Sustainable and modern prototype of technologies with less carbon emissions for PM Mega Integrated Textile Region and Apparel (MITRA) park at Virudhunagar district in TAMILNADU

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Abstract - *An ideal suggestion for a sustainable and modern prototype of technologies that could add value to the live project of Mega integrated textile region and apparel park in E. Kumaralingapuram (SIPCOT) at Virudhunagar district in TAMILNADU. This journal explores all the possible and practical technologies that could mitigate carbon emissions through electricity and vehicular transportation in the logistics of the manufacturing processes involved in the textile industry and efficient conservation of natural resources such as water and energy management for sustainable maintenance and operations. This journal concludes with the results and advantages of the prototype that is suggested for the live project PM MITRA PARK at VIRUDHUNAGAR.*

Key Words: Sustainable technology , modern , prototype , textile park , carbon emissions , water usage , water less dyeing , energy efficiency , solar , solar power , poly pond , bio-gas , conveyor system

1.INTRODUCTION

This research journal is an ideal suggestion of sustainable and modern prototypes of technologies that could be ideally possible for implementation in the commissioned live project of PM MITRA PARK in E. KUMARALINGAPURAM (SIPCOT) at VIRUDHUNAGAR district of Tamil Nadu. This research had been initiated with the literature studies on the functionality and operations held in the textile industries along with the live case studies held at TIRUPPUR, which made me overgo studies on sustainable technologies that could minimize the carbon emissions from the industry. Post-completion of the studies related to this research topic, all possible sustainable and modern prototypes of technologies are being studied, along with their key benefits in minimizing the carbon emissions from the industry. This research has its outcomes in sustainable and modern prototypes of technologies that could favor the nation's goal of becoming a net zero carbon emitter by 2070. This integrated textile township could be provided with sustainable and modern prototype technologies, including green power utilization, effective water management, and carbon-free transportation within each process involved in the manufacturing process, minimizing the utilization of non-renewable sources necessary to meet their daily needs. This research provides an innovative solution for the integration of the mega-integrated textile region and apparel park that is provided to attract a lot of foreign buyers and investments by providing eco-labelling and adding value to their completed products.

2. METHODOLOGY

- Literature study on the live project proposal of PM Mitra Park
- Literature study on the environmental damages caused by the industrial development of a textile park
- Journal studies on the sustainable development of the textile industries globally for their finished products
- Literature and live case studies on vertical integration of textile parks along with residential and commercial development
- Comparative analysis of the case studies and their innovations towards sustainable production and manufacturing of their textile products
- Final proposal for PM Mitra Park at Virudhunagar with sustainable and modern prototype technologies
- Results
- Recommendations
- Conclusion

3. PM MITRA PARK PROJECT PROPOSAL

The process of integrating all the manufacturing units necessary for the production of finished textile products is inspired by the vision of Shri. Narendra Modi as "farm to fibre to factory to fashion to foreign in the seven states of India. This project is pre-planned by the government to provide development capital support of INR 500 crores for infrastructure development for greenfield projects and INR 200 crores for brownfield projects in which the parks are owned by the state and the central government in PPP mode. This project is set up to lower the logistics cost of the manufacturing process involved in the textile industry and to increase the strength of the textile industry, supporting the economy of the nation and providing a huge amount of employment opportunities directly and indirectly through this project.

4. ENVIRONMENTAL DAMAGES BY THE TEXTILE INDUSTRY

4.1. SOIL and WATER POLLUTION

The dyeing process in the textile industries, due to their lack of environmental concerns, is majorly responsible for the soil and water pollution of two major rivers, namely the Noyyal and Bandhi rivers, in India, making the water unsuitable for drinking or irrigation purposes. This led to huge environmental costs for the reclamation of the natural sources of fresh water.

4.2. AIR POLLUTION

Lack of integration of the textile industry paved the way for nucleated units serving the manufacturing process, making logistics a necessary option to transport the goods from each process involved in the textile industry, causing carbon emissions through transportation along with larger electricity needs for the operation, which are also met through the combustion of fossil fuels and coal instead of utilizing natural resources, causing carbon emissions through combustion and all pollution.

5. RESEARCH PURPOSE

- Carbon-free, structured framework to mitigate further pollution from the textile industry.
- Attracting foreign buyers through a structured, sustainable framework with an environmentally friendly production process for their finished products
- Improving the strength among the foreign competitors, namely Bangladesh and China.
- Ensuring profitability for the environment and the economy through the innovative development of the textile industry with sustainable and modern technologies.
- The prototype suggested also paves the way for the nation to meet its sustainability goal of becoming a zero-carbon emitter by 2070 through its development vision for the textile industry.

6. ADVANTAGES

The process of integrating all the textile units involved in the manufacturing of the finished textile products offers several advantages, including:

1. Improved collaboration: Integrating all the textile units could provide better collaboration and a better outcome for the finished products.
2. Lowering logistics costs and carbon emissions: Integrating all units could also provide a sustainable source of transportation of materials from each unit within the manufacturing process. Materials from each unit can be transported through conveyor systems, replacing vehicular transportation, which could mitigate the costs involved in the logistical transportation of goods and carbon emissions from the burning of fossil fuels.
3. Energy efficiency and water conservation: Integrating these units together could require a larger area for operation, which in turn could be utilised to generate electricity through solar power to meet their electricity needs. With larger roof areas, these roofs could also collect runoff water through rainwater harvesting systems and utilise it for future purposes as a safer way to face scarcity.

