

Developing a range of Sustainable Graphic T-shirts for men

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Date of Submission: 11-03-2024

Date of Acceptance: 21-03-2024

ABSTRACT

Sustainability is defined as an improvement that meets existing requirements without threatening forthcoming generations' ability to meet their own. Sustainability augments our eminence of life while also preserving our environment and natural resources for coming generations. Sustainable graphic design is an approach that takes into account the environmental impact of the design. Sustainability can be seen in digital paper printing, but sustainability in a graphic print T-shirt is a new initiative. Generally, a graphic print T-shirt is produced with a chemical dye. For graphic design- correct material choice, ink choice and, the process can significantly reduce the effect on the environment of a design piece. In this research, an attempt was made to produce a sustainable graphic print T-shirt using water-based ink. Water-based inks are made up of 60% water/other solvents, 20% vehicle (resin), 15% colorant, and 5% additives. This approach would be accepted by the industries and would create awareness among consumers as it reduces pollution and is eco-friendly.

Keywords: Graphic design, Screen printing, Sustainability, T-shirt and Water-based ink.

I. INTRODUCTION

The Brundtland Commission, formerly known as the World Commission on Environment and Development, is credited with discovering the term "sustainability" (WCED). It brings countries together to work toward a common goal of sustainable development. According to the Brundtland Commission, sustainability is defined as "agreeing for the necessities of all individuals to be met without inhibiting those similar wants from being met by coming generations". [1]

Brian Dougherty, one of the major experts in Sustainable Graphic Design (SGD), defines "sustainability" as "The term 'sustainable' refers to any behavior that does not damage the systems that support it and may thus continue indefinitely." [2]

Industrialization is one of humanity's main endeavors to restructure its environment. But the protection of the surroundings itself was in no way part of the concern at the time the Industrial Revolution took place. [2] Everything that is made now is built on the assumption that natural resources and materials are inexhaustible. The task of restructuring has become the designer's obligation. The designer plays an important part in emerging the modification for sustainability. Influences and behaviors of materials and resources, as well as their origins, have to be considered when we restructure and produce the products. [1] Some experts' desire terms like "Green Design" or "Green Graphic Design", the adjective 'Green' indicates environmental knowledge, but leaves out economic and social aspects. Only if they go hand in hand and are maintained in equal balance, sustainability can be attained. Still, sustainable exercise does not alone end with materiality; rather the whole design thinking process, as well as the business practice has to be reanalyzed. [2]

The fashion industry is one of the major pollution-causing industries in the world. It produces a large amount of carbon emission and it also causes water pollution with its microplastics. The vast overproduction of the fashion industries causes huge wastage. [3] So, a sustainable approach should be made in the fashion industry to make a positive effect on the environment.

II. LITERATURE REVIEW

A. SUSTAINABLE GRAPHIC DESIGN

Designers are being forced to see defects in their creative and design processes due to current unfavorable environmental and social challenges. As a result of seeing these environmental challenges, designers must take the initiative to lead the sustainable design revolution rather than waiting for others to do so. [3] Designers' ability to initiate change is crucial since they are makers, but

what should we do to make graphic design more sustainable? Sustainability, according to the US Environmental Protection Agency (EPA), is defined as "meeting present economic requirements while protecting biodiversity and ecosystems in order to sustain the equivalent superiority of life for coming generations," according to the US Environmental Protection Agency (EPA). However, in order to define sustainability in terms of the graphic designer, one must consider the tools and resources required for each stage. [5]

B. EDUCATION TO GRAPHIC DESIGNER

Sustainability is a significant and troubling subject, but graphic designers have yet to figure out how to successfully address it. Sustainability must be recognized as critical to the future and public concern to partake a significant position in education. Additions to this point should include 8 sustainable forms of production, energy utilization, material selection, and waste reduction when new project assignments are made. Because the printing and production industries are always changing, graphic designers must stay up to date on current trends. [8]

