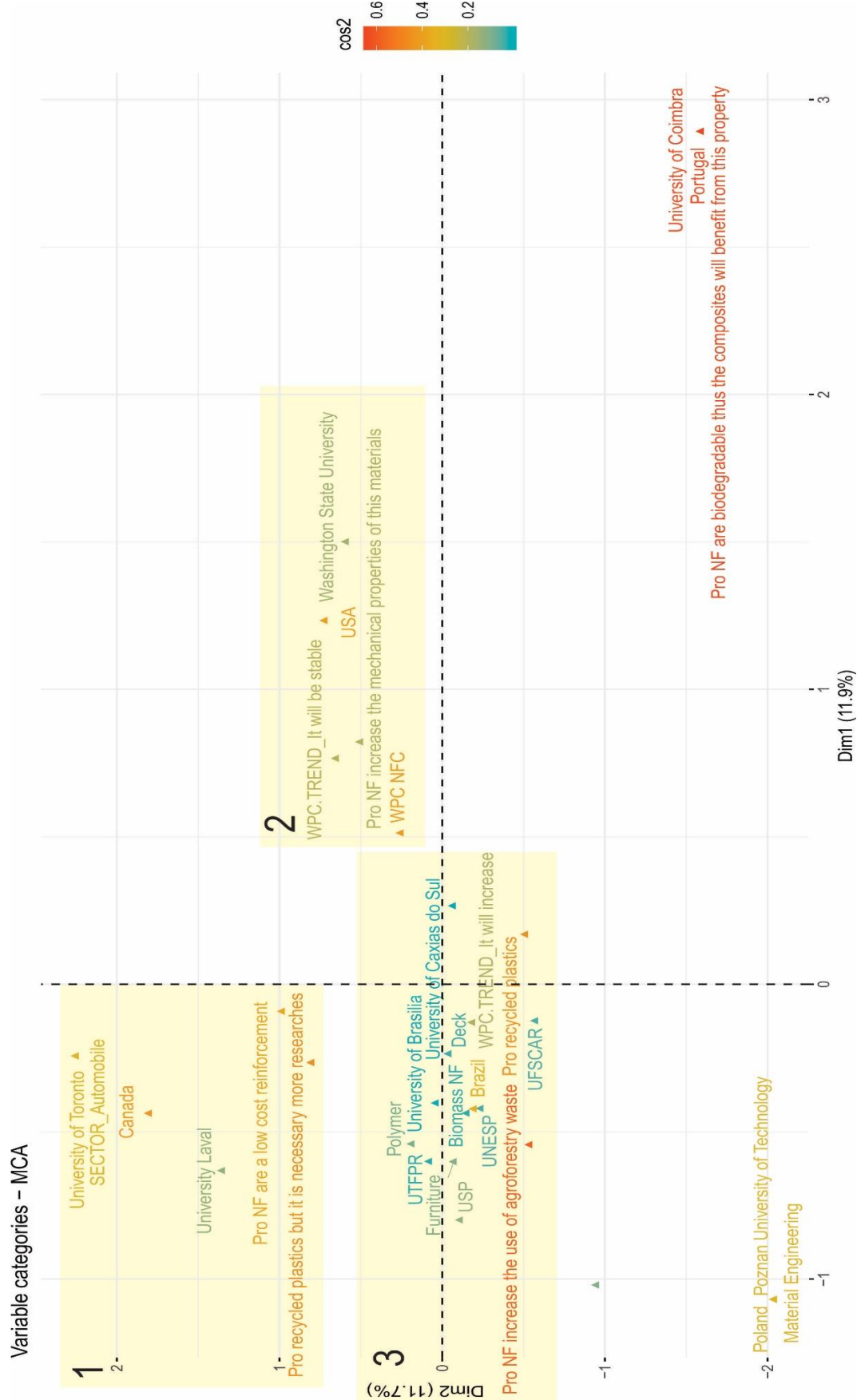
The graphic 25 shows that the consumers participants needed to hire someone to install the WPC product. This is also the way wood products are installed, so both products need a skilled labor and have an installation cost. The following answered was installation by consumer himself. That kind of installation is one of the most used in USA, the DIY (do it yourself), where the customer buys the product in the store and install. Brazilian market can also become important in this DIY segment.

Graphic 25 – How did you install the product?

1.3.4 Researchers

The responses obtained for the researchers' segment were 18 responses, from Brazil and abroad. Based on these responses, the MCA was performed and the graphic 26 below was obtained. The total variance in the axes account was 23.6% (11.9% + 11.7%). It was also obtained 3 different clusters among them that will be discussed in the following graphics. Cluster number 3 is close to the axis has low correspondence than cluster number 1 and 2.

Graphic 26 – Researchers MCA



The cluster 1, as shown in figure 15, is formed by the researchers' survey represent the researchers from Canada who are pro-natural fibers in the composites. They believe natural fibers are a low-cost reinforcement, and they are also pro-recycled plastics usage in the composites, but it is necessary more data to conclude their efficiency. This cluster answered the most promising sector for WPC material is the automobile.

Figure 15 – Cluster 1: Researchers



The figure 16 with cluster 2 was a resulted of researchers from USA. Their field of study is wood-plastic composites/natural fibers composites. They think the WPC market will be stable in the future, and they are also pro-natural fibers, because the mechanical properties of the material can be better.

Figure 16 – Cluster 2: Researchers



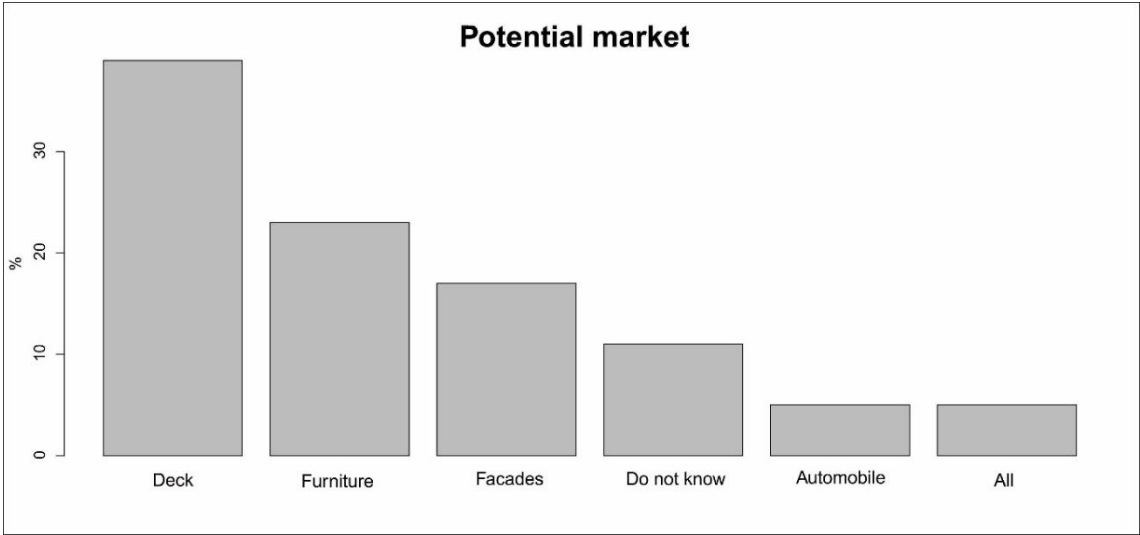
The cluster 3, presented in figure 17, the researchers are Brazilian. The participants were from polymer field study and biomass/natural fiber. Their opinion about the WPC market is that will increase, mostly in deck and furniture products sectors. All of them are in favour of the natural fibers in composites, because this can increase the usage of agroforestry waste. The researchers are also pro-recycled plastics to produce WPC.