Each of these principles encourages the designer to take on more specific tasks, such as choosing locally made or recycled materials, selecting renewable materials to finish the product's manufacturing process, educating the consumer or client about the object's life cycle through marketing and advertising, and selecting vendors who practice environmentally friendly business practices. [5]

C. SUSTAINABLE METHODS

Water-based screen printing for T-shirts:

Plastisol ink is the most frequently used ink for screen printing. It is made of PVC particles that sit on top of the fabric rather than being incorporated into it, and it is not water-soluble. PVC is a proven carcinogen that is harmful to both the environment and humans. [11]

Water-based screen printing, on the other hand, is not only an environmentally safe printing method, but it also produces a finer, smoother, and brighter print due to the absence of a plasticized structure on the fabric's surface. Furthermore, as compared to other eco-friendly inks, these water-based inks have higher colorfastness and durability. [12]

Bespoke Printing

To print an all-over design on your T-shirt the best method is to follow bespoke printing. This

form of printing assists in the selection of cloth, color, and cut. The first step is to use water-based inks to dye the entire roll of eco-friendly fabric that has been chosen, and then screen print the graphic all over the fabric roll to create an all-over print result. Then cut and sew the fabric according to the style to produce the final garment of one's choice. However, this technique can only be used for bulk production. [7]

Product On-Demand Method [Pod]

The main benefit that POD firms have over giant fashion retailers is that they can produce on-demand products with less wastage. Usual shopping chains produce items to sell, which continuously manufactured the products in bulk amounts to save money. But if we print a product only when a client places an order that is producing a product that previously has a known buyer can avoid overproduction. [7] The surplus item that is not saleable has to be thrown out and ends as landfills. The fashion industry produces 92 million tons of wastage each year; a business model like this is a game-changer. [13] Waste in POD mainly comes from items that are damaged during printing and during the production process. [7]

Direct To Garment Printing [DTG]

The DTG direct printing technology is used to create high-quality textile printing in limited quantities, resulting in a new and distinct style. Using inkjet printing, we can print graphics with an endless number of colors directly on a range of materials. [7] Most commonly used printing technologies, such as screen printing, are less sustainable and environmentally friendly than direct-to-garment (DTG) printing. Screen printing does not only use a lot of water and Plastisol inks that are non-biodegradable but it is also used for producing bulk orders which can lead to overproduction. If we compare these aspects, DTG printing is eco-friendlier as products get printed only when there is a need for them. Inks like biodegradable vegan, neo-Pigment inks which are water-based, toxin-free and non-hazardous are used in this method. [7]

Natural Dye

Natural dyes and pigments could be made from insects, plants, animals and various other natural sources. [14] Unlike non-renewable raw materials present in synthetic dyes, natural dyes contain mostly renewable and sustainable particles in them. In terms of sustainability, artificial dyes are made from non-renewable raw materials; though, natural dyes are extracted from renewable

sources. [15] The ability to make the dye from renewable natural sources makes natural dyes a good option for a more sustainable world. Natural dyes can be useful to the fibers not only by using the dyeing method but also by using the printing method. Textile printing is one of the utmost significant and commonly used methods among the methods used to design and print textile fabrics. [14]

III. METHODOLOGY

The methods followed to carry out the process are shown in Figure 1. The workflow carried out in this study consist of creating graphics, producing sustainable graphic T-shirts, and comparing sustainable prints with chemical print.