Figure 17 – Cluster 3: Researches

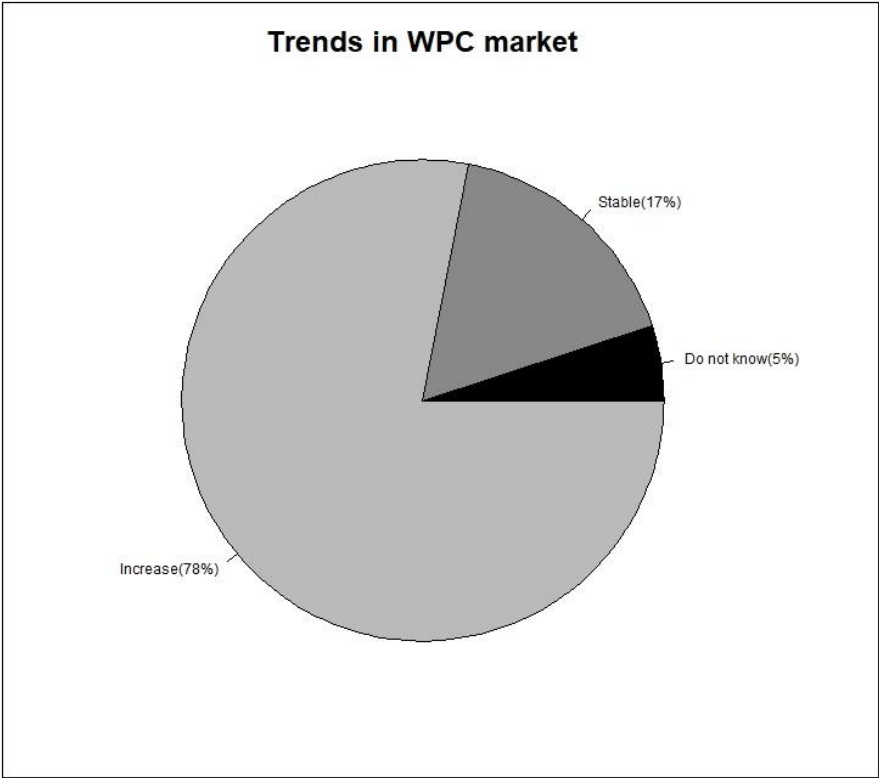


The percentage analyses below in graphic 27 and 28 show the potential market according to the researchers in this survey and their opinion about the WPC future. Deck and furniture were the products most quoted. This answer is linked to the general population and consumers answer too. None of them answered about a decrease of market in the future, 78% of them believe in market growth.

Graphic 27 – Products with potential market growth



Graphic 28 – Trends in WPC market



1.4 CONCLUSIONS

Finally, the Brazilian WPC market has some challenges to overcome. Such as making WPC material known to society, once the most part of population showed to know nothing about WPC material. Also, the WPC industry and sellers need to invest more in advertising and marketing, as media appeared as the main way general people and consumers have heard about WPC. To gain the confidence of engineers; architects have already been the influencer of WPC products in the market. Any brand is the “top of mind” in WPC market, so producers can work on that, and be closer to influencers. Consumers are the most female, have graduation at least in their education, and are in southeast area. That can mean, a need of more investment in media (social media, internet, TV, magazines, *etc.*) to access other social classes and other Brazilian region. The sustainability and no maintenance as the main attributes can be used in the market, once these are the most important advantage of WPC material. Make raw material information clear to consumers so that they can compare products; increase the number of research and studies that support investments.

However, there is a huge prospect of growth and many opportunities in this market, the Brazilian population still does not know the material, and between those who know it have not yet bought WPC products due to lack of opportunity. Furnitures showed a good opportunity of development in WPC market. The Brazilian government and companies, tend to be increasingly demanded to promote sustainability and to execute a circular economy and non-linear, thus creating opportunities for WPC products.

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APPENDICES

APPENDIX A – General Population Survey

GENERAL POPULATION SURVEY									
PART 1 - Acceptance									
Do you wish to participate? ☐ Yes ☐ No									
PART 2 - Questions									
1. Age	☐ 18-25 y. old	☐ 26-35 y. old	☐ 36-45 y. old	☐ > 45 y. old					
2. Sex	☐ Female	☐ Male	☐ Prefer not to answer						
3. School level	☐ Elementary School	☐ High School	☐ College Education	☐ Post-graduation	☐ Other (opened answer)				
4. Family Income	☐ until 1 min. sal.	☐ 1 to 3 min. sal.	☐ 3 to 6 min. sal.	☐ 6 to 9 min. sal.	☐ 9 to 12 min. sal.	☐ > 12 min. sal.	☐ Prefer not to answer		
5. Region of residence	☐ South	☐ Southeast	☐ Central-west	☐ North	☐ Northeast				
6. Do you know what is WPC?	☐ Yes, I know it well	☐ Have heard about it, but not know well	☐ No, I don't know						
PART 3 - Know well or have heard about it									
7. How did you know WPC?	☐ Indication of engineering/architect	☐ Indication of friends/family	☐ Media	☐ Supply store	☐ Other (opened answer)				
8. Which attribute did you like the most?	☐ Resistance	☐ Durability	☐ Sustainable	☐ Best cost-benefit					
9. Have you already bought any WPC product?	☐ Yes	☐ No							
PART 4 - Yes, I bought something									
10. Which product did you buy?	☐ Deck	☐ Furniture (bench/garbage)	☐ Facade	☐ Pergola	☐ Other (opened answer)				
11. Satisfaction level	☐ Pleased	☐ Indifferent	☐ Unhappy						
PART 5 - I didn't buy anything									
12. What is the reason to not buy?	☐ I didn't have opportunity	☐ High cost	☐ No offer in my region	☐ Other (opened answer)					
PART 6 - What is the WPC material?									
☐ WPC is the result of a mixture between plastic and wood (natural fiber) with higher attributes.									