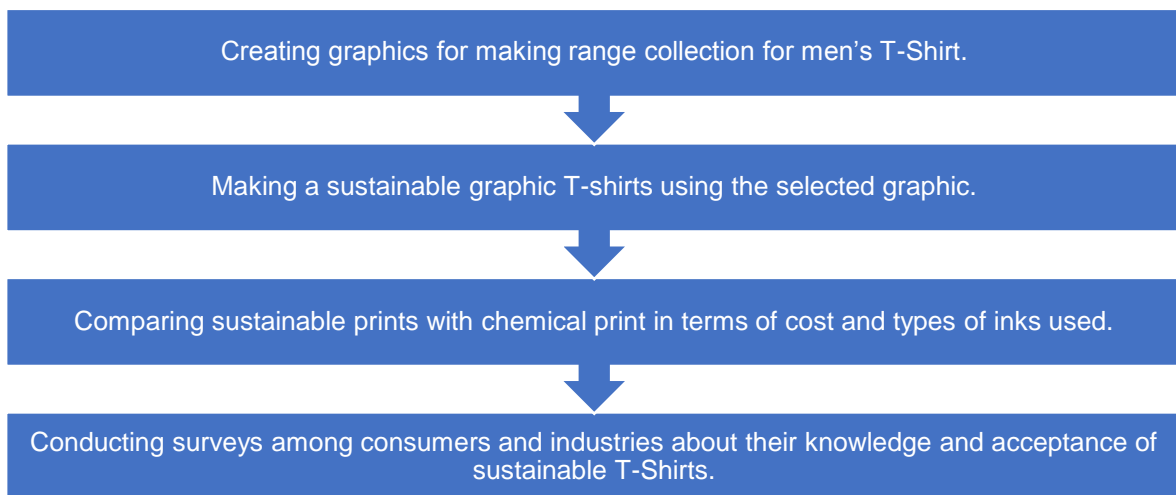


Figure 1. Methods

A. RANGE COLLECTION

a. Mood board:

i. Positive quotes:

The theme chosen for this article is positive quotes. Are you looking for a good time? The best place to start is with positive quotes and sayings. Positive thinking involves developing optimism in our minds so that we can continue in the face of difficulties. Are you looking for a way to cheer someone up? A few positive comments or words of encouragement might sometimes be all it takes to make someone's day. [16]

According to the selected theme mood board is created which is shown in Figure 2.



Figure 2. Mood board

b. Color board:

Figure 3 shows the color board of the graphics. For color board, colors like mustard, white, magenta, sky blue, black and cream is selected

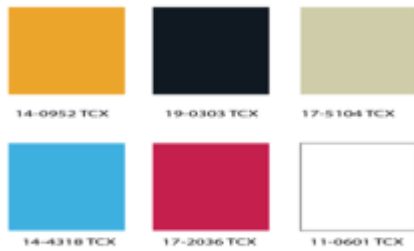







Figure3. Color board

c. Graphic Creation

From the mood board, graphics are created. Keeping the image as a reference graphic is created. For creating graphic design software like Adobe Illustrator and Adobe Photoshop are used. 5 designs were created. Keeping the mood board as a reference, the following designs shown in Table 1 is created.

Table 1. Created Graphics

S.NO	DESIGN	STEPS
D1		For the D1 graphic first the image from the mood board is traced using the image trace tool. After tracing the fonts are edited by removing the watermark. The fonts are given shape using the pen tool. The colors used are mustard and black. For the background rectangle tool is used.
D2		For the D2 graphic Segoe print italic is used for the fonts and the words are given three different colors. For the background rectangle tool is used. The colors used here are white, black, sky blue, and magenta.
D3		D3 graphic is done using the image trace tool. The image from the mood board is traced in 3 colors. Then the extra bits and watermarks are removed using a pen and cut tool. The colors used here are navy blue and white.
D4		6 color image trace tool is used for this D4 graphic. To sharpen the edge of the font blend tool is used. The colors used here are mustard, sky blue, cream, and black.
D5		For D5 graphic image trace tool is used and the watermark is removed. The top font is given using a type-on-path tool. The dumbbell is traced separately and placed. Here black and mustard colors are used.

d. Selected graphic:

Figure 4 shows the final selected graphic to be printed on T-shirt. The created graphics are shown to the manufacturers and from those D3 graphic is selected as it has minimal color. The water-based ink has navy blue which will make the process easy to proceed.



Figure 4. Selected graphic

e. **Making Sustainable T-Shirt**

i. **Screen Printing**

After analyzing various techniques through literature review screen printing technique was selected as it is a commonly used method of printing. It is often used by manufacturers for producing graphic print T-shirts. The change was done in screen printing to make it sustainable is by using a non-PVC binder and water-based ink. The non-PVC binder and water-based ink are environmentally friendly and cause less pollution compared to chemical binder and ink. In this process, we only use the most sustainable materials while printing the apparel. The process is 100% non-toxic, only utilized materials that are water-based and plant-based ingredients. In this process, we can also reduce energy consumption drastically by printing everything by hand, recycling everything possible, up-cycle the leftover inks, filtering reusing water, and maintaining a zero-waste mindset in all processes of our production.[20]

ii. **Non-PVC Binder**

PVC stands for Polyvinyl Chloride and is a type of ink that is primarily used for screen printing. PVC inks are harmful to the environment since they include heavy metals and phthalates particles. These inks are also hazardous to children. [22] Changes have been made to introduce Plastisol, which is PVC released, due to rising demand from various authorities and industrialists to get rid of this ink. [20]

iii. **Water-based Ink**

Recently, there has been a major push toward "environmental" manufacture and process approaches," led by the Consumer Product Safety Information Act (CPSIA) and a number of major brands and companies, in determination to lessen the usage of PVC and eliminate the use of phthalates, which is an even more toxic polymer.

As a result of this shift and initiative, prominent industry players are promoting water-based inks as a way to include sustainability into their manufacturing processes. [12] Water-based inks are made up of 60% water/other solvents, 20% vehicle (resin), 15% colorant, and 5% additives. [22]

iv. **Water-Based Inksto the Environment**

Each ink has a unique impact on the environment, and there are particular characteristics of water-based ink that make it more environmentally friendly. Water-based inks, according to the research, are not totally sustainable because they contain plastic in the form of acrylics and other binders. [12] However, because water-based inks do not include PVC, they depend on solvents that evaporate, leaving colored binder components on the clothing. Water is the principal solvent of water-based inks, although they also contain co-solvents including formaldehyde and alcohol. These co-solvents can harm the environment and endanger printers; thus they must be well-covered from evaporative vapors. [23]

v. **Sustainable T-Shirt**

Fabrics made from eco-friendly raw resources, such as fiber crops farmed in environmentally acceptable ways or recycled materials, are referred to as sustainable apparel. It also refers to the process of creating these fabrics. The core materials should not have been grown or created in a detrimental manner, and the production method should be environmentally friendly and use the fewest resources possible. Furthermore, carbon emissions are reduced to a minimum. An environmentally friendly T-shirt should meet the above criteria and is becoming a more appealing alternative for those looking for a long-lasting product. [24]

f. **Steps in Making Sustainable T-Shirt Print Using Screen Printing**

In the first step, the screen is prepared after the selection of graphic design. The selected graphic is saved in pdf form and it is inputted in the screen-making machine, the frame is placed in the machine and the desired design is produced and it is shown in Figure 5.

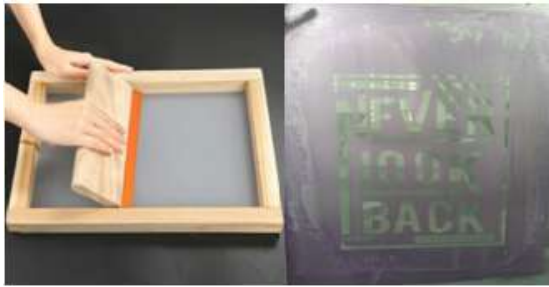


Figure 5. Screen printing screen

Step 2 is where cello tape is pasted on the areas where there is no design to avoid the dyes being printed on the wrong areas as the screen may contain some pinholes which can be a mistake. The taped screen is shown in Figure 6.



Figure 6. Taped screen

Step third is mixing the dye according to the required color. Navy color is selected; hence the blue color is mixed with the binder to get the required shade. The mixing of color and process is shown in Figure 7



Figure 7. Mixing the Color

The T-shirt is placed in the correct position to get the right design. The center is marked and placed correctly as shown in Figure 8. It is ironed to avoid wrinkles. The frame is also placed in the machine panel.