APPENDIX B – Influencers Survey

INFLUENCERS SURVEY					
PART 1 - Acceptance Do you wish to participate? ☐ Yes ☐ No					
SEÇÃO 2 - Questions					
1. Education	☐ Civil Engineering	☐ Architect	☐ Other (opened answer)		
2. How long do you work in this area?	☐ 1-5 years	☐ 6-10 years	☐ 11-15 years	☐ 16-25 years	☐ > 25 years
3. Region of residence	☐ South	☐ Southeast	☐ Central-west	☐ North	☐ Northeast
4. Do you know WPC?	☐ Yes	☐ No (follow to part 6)			
PART 3 - Know the product 5. Do you recommend WPC products? ☐ Yes ☐ No					
PART 4 - Recommend WPC products					
6. What is the reason to recommend WPC?	☐ Appearance	☐ Durability	☐ Low maintenance	☐ Best cost-benefit	☐ Sustainable ☐ Other (opened answer)
7. Which products do you recommend?	☐ Deck	☐ Furniture (bench/ garbage)	☐ Facade	☐ Pergola	☐ Other (opened answer)
8. Can you name a brand that you recommend?	☐ Opened answer				
PART 5 -Do not recommend WPC					
6. Whats is the reason to not recommend WPC?	☐ High cost to install	☐ Prefer wood	☐ Lack of standardization in product quality	☐ No offer in my region	☐ Low customer acceptance ☐ Other (opened answer)
PART 6 - What is the WPC material? ☐ WPC is the result of a mixture between plastic and wood (natural fiber) with higher attributes.					

APPENDIX C – Consumer Survey

CONSUMER SURVEY									
PART 1 - Acceptance									
Do you wish to participate? ☐ Yes ☐ No									
PART 2 - Questions									
1. Age	☐ 18-25 y. old	☐ 26-35 y. old	☐ 36-45 y. old	☐ > 45 y. old					
2. Sex	☐ Female	☐ Male	☐ Prefer not to answer						
3. School level	☐ Elementary School	☐ High School	☐ College Education	☐ Post-graduation	☐ Other (opened answer)				
4. Family Income	☐ until 1 min. sal.	☐ 1 to 3 min. sal.	☐ 3 to 6 min. sal.	☐ 6 to 9 min. sal.	☐ 9 to 12 min. sal.	☐ > 12 min. sal.	Prefer not to answer		
5. Region of residence	☐ South	☐ Southeast	☐ Central-west	☐ North	☐ Northeast				
6. How did you know WPC?	☐ Indication of engineering/architect	☐ Indication of friends/family	☐ Media	☐ Supply store	☐ Other (opened answer)				
7. Why did you purchase the WPC product?	☐ Sustainable	☐ Low/no maintenance	☐ Better quality	☐ Apperance	☐ Other (opened answer)				
8. Which product did you buy?	☐ Deck	☐ Facade	☐ Pergola	☐ Furniture	☐ Other (opened answer)				
9. Who did install the product?	☐ Hired someone	☐ Salespeople	☐ myself	☐ Other (opened answer)					
10. Satisfaction	☐ Happy	☐ Indiferent	☐ Unhappy						
11. Would you buy another WPC product?	☐ Yes	☐ No							
PART 3 - No									
12. Why would not buy WPC again?	☐ No after sales assitance	☐ Low quality	☐ Expensive product	☐ Other (opened answer)					

APPENDIX D – Researchers Survey

RESEARCHERS SURVEY					
PART 1 - Acceptance					
Do you wish to participate?	☐ Yes	☐ No			
PART 2 - Questions					
1. University or Institution	opened answer				
2. Country					
3. Research area	☐ Natural fiber/Biomass	☐ Polymers	☐ WPC/NFC	☐ Circular economy	☐ Other (opened answer)
4. How long have you been working in this area?	☐ 0-5 years	☐ 6-10 years	☐ 11-15 years	☐ 16-20 years	☐ more than 20 years
5. Do you the WPC material?	☐ Yes (follow to part 3)		☐ No		
PART 3 - Yes					
7. What is your opinion about WPC?	opened answer				
8. What is your opinion about the usage of natural fibers in the composites production?	☐ I agree, it can improve the mechanical properties	☐ I agree, it is a cheaper reinforcement	☐ possibilities the usage of agroforestry waste	☐ I am against	
9. What is your opinion about plastic waste to produce WPC?	☐ I am for it	☐ I am for it, but it needs more searches	☐ I am against	☐ other (opened answer)	
10. Which sector do you think WPC can have success?	☐ deck	☐ pergola	☐ furniture	☐ automobiles	☐ other (opened answer)
11. What is your opinion about the future WPC market?	☐ growth	☐ stable	☐ reduction	☐ I do not know	

APPENDIX E – Approval of research from the Ethical Committee in Scientific Research

Ethical Committee in Scientific Research from Medical School in Botucatu - UNESP

Research Project Data

Research Title: WPC MARKET ANALYSIS IN BRAZIL
Researcher: MIRELA BERTIN CARNIETTO
Version: 4
CAAE: 08073019.9.0000.5411
Proposing Institution: Botucatu Campus – Agriculture School
Main Sponsor: Ministry of Science, Technology and Innovations

Approval Data

Approval Number: 4.048.215

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CAPÍTULO 2 - ANÁLISE ECONÔMICA DO *WOOD-PLASTIC COMPOSITES*

2.1 INTRODUÇÃO

Problemas ambientais tem sido causado ao longo do tempo pelo consumo desenfreado de energias de fontes fósseis para produção de bens de consumo e diversos outros materiais. O aumento crescente da população mundial associada ao grande consumo de produtos e a geração de resíduos sólidos surgem como um desafio a ser solucionado. Atualmente, as cidades utilizam quase dois terços da energia global e produz 80% da emissão de gás estufa e 50% de resíduos global. A economia circular aparece nesse cenário para promover uma resposta política para lidar com esses desafios e impulsionar o crescimento econômico, o emprego e a qualidade ambiental (OECD, 2019).