Figure 8. Placing the T-shirt

Using the slide, the dye is printed on the T-shirt. It should be spread evenly to get the print even and in bright color. The spreading of dye is shown in Figure 9.



Figure 9. Spreading of dye

The screen should be removed carefully after printing the T-shirt to avoid smudging the color. The printed T-shirt is shown in Figure 10.



Figure 10. Printed T-Shirt

The printed T-shirt is passed through the heater to dry the dye. It is passed under 180 degrees Celsius. The heat process technique is shown in Figure 11.



Figure 11. Heat process for drying

The final process in screen printing is either curing or fusing. Fusing was used to give a finish to the print and it provides a shining finish. This T-shirt is placed in the machine with the print facing upward and a shining sheet is placed on top of it. The machine is pressed at a high temperature. The fusing process is shown in Figure 12. The T-shirt is thus printed with the selected design using sustainable dye and using a non-PVC binder.



Figure 12. Fusing

g. Making Chemical Print T-Shirts Using Screen Printing

The same steps of screen printing are followed for printing chemical print T-shirts. The only difference is using PVC binder and plastisol ink instead of non-PVC binder and water-based ink. This causes high pollution to the environment because it has high metal and plastic content in it. The final T-shirts made out of sustainable print and chemical print is shown in Figure 13 and 14 respectively.



Figure 13. Sustainable print



Figure 14. Chemical print

h. Conducting surveys among consumers and industries about their knowledge and acceptance of sustainable T-shirts.

i. Data Collection

The survey was conducted to see the acceptance and awareness on sustainable graphic print t-shirt among consumers.

ii. Study Population

The quantitative research was conducted on a group of 60 respondents. Gender: Both men and women

iii. Preparation of Questionnaire

A questionnaire is the primary source of information in this study. Google forms are used and this contains basic questions like age and gender as these are kept as independent variables. Questions related to the sustainable graphic print shirt are specified just to learn about the consumer's awareness and acceptance. This consists of multiple-choice questions, linear scale questions and, short answers. The link to this Google form is sent to all the respondents through the mail. The first page of the questionnaire is the title of the project and a short text, followed by the questions and a thank-you note. The questionnaire starts with multiple-choice questions and ends with a short answer. This survey was mainly conducted among teenagers of age between 18-25 years old. The study helps us to create awareness about sustainable print among future generation.

IV. RESULTS AND DISCUSSION

A. COMPARING SUSTAINABLE PRINT WITH CHEMICAL PRINT IN TERMS OF COST

In order to understand the cost difference between sustainable print and chemical print cost analysis was carried out. Table 2 and Table 3 show the cost of making a sustainable print T-shirt and chemical print T-shirt respectively.

Table 2. Cost Analysis of sustainable print

S.NO	ITEMS	COST in Rs.
1	T-shirt	200
2	Non-PVC binder	5 per T-shirt
3	Water-based ink	10 per T- shirt/ per color
4	Curing	3 per Tshirt
5	Packing	5 per T-shirt
	TOTAL	223/-

Table 3. Cost Analysis of chemical print

S.NO	ITEMS	COST in Rs.
1	T-shirt	140
2	Binder	3 per T-shirt
3	Plastisol ink	7 per T-shirt/per color
4	Curing	2 per T-shirt
5	Packing	5 per T-shirt
	TOTAL	RS. 157

The cost of making a sustainable print T-shirt is Rs.223. whereas the cost of making a chemical print T-shirt is Rs.157. It is observed that the cost of sustainable print T-shirts is higher than the cost of chemical printing T-shirts. The cost difference is mainly due to the fabric and ink used in the printing.

B. COMPARING SUSTAINABLE PRINT AND CHEMICAL PRINT IN TERMS OF THE INKS USED:

For sustainable print water-based ink is used as it is eco-friendly compared to other types of ink. Plastisol ink is used for printing chemical print T-shirts. The ink is expected to be soft and lightweight that has accuracy in color matching with correct levels of vibrancy that durably grips the details of a design. The ink should be solid and adequate to stay up to years of wearing and laundry. It should be comfortable, affordable, and eco-friendly.

WATER-BASED INK HAS SOFTER HAND

The print using water-based ink and plastisol ink is shown in Figure 15. In printing terms; "hand" means the way a print feels when we touch it, along with its weight. It is observed that water-based inks give softness and lightness to T-shirt prints.



Figure 15. Softer hand

This is due to the fact that Plastisol ink is made up of PVC particles and contains plastic. Plastisol prints are constructed of solidifying plastic that is applied to the surface of the fabric. Water-based ink, on the other hand, is mostly water-soluble and enters the fabric. The water-based solutions dissolve when this ink is heated at temperatures, leaving only the pigmented binder chemicals on the fabric's surface, resulting in a smaller ink deposit than Plastisol.

PLASTISOL INK AND COLOR VITALITY

Color vibrancy is nothing but the brightness and saturation level of the print. Figure 16 and 17 shows the color vibrancy of plastisol ink and water-based ink respectively. It is observed that

Plastisol ink has a brighter print than water-based ink. This is due to the PVC particles present in plastisol ink. These PVC particles sit on the surface of the fabric creating color vibrancy.



Figure 16. Color vibrancy of Plastisol ink



Figure 17. Color vibrancy of water-based ink

PLASTISOL HAS BETTER COLOR ACCURACY

When you want the colors in the print to be exact as the Pantone shade then Plastisol is the most preferred one. The color accuracy of plastisol ink and water-based ink prints are shown in Figure 18. When comparing the ink color with navy blue Pantone shade, it is observed that plastisol ink has an accurate shade.



Figure 18. Color accuracy

PLASTISOL INK HAS A LOWER COST

Figures 19 and 20 are the cost of water-based ink and plastisol ink respectively. The cost of

water-based ink is higher than Plastisol ink, making it a premium product. The cost is higher because of the ingredients in it. To make the water-based ink eco-friendly, the plastic particles are replaced by other solvent particles like formaldehyde and alcohol which makes the cost higher.



Figure 19. Cost of water-based ink



Figure 20. Cost of Plastisol ink

BOTH INKS ARE DURABLE

The durability of a print is determined by a number of factors. Because water-based inks absorb into the cloth, the print should ideally last for an extended time. Even though Plastisol is enduringly bound to the fabric's surface, it should stay a long time on a T-shirt. No matter what type of ink we use, if a print is not properly cured, the print's longevity will suffer. The quality of the ink and the nature of the material are two other key criteria that influence ink longevity. The treatment and preservation of the garment itself is by far the most important element.

PLASTISOL INK HAS A GOOD LAUNDRY EFFECT

To see the laundry effect of the inks the T-shirt is washed around 18 times. The prints were compared after every 5 washes to see the effect. It is machine washed using Ariel liquid at 40 degrees Celsius at 600rpm.



Figure 21. Plastisol ink after 5 washes



Figure 22. Water-based ink after 5 washes

Figure 21 and 22 shows the laundry effect of plastisol ink and water-based ink after 5 washes respectively. After 5 washes plastisol ink shows fewer cracks in the print whereas the print accuracy and vibrancy with water-based ink were poor. There were cracks observed in water-based inks and at some places print was broken and at some places, the print came off.



Figure 23. Plastisol ink after 10 washes



Figure 24. Water-based ink after 10 washes

Figures 23 and 24 show the laundry effect of plastisol ink and water-based ink after 10 washes respectively. After 10 washes there is not much change noted in the plastisol print, the print looks

similar to the print after 5 washes. A few changes noted were the print looked dull and that when the fabric was pulled crack was noticed in the print. The water-based ink after 10 washes shows a drastic change. The cracking of print was seen in many areas.



Figure 25. Plastisol ink after 18 washes



Figure 26. Water-based ink after 18 washes

Figures 25 and 26 show the laundry effect of plastisol ink and water-based ink after 18 washes respectively. The plastisol ink seems to be durable. The color looked dull than before but the print remained the same after 18 washes. It does not have many cracks compared to water-based ink. The color was very dull in water-based ink and many cracks were noticed all over the print. While comparing plastisol ink and water-based ink, water-based ink is less durable.