A economia circular tem impulsionado o desenvolvimento de produtos inovadores, que surgem a partir do uso de resíduos, e fontes renováveis de energia (FUNDAÇÃO ELLEN MACARTHUR, 2020). Nesse sentido, o *Wood-Plastic Composites* (WPC) mostra-se como um desse tipo de produto, que tem sido estudado em muitos países. O WPC é um compósito produzido através da mistura de uma matriz polimérica e uma fibra natural, no caso, a madeira. Ambos podem ser resíduos provenientes de outras cadeias produtivas, como o plástico ou o pó-de-madeira.

Além do aspecto ecológico e sustentável do uso de resíduos agroflorestais em sua produção, o uso de fibras naturais traz inúmeros benefícios aos compósitos, dentre eles, uma melhora nas propriedades mecânicas do material; baixo custo de produção; produto final mais leve; entre outros (KESKISAARI; KARKI, 2018).

Outro aspecto do WPC é a utilização de resíduo plástico em sua produção. O resíduo plástico descartado de forma incorreta é uma enorme barreira a ser vencida mundialmente. Porém ao passar pela cadeia de reciclagem e ser inserido em uma nova cadeia produtiva, ganha novo valor, gera emprego e possibilita novas oportunidades de investimentos. No Brasil, a Política Nacional de Resíduos Sólidos (PNRS) de 2010 tem alavancado a coleta seletiva nos municípios, além de promover a logística reversa na cadeia de diversos materiais (ZANIN; MANCINI, 2015).

O WPC tem sido produzido principalmente pelos Estados Unidos, China e Europa, com relevância para a Alemanha (DAMMER et al., 2013). Segundo Dammer

et al. (2013) na América do Sul havia 10 fabricantes em 2013, mas nesse estudo, em 2020, foi levantado que somente no Brasil o número é de 23 fabricantes. Porém, apesar de tal crescimento o produto WPC ainda segue sendo desconhecido pela população brasileira, segundo estudo do Sebrae (2014).

Trigueiro e Bocardi (2012) reportaram que fabricantes de WPC no Brasil acreditam que mesmo que o preço do WPC ao redor de 30% mais elevado do que a madeira natural, pode haver um aumento no mercado, desde que a produção aumente, conforme economia de escala. Guimarães (2013) depois de citar várias vantagens do produto de WPC, também apresentou o impasse do alto custo inicial em relação a madeira natural.

Porém, investidores necessitam conhecer o material e entender que é um mercado potencial para investimento. Além disso, para que haja sucesso desse investimento, estudos envolvendo análise econômica tornam-se necessários. Pois fornecerá ao investidor uma tomada de decisão com maior margem de confiança. Portanto, este trabalho tem por objetivo a realização de uma análise de viabilidade econômica de uma empresa de produção de WPC, através do cálculo da Taxa Interna de Retorno (TIR) e Valor Presente Líquido (VPL) de um fluxo de caixa de um fabricante de deck de WPC.

Outra análise econômica relevante para desenvolver o mercado de WPC no Brasil é uma análise comparativa de preço de um deck de madeira natural e WPC. Com tal comparativo, o potencial consumidor pode entender o valor de investimento inicial do WPC comparado a madeira ao longo do tempo, a princípio com menor custo. Além de uma análise exploratória dos preços ofertados para o deck de WPC no mercado brasileiro pelos fabricantes existentes no país.

2.1.1 Análises de viabilidade-econômica de WPC no Brasil

Poucos trabalhos publicados relatam análises econômicas do setor de WPC no Brasil. Almeida (2013) estudou a viabilidade econômica do WPC e constatou que o investimento inicial e o tempo de retorno do capital foram alto, de acordo com as premissas abordadas por ele. Porém, os valores de Valor Presente Líquido (VPL) e Taxa Interna de Retorno (TIR), R\$1.383,31 e 24,88% respectivamente, foram animadores, considerando Taxa Mínima de Atratividade (TMA) de 12%. E de acordo

com as oportunidades e os pontos fortes analisados na matriz SWOT, para os investidores com perfil mais arrojados valeria a pena o investimento.

Outro estudo publicado relativo à análise econômica da produção de WPC, de Guimarães (2013), concluiu que de acordo com as premissas consideradas obteve o VPL acima de zero e a TIR acima da TMA, R\$1.117.603,97 e 19,96%, respectivamente. As premissas utilizadas nesse estudo consideraram uma fábrica de madeira plástica, com a produção de dormentes, pallets entre outros. A TMA desejada era de 10,8% com tempo de análise de projeto de 15 anos.

O autor ainda afirmou que como resultado do seu trabalho, o investimento em produção de WPC era “viável, rentável e atrativo para o investidor”. Ou seja, ambos estudos, relatam que a produção de WPC é viável e rentável, que acrescentará valor ao investidor. Estudos animadores para esse mercado que tem características técnicas tão apreciadas pela sociedade.

Pisanu et al. (2017) também estudaram a produção e comercialização de compósitos de fibra natural (coco) com polímero (PP) no Brasil e obtiveram uma TIR de 43,7%, e um VPL de R\$ 1.068.932,41. Tendo adotado uma TMA de 8% no projeto, concluíram que o investimento era viável.

2.2 MATERIAL E MÉTODOS

Foi realizada uma revisão bibliográfica através de pesquisas sobre análises econômicas para produção de deck de WPC. A revisão foi realizada buscando os temas deste capítulo em livros, revistas, periódicos, dissertações, teses, sites on-line e outras fontes de publicação. A revisão contribuiu para uma base maior sobre o tema desta pesquisa. As análises referentes aos preços de deck no mercado foram realizadas de maneira exploratória com a finalidade de compreender mais a atuação das empresas no mercado.

A análise comparativa entre um deck de madeira natural e WPC foi inserida, devido ao fato de ser um argumento usado para não recomendação de produtos de WPC pelos influenciadores do mercado, e pela população geral quanto ao valor inicial de investimento ser mais alto do que a madeira. Para isso, os valores utilizados nos cálculos foram coletados no interior do estado de São Paulo, para instalação em obra também no estado de São Paulo. O custo de mão-de-obra para instalação do deck de

WPC e de madeira natural é o mesmo, conforme indicado pelos fabricantes de WPC. Para manutenção do produto de madeira, o tempo de intervalo para manutenção levado em consideração é de um ano. O preço do deck de WPC utilizado foi o preço de venda da empresa produtora de WPC neste capítulo inserida.

A análise de preços de deck de WPC comercializados no Brasil foi inserida para conhecer a média de preço na comercialização de um metro quadrado de deck de WPC, além de permitir o conhecimento da forma como comercializa o produto, canais de distribuição, uma vez que não existe série de preço de WPC documentado. Foi enviado um projeto arquitetônico de uma obra com deck para os fabricantes e solicitado o orçamento. Os valores recebidos foram acrescidos de frete quando não incluso, para entrega a ser realizada na cidade de Botucatu-SP.

2.2.1 Cálculo de TIR e VPL

A análise da viabilidade econômica da produção do WPC é muito importante para que haja maior interesse de investimento no setor. Essa análise será feita através de dados fornecidos por uma empresa produtora de deck de WPC localizada no interior do estado de São Paulo. Normalmente esse estudo é obtido na fase de avaliação de implantação de um projeto por uma empresa. Essa análise mostra o retorno do investimento através de uma visualização de números e projeções. A avaliação econômica de um projeto considera os efeitos do valor do dinheiro no tempo.

O real retorno do investimento do projeto especificado permite um maior embasamento para tomada de decisão para aceitar ou recusar o projeto. Para esse estudo é necessário o entendimento de alguns conceitos econômicos, tais como fluxo de caixa, TIR e VPL, que são os principais métodos para avaliar projetos.

O fluxo de caixa é o resultado dos efeitos das entradas/recebimentos (+) e saídas/pagamentos (-) de dinheiro, resultantes das operações de aplicações e empréstimos de dinheiro ao longo do tempo. Refere-se ao movimento de dinheiro entrando e saindo de um negócio, projeto ou produto financeiro. É geralmente medido durante um tempo finito e específico e pode ser utilizado como *input* para modelos financeiros como a TIR ou o VPL.

Hoji (2006) afirmou que a TIR pode ser compreendida também como a taxa de desconto do fluxo de caixa. A taxa de juros de desconto que igualará o valor presente das entradas (recebimentos) com o das saídas (pagamentos) previstas de caixa, em

determinado momento do tempo. Um investimento é considerado aceitável se sua TIR é maior que uma Taxa Mínima de Atratividade (TMA) do investimento. A TMA é escolhida pelo investidor como base para decidir se o projeto é viável ou não, normalmente é uma outra oportunidade de negócio que ele tem para investir o mesmo capital e obter um retorno.

Fittipaldi (2018) relatou que o objetivo da TIR é determinar a taxa de juros de um fluxo de caixa que iguala a soma do valor presente dos investimentos com a soma do valor presente dos retornos em um projeto. Castro Jr (2017) ainda descreveu a TIR como sendo a taxa de desconto para qual um projeto tem VPL igual a zero. O mesmo autor apresenta a equação 1 para cálculo da TIR:

$$\left(\sum_{t=1}^n \frac{I_t}{(1+K)^t}\right) = \left(\sum_{t=1}^n \frac{FC_t}{(1+K)^t}\right) \quad \text{eq. 1}$$

FC_t = fluxo de caixa em cada período;

K = taxa de desconto do projeto, rentabilidade mínima requerida pelo investidor;

I_0 = montante do investimento no momento “zero” (início do projeto);

I_t = montante de investimento no momento subsequente (após início do projeto).

O simples fato de a TIR ser positiva não indica que o projeto deverá ser aceito, pois ainda deve-se levar em conta outro fator, o valor apresentado pelo VPL. Porém, na teoria financeira, se a decisão a ser tomada estiver entre duas opções com TIR aceitável, opta-se por aquela que tiver o maior VPL (GUIMARÃES, 2013)

De acordo com Puccini (2000) o VPL analisado de um determinado fluxo de caixa é igual ao valor presente de futuras parcelas descontadas a uma determinada taxa de desconto, mais o valor colocado no ponto zero, que é o valor do investimento inicial que geralmente é uma saída de caixa. O VPL considera o valor do dinheiro no tempo.

Ainda, segundo Castro Jr (2017) o VPL é obtido pela diferença entre os fluxos de caixa durante a duração do projeto e o valor presente do investimento, descontando a taxa mínima de atratividade. O mesmo autor apresenta a equação 2, abaixo para cálculo do VPL:

$$VPL = \left(\sum_{t=1}^n \frac{FC_t}{(1+K)^t} \right) - \left(I_0 + \sum_{t=1}^n \frac{I_t}{(1+K)^t} \right) \quad \text{eq. 2}$$

FC_t = fluxo de caixa em cada período;

K = taxa de desconto do projeto, rentabilidade mínima requerida pelo investidor;

I_0 = montante do investimento no momento “zero” (início do projeto);

I_t = montante de investimento no momento subsequente (após início do projeto).

O resultado do cálculo do VPL indicará qual o valor que um investimento ou projeto adicionará à empresa ou acionistas. Caso o VPL seja positivo em um determinado período calculado, o projeto fornecerá um ganho financeiro e agregará valor. Ao contrário, se negativo durante esse período “n” haverá uma perda de dinheiro. Caso o VPL seja igual a zero, o investimento não resultará nem em ganho ou perda, portanto a decisão de investimento pode ser pautada em outros critérios, como por exemplo a posição de mercado da empresa.

A análise econômica foi elaborada com o fluxo de caixa de um projeto de produção, dados empíricos, de uma empresa de produção de deck de WPC, de pequeno porte no interior do estado de São Paulo. Os parâmetros foram estabelecidos pela empresa que forneceu dados empíricos de produção. Como abordado, a TIR e VPL do projeto foram calculados através do fluxo de caixa no Excel.

2.3 RESULTADOS E DISCUSSÕES

Para análise de viabilidade econômica foi adotado as premissas de acordo a empresa fornecedora dos dados, apresentadas na tabela 1. A fábrica está localizada na região com maior concentração de potenciais consumidores, maior população com conhecimento sobre o material e, portanto, apresenta proximidade ao cliente. Os investimentos feitos pelos empresários são demonstrados na tabela 2.

Tabela 1 – Premissas para cálculo de Fluxo de Caixa, TIR e VPL

Premissas	
Localização	Centro-oeste do estado de SP
Produção Mensal WPC	500 m ²
Preço de Venda WPC	R\$ 250/m ²
TMA	8% a.a.

Tabela 2 – Investimentos iniciais

Investimentos	Quantidade	Valor Unitário R\$	Valor Total R\$
Extrusora	1	1.100.000,00	1.100.000,00
Matriz do perfil	1	60.000,00	60.000,00
INVESTIMENTO TOTAL			1.160.000,00

Na tabela 3, tem-se os cálculos do custo total de produção da empresa, divididos entre custos fixos e custos variáveis. Isto é, o valor total das despesas que resultará em uma determinada quantidade de produto. Onde, os custos variáveis totais são aqueles dependentes da produção e por isso é modificado de acordo com a variação do volume produzido, por exemplo energia e matéria-prima. E os custos fixos totais, aqueles que independem da produção, decorrentes dos gastos com fatores fixos de produção, como aluguel ou salários.