C. PERCENTAGE ANALYSIS

One of the most used statistical strategies for analyzing and interpreting primary data is percentage analysis. It is concerned with the number of responses to a given inquiry. The percentage is calculated using the study's total population. It is one of the most basic types of analysis, with the results of the study being simple to explain to everyone. It is typically employed by commercial research organizations and is represented graphically with various diagrams.

$$\text{Percentage of Responses} = \frac{\text{No of Responses}}{\text{Total Responses}} \times 100$$

i. Preference of Sustainable Product
 Preference of sustainable product

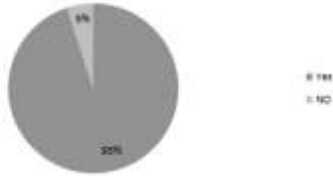


Figure 27. Preference for sustainable product

From Figure 27 it is observed that 95% of the respondents are willing to buy sustainable products. The respondents were asked about their preference for sustainable products. Figure 27 shows the percentage of respondents who answered.

ii. Awareness of sustainable graphic print T-shirts:

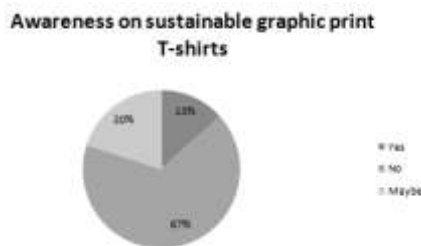


Figure 28. Awareness of sustainable graphic print T-shirts

Figure 28 shows the respondent's awareness of sustainable graphic print T-shirts. It is observed that 66.7% of the respondents are not aware of sustainable graphic print. There is definitely a need to educate people about sustainable print.

iii. Level of Color Accuracy
 Color accuracy

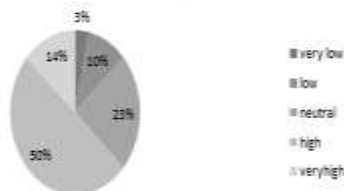


Figure 29. Color Accuracy

Figure 29 shows the level of color accuracy preferred in sustainable print. It is observed that the respondents preferred to have a higher level of color accuracy in sustainable print. Since the respondents are mostly of age between

18-25 years old, they prefer the print color to be bright and attractive.

iv. Level of Durability
 Durability

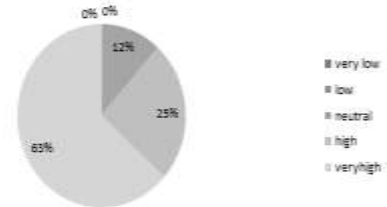


Figure 30. Durability

Figure 30 shows the level of durability preferred in sustainable print. It is observed that the respondents need durability to be very high in the sustainable print. The primary factor required in print is durability. Consumers will like only the type of print which can withstand the number of washes.

v. Level of Color Brightness
 Color brightness

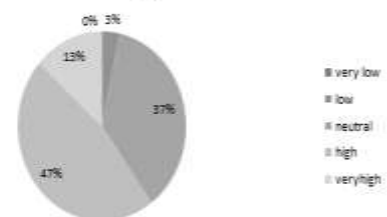


Figure 31. Color brightness

Figure 31 shows the level of color brightness preferred in the sustainable print. It is observed that the respondents preferred to have a very high level of color brightness in the sustainable print. Respondents want the print to be brighter.

vi. Level Of Color Fastness
 Color fastness

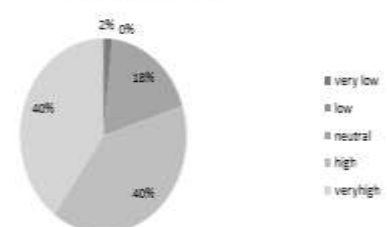


Figure 32. Color Fastness

Figure 32 shows the level of colorfastness preferred in sustainable print. It is observed that the respondents need the color fastness to be very high

in the sustainable print. The print needs to withstand the wash and maintain its original color. It should not fade.

vii. Cost of the Sustainable Print:

Pricing of sustainable graphic T shirt

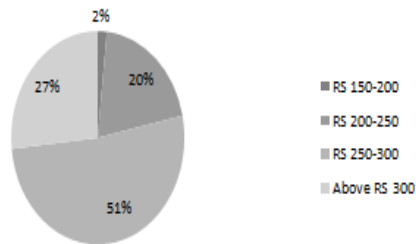


Figure 33. Pricing of sustainable Graphic T-shirt

Figure 33 shows the price preferred by the respondents for sustainable print. It is observed that the majority of the respondents prefer the price to be between Rs. 250-300.

viii. Acceptance Of the Product
acceptance of the product



Figure 34. Acceptance of the Product

The produced sustainable graphic print T-shirt and chemical print T-shirts were shown to the respondents to see their preferences. Figure 34 shows the percentage of acceptance level of the product. The majority of the respondents are willing to prefer sustainable graphic print T-shirts developed. The cost of the sustainable print T-shirt is also accepted by the respondents. If the T-shirt is durable then the consumers will definitely accept the sustainable graphic print T-shirt.

D. FEEDBACK FROM MANUFACTURERS

One on one survey was conducted to understand the knowledge and difficulties in producing sustainable graphic print T-shirts. Three industry managers in the printing industries in Tiruppur were contacted and gave their feedback on producing sustainable graphic print T-shirts. The industries were Organic printers, Dhyani printers and Arul printers.

i. Awareness of Green Printing

The first question reported their understanding and knowledge of green printing. The managers were well aware of the green printing process. They answered that green printing at a very basic level is that which is produced using environmentally and socially sustainable materials. A circular economy is centered on designing and producing products that eradicate waste and contamination, retain products and resources in use, and renew natural systems. Consumer demand for environmentally friendly products is driving research and development of innovative packaging and printing substrates. Eco-inks is undergoing technological advancements, such as vegetable-based eco-solvent inks and waterless-based inks that are less harmful to the environment. As more corporate and production activities migrate to the cloud, distributed print with centralized operating functions will become more common, allowing for more sustainable practices.

ii. Adoption of Green Printing Procedure

Managers informed that they are not producing it because they do not get any orders based on it and they feel that the buyer wants an easy process and a cheap one. They also reported that the orders placed related to green printing are fewer. Hence, investing in sustainable printing methods will establish over the years. Very few printers are producing sustainable graphic T-shirts.

iii. Difficulty in Production

Respondents stated that the disadvantage of producing sustainable graphic print T-shirts is that they cannot be produced in bulk amounts as still there is no developed technology and ink. These are under research and development. Another main factor is to achieve good quality like normal chemical print. The limitation of shades also plays a role as it can lead to the limitation of the design created. Another difficulty is using this ink to print different materials is very limited. The production cost will also be high compared to other print. To produce this sustainable print, the industries, have to get certain certificate verification which is a long process. The manufacturers need to get a certificate from United Nations Sustainable Development Goal (SDG) Programme to register their ink as sustainable.

V. CONCLUSIONS

Sustainability has become a new trend in the fashion industry. Consumers, manufacturers, and designers show interest in producing and buying sustainable products. In this research we

have analyzed various techniques to produce sustainable graphic print, produced a sustainable print, and compared its effect with chemical print, and analyzed the awareness and acceptance of sustainable print among consumers and manufacturers. It is evident that there is a lack of awareness about the product among consumers and manufacturers which needs to be taken into consideration. It also implies that there is a need for technological development to make the product fully sustainable. Research should be done on organic inks and binders. Production technologies have to be improved to make bulk production. The findings of the research show that sustainable graphic print T-shirt is well accepted by consumers and it has scope in the future provided that technological advancement in machines and raw material should be done to make the product fully sustainable and durable.

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