Tabela 3 – Custos Totais de Produção

CUSTOS	Valor Mensal R\$	Valor Anual R\$
CUSTOS FIXOS		
Aluguel	10.000,00	120.000,00
Salários	6.000,00	72.000,00
13º Salários	-	6.000,00
Férias	-	2.000,00
Benefício - Plano de Saúde	50,00	600,00
Benefício - Vale Transporte	-	2.350,00
INSS	-	21.440,00
FGTS	-	9.200,00
Depreciação	8.700,00	104.400,00
Despesa administrativa	300,00	3.600,00
Internet + celulares	300,00	3.600,00
CUSTO FIXO TOTAL	25.350,00	345.190,00
CUSTOS VARIÁVEIS		
Energia	2.500,00	30.000,00
Água	115,00	1.380,00
Manutenção	1.250,00	15.000,00
Matéria-prima	55.000,00	660.000,00
Comissão Venda	6.250,00	75.000,00
Impostos (Simples Nacional)	13.750,00	165.000,00
CUSTO VARIÁVEL TOTAL	78.865,00	946.380,00
CUSTO TOTAL		1.291.570,00

Na tabela 4 é apresentado o faturamento bruto da empresa a partir da venda dos 500 m² que serão produzidos mensalmente, com previsão de venda no mercado a um custo de R\$ 250,00. Para o caso mencionado, é possível manter uma constante de produção, sem modificação portanto da receita ao longo do tempo.

Tabela 4 – Receita Bruta de Venda

RECEITAS	Faturamento Bruto Mensal R\$	Faturamento Bruto Anual R\$
deck WPC	125.000,00	1.500.000,00

Assim, com os dados acima apresentados, foi possível elaborar o fluxo de caixa da empresa com horizonte temporal de 10 anos, conforme apresentado na figura 1 abaixo. Os valores representados abaixo da linha são valores de saída e valores acima, valores positivos de entrada.

Figura 1 – Fluxo de Caixa

	R\$208.430,00	R\$208.430,00	R\$208.430,00	R\$208.430,00	R\$208.430,00	R\$208.430,00	R\$208.430,00	R\$208.430,00	R\$208.430,00	R\$208.430,00
0	1	2	3	4	5	6	7	8	9	10
-R\$1.160.000,00										

Com o fluxo de caixa, pode-se calcular TIR e VPL e os resultados estão abaixo na tabela 5. Como os investidores optaram por uma TMA de 8%, obteve-se um resultado positivo já que a TIR resultou em 12,37%, e VPL de R\$ 238.582,27, baseado no Fluxo de Caixa acima. O VPL com valor positivo, também demonstra que o projeto é viável economicamente e agregará valor ao investidor.

Tabela 5 – Valores de TIR e VPL da análise do Fluxo de Caixa

TIR	12,37%
VPL	R\$ 238.582,27

Uma análise econômica útil para o potencial consumidor é o comparativo de preço para instalar um deck de madeira natural (jatobá) e um deck de WPC (pinus + PVC), pois esse foi um dos motivos citados pela população geral para não comprar materiais de WPC. Na tabela 6, temos o preço de instalação de 2 tipos diferentes de deck.

Tabela 6 – Preço de compra e instalação de deck de madeira x deck WPC

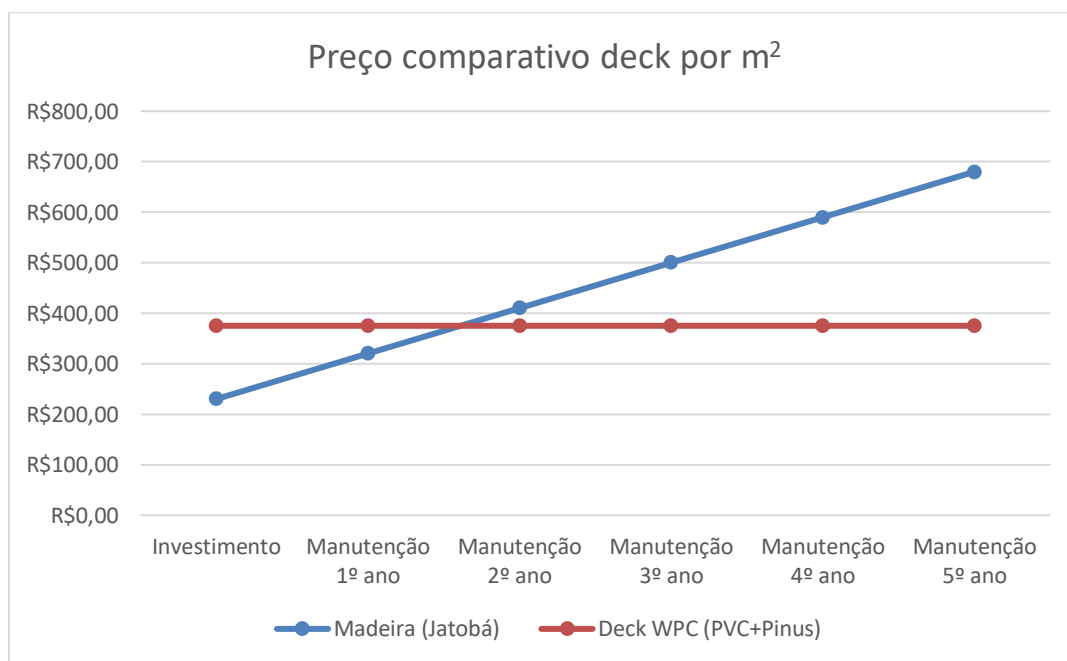
Deck	Madeira (Jatobá)	Deck WPC (PVC+Pinus)
Preço do material	R\$115,00	R\$250,00
Perda de material (10%)	R\$15,00	R\$25,00
Mão-de-obra (Instalação)	R\$100,00	R\$100,00
TOTAL	R\$230,00	R\$375,00

Ao longo dos anos os decks de madeira necessitarão de manutenção, anual, diferentemente do deck de WPC que não necessita. Uma das vantagens que o WPC possui frente aos concorrentes, mas que a população ainda desconhece. Assim, a tabela 7 abaixo, demonstra os valores de investimento e manutenções ao longo do tempo, R\$ 90,00/m²/manutenção/ano.

Tabela 7 – Comparativo de preço ao longo dos anos

Deck	Madeira (Jatobá)	Deck WPC (PVC+Pinus)
Investimento	R\$230,00	R\$375,00
Manutenção 1º ano	R\$320,00	R\$375,00
Manutenção 2º ano	R\$410,00	R\$375,00
Manutenção 3º ano	R\$500,00	R\$375,00
Manutenção 4º ano	R\$590,00	R\$375,00
Manutenção 5º ano	R\$680,00	R\$375,00

O gráfico 1, apresenta o preço comparativo total de um deck de madeira e um deck de WPC ao longo dos anos. Nele é possível observar que pouco antes da 2ª manutenção o investimento para instalação do deck de WPC já terá sido pago. Ou seja, apesar de um maior valor inicial para instalação, no decorrer do tempo o valor se torna viável pelo motivo do WPC não precisar de manutenção.

Gráfico 1 – Preço comparativo deck madeira x deck WPC

Na tabela 8, é apresentado os orçamentos para deck de WPC das principais empresas fabricantes do material. O valor de frete R\$ 0,00 significa que a entrega já está inclusa, sendo apresentado pelo fabricante como “frete grátis”. Os preços orçados têm como forma de pagamento o valor em até 3 vezes. No caso da empresa 2, é a única no levantamento que não faz venda direta ao consumidor, utilizando como

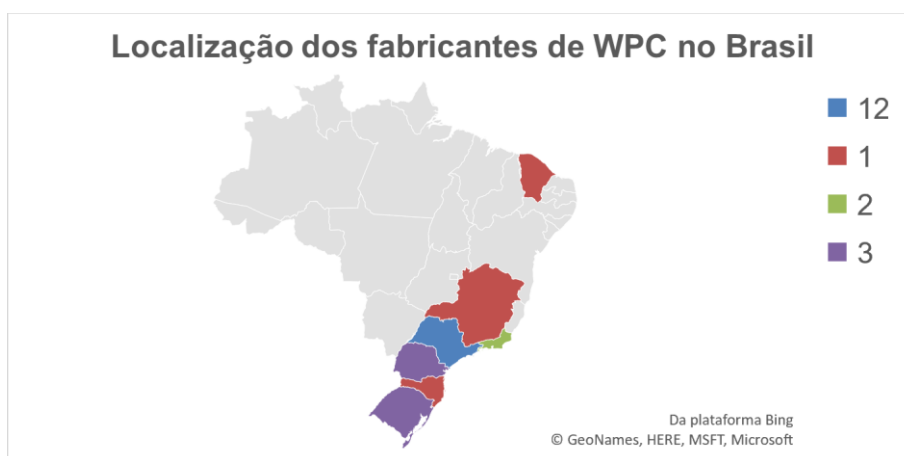
canal de venda o representante da região do comprador. Como o orçamento foi feito com base na cidade de Botucatu-SP, o representante a atender selecionado pelo fabricante foi de Sorocaba-SP. Para a amostra dos preços dos fabricantes abaixo, a média de preços foi de R\$ 285,15 $\pm$ R\$ 30,84 (desvio padrão).

Tabela 8 – Preço de venda de deck de WPC

Empresa	UF	Canal de Venda	Preço/m ²	Valor frete	Preço Total
Empresa 1	MG	venda direta representante	R\$279,10	R\$43,26	R\$322,36
Empresa 2	PR	Sorocaba/SP	R\$293,41	R\$0,00	R\$293,41
Empresa 3	SP	venda direta	R\$302,28	R\$0,00	R\$302,28
Empresa 4	RS	venda direta	R\$246,81	R\$0,00	R\$246,81
Empresa 5	PR	venda direta	R\$260,90	R\$0,00	R\$260,90

Além das análises acima reportadas, também foi realizado um levantamento dos fabricantes de WPC no Brasil através de sites pela internet e através de uma observação descritiva descobriu-se que existe 23 produtores mapeados abaixo na figura 2. No mapa é possível observar uma concentração dos fabricantes na região Sul e Sudeste. Fatores como maior concentração da população brasileira e potencial consumidor estar nessas regiões; a renda *per capita* ser mais alta; e uma possível tendência de perfil consumidor mais propenso a experimentar novos produtos e desejar inovações.

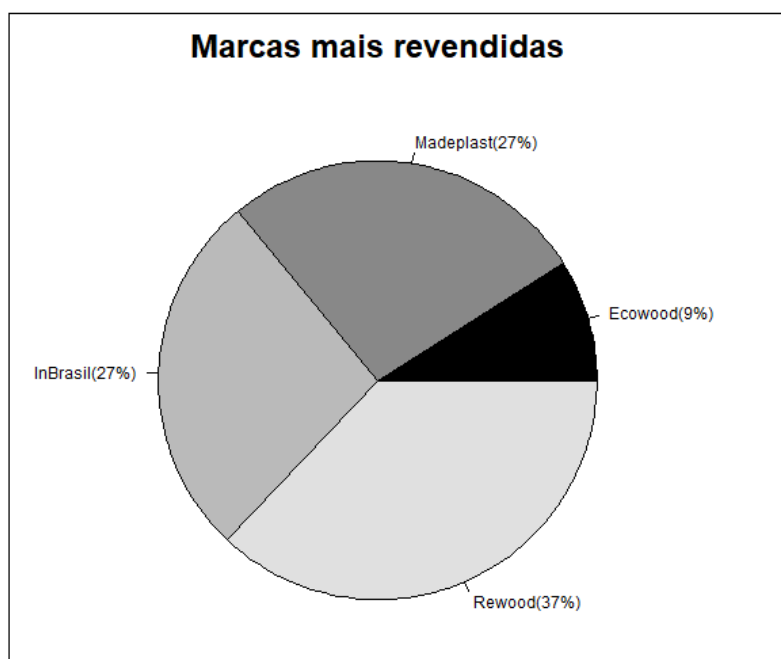
Figura 2 – Localização dos fabricantes de WPC no Brasil



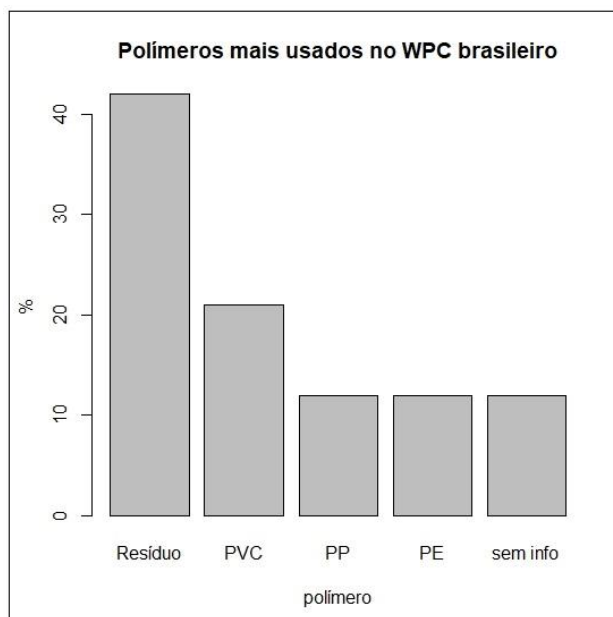
No gráfico 2 abaixo é apresentado as marcas de WPC mais revendidas no mercado brasileiro. Tal informação foi obtida através do contato da pesquisadora com

cada empresa fabricante e revenda. Porém, não é possível associar essa informação com o *market-share*, por exemplo, e nem com o faturamento no mercado. É possível dizer que de 23 fabricantes, 4 se destacam quanto à revenda – aproximadamente 17%. Informação que pode ser ligada ao item analisado dos questionários dos Influenciadores que citaram inclusive as mesmas marcas abaixo.

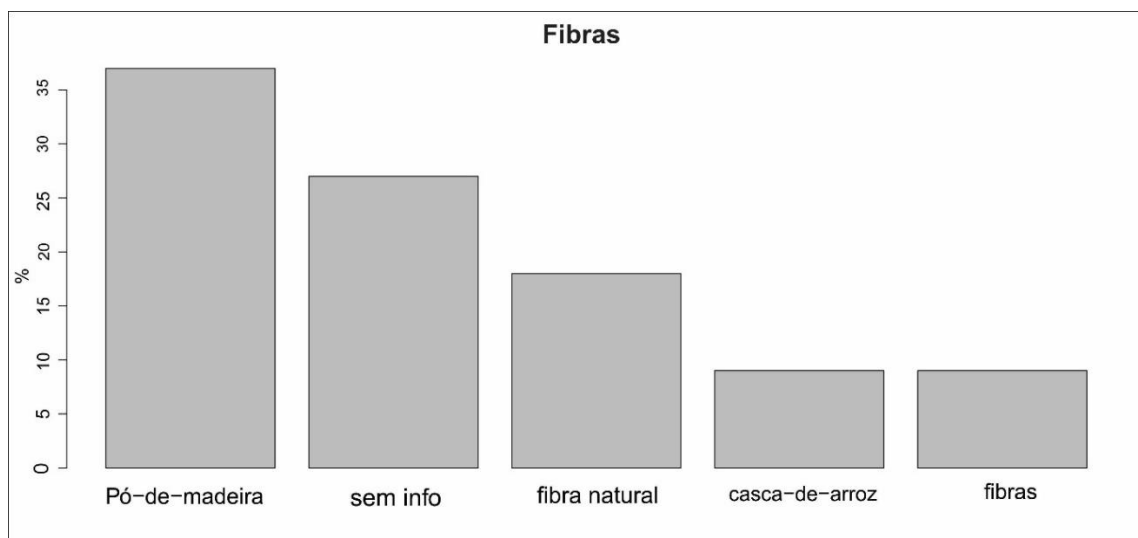
Gráfico 2 – Marcas mais revendidas no mercado brasileiro



De acordo com o mesmo levantamento, dentre os polímeros mais utilizados no WPC produzido no Brasil, o resíduo plástico é o que apresenta maior representatividade. Seguido pelo PVC, PP e PE. Ainda tem uma quantidade de fabricantes que não fornece essa informação em seus meios de comunicação, gráfico 3.

Gráfico 3 – Polímeros mais usados no WPC brasileiro

No gráfico 4 também aparece a informação das fibras mais utilizadas na produção do WPC brasileiro. O pó-de-madeira é o principal componente como reforço no compósito. Infelizmente, muitos fabricantes não fornecem a informação, ou classificam somente como fibras naturais e fibras. Também existe alguns que utilizam casca-de-arroz. Tais informações como polímero e fibra utilizados na produção do WPC são importantes para os consumidores decidirem a compra e compararem produtos. Pode-se comparar uma marca com outra, e checar se o preço do produto está dentro da faixa para aquele material, entre outros motivos. Portanto, para que o mercado de WPC consiga melhorar seu desempenho, é preciso que essas informações estejam claras para o consumidor.

Gráfico 4 – Fibras mais usadas relatadas no WPC brasileiro

2.4 CONCLUSÃO

A análise econômica da fábrica de WPC mostrou-se viável para investidores e o comparativo do investimento inicial na instalação de um deck de WPC versus deck de madeira natural mostrou que em um período curto o deck de WPC era completamente viável e até mais barato para o consumidor, por não demandar constante manutenção como a madeira natural. A sua durabilidade e aparência ao longo do tempo colaboram para ser um produto competitivo no mercado.

Seu apelo para o não-desmatamento ou ao não consumo de madeira ilegal também faz do WPC um material com vantagem ambiental. A possibilidade de utilizar resíduos em sua produção também o torna um produto no padrão do novo modelo econômico, a economia circular.

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CONSIDERAÇÕES FINAIS

A análise econômica da fábrica de WPC mostrou-se viável para investidores e o comparativo do investimento inicial na instalação de um deck de WPC versus deck de madeira natural mostrou que em um período curto o deck de WPC era completamente viável e até mais barato para o consumidor, por não demandar constante manutenção como a madeira natural. A sua durabilidade e aparência ao longo do tempo colaboram para ser um produto altamente competitivo no mercado. Seu apelo para o não-desmatamento ou ao não consumo de madeira ilegal também faz do WPC um material com vantagem ambiental. A possibilidade de utilizar resíduos em sua produção também o torna um produto no padrão do novo modelo econômico, a economia circular. Podendo tornar-se futuramente alvo de incentivos públicos e privados, como projetos de reciclagem de fabricantes de plásticos.

O mercado brasileiro de WPC tem inúmeros desafios, como fazer o material WPC conhecido pela sociedade, investir mais em publicidade e marketing; ganhar a confiança de engenheiros e arquitetos; tornar a informação de matéria-prima clara aos consumidores para que possam comparar os produtos; aumentar o número de pesquisas e estudos que suportem investimentos, entre outros. Porém, existe uma enorme perspectiva de crescimento e muitas oportunidades nesse mercado, já que boa parte da população brasileira ainda não conhece o material, e os poucos que conhecem não compraram ainda por falta de oportunidade. O governo e as empresas brasileiras, tendem a ser cada dia mais cobrados a promoverem a sustentabilidade e executarem uma economia circular e não linear, criando assim oportunidades para produtos de WPC.

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