7.DISADVANTAGES

While integrating textile units offers many benefits, there are also some potential disadvantages to consider:

1. HIGHER INVESTMENT COST: Integrating all textile units requires a higher investment cost for the construction of the built-up structures, which, together with the automated machinery necessary for the processes, make for higher investment costs for the project.
2. LONGER TIME PERIOD FOR COMPLETE DEVELOPMENT: As the project tends to be a large-scale development on 1054 acres with a scheme of long-term investments on commercial, hospital, and housing facilities integrated, the project could take a longer time than usual.
3. Lack of uniformity: As this will be the first PPP model for large-scale industrial development in the textile industry, investors lack the ability to follow the design prototype.

8. CASE STUDIES

The case studies that are executed for the research on sustainable development of the textile industry are:

1. ANUGRAHA FASHION MILLS PRIVATE LIMITED
2. KPR MILLS PRIVATE LIMITED
3. VIJI KNITTING PRIVATE LIMITED
4. MITHRA AND CO DYEING PROCESSING
5. NAADHAN AND CO
6. MAHINDRA GLOBAL CITY

8.1. ANUGRAHA FASHION MILLS PRIVATE LIMITED

Anugraha Fashion Mills at Kangeyam in Tirupur district is a vertically integrated textile manufacturing mill except for their dyeing unit, which is being provided outside the textile complex, which is 35 km from this complex. This mill offers finished textile product export services to 07 international buyers, with a production capacity of 350MT/month, knitting capacity of 250MT/month, dyeing capacity of 350MT/month, printing capacity of 50,000 Pcs/day, embroidery capacity of 20,000 Pcs/day, and finally garmenting capacity of 1,00,000 Pcs/day in 350 acres, as well as hostel facilities for workers and housing facilities for their employers. This fashion mill is provided with sustainable sources to cater to almost 90% of their electricity needs through roof-top solar panel installation and a 2MW solar farm to generate electricity for their operational needs. They are also provided with an in-house water treatment plant for reusing treated effluent water for dyeing processes, mitigating the consumption of fresh water. In order to mitigate the usage of LPG gases for cooking purposes for the people inside the complex, an in-house biogas plant recycles food waste to cater to the gas needs for cooking purposes. This integration of all units inside a single complex, excluding the dyeing unit, provides better results on the quality of the finished garments that undergo quality checks for exporting. This integration provides complete in-house production, mitigating the risks involved in quality and delays due to transportation, an inadequate workforce, or inefficient capacity to deliver the job orders on time by other nucleated units in and around the city.

Construction technology	Conventional
Sustainable technologies implemented	Solar power generation . ZLD plant for water recycling and Bio-gas plant for recycling of food waste to generate CBG for cooking purposes
Construction typology	Industrial shed roofing for factory buildings, RCC slab roof structures for office and hostel facilities

Tab -1: Construction configurations of Anugraha fashion mills

8.2. KPR MILLS PRIVATE LIMITED

The KPR mills at Karumathampatti in Coimbatore district are also similar vertically integrated textile production units, twice as big as the Anugraha fashion mills in Kangeyam. This mill is also provided with separate dyeing units outside the textile complex due to the heavy water requirement for the dyeing process to cater to their production needs. This KPR mill has its own open international brands of textiles along with export operations of finished textile garments to more than 15 international buyers globally. This integration of a vertical complex mitigated the logistics costs involved in the transportation of goods for the manufacturing process and also ensured quality production of garments along with following deadlines for delivery. This KPR mill has a spinning capacity of 100,000MT/year, knitting capacity of 40,000MT/year, dyeing capacity of 18,000MT/year, and garmenting capacity of 115 million readymade garments/year. Their careful integration strategy paved the way for a seamless flow of their operations for a healthy business. This KPR mill is provided with 66 windmills, each with a power generation capacity of 45–55 MW, to cater to their electricity needs.

Construction technology	Conventional
Sustainable technologies implemented	Wind power generation . ZLD plant for water recycling and Bio-gas plant for recycling of food waste to generate CBG for cooking purposes
Construction typology	Industrial shed roofing for factory buildings, RCC slab roof structures for office and hostel facilities

Tab -2: Construction configurations of KPR mills

8.3. VIJI KNITTING PRIVATE LIMITED

Viji Knitting Private Limited, located at Ganapathipalayam in Tirupur, is a nucleated knitting unit with a built-up area of around 45,000 sq. ft. and equipped with solar roof panels to generate electricity to cater for 1/3rd of their daily electricity needs with a seamless flow of knitting operations. This unit provides job assistance to knitters involved in the process after spinning and before dyeing in the textile industry. This unit procures yarns for the process of knitting and delivers the knitted fabric to the dyeing process, which is also a nucleated unit catering to the dyeing purposes of the finished yarn and fabric for the process of garmenting. These nucleated units are very popular in textile industrial cities, causing a major need for logistics for production purposes.

Construction technology	Conventional
Building typology	Industrial shed roofing structure
Sustainable technologies implemented	250KWp solar powered roof top with a power generation of 875-975 units/day
Industrial identification	Nucleated knitting unit serving job orders.

Tab -3: Construction configurations of VIJI knitting

8.4. MITHRA AND CO DYEING PROCESSING UNIT

Mithra and Co. Dyeing Processing Unit is also another nucleated dyeing processing unit for dyeing finished yarns and fabrics for the process of garmenting the final products. This dyeing unit is provided with an in-build effluent treatment plant with a capacity of 1lakh litres in 1.5 days to minimize the consumption of fresh water for the dyeing process. This in-built effluent plant is provided by perfect drains that connect to the tank through separate built-up drains without contaminating the soil. This unit is also provided with a 200 KW solar-powered rooftop with an electricity generating capacity of 150–200 units per day. Their energy requirement per day is around 850–950 units, which is $1/4^{th}$ of the need with a waiver on electricity bills of around INR 50,000 per month.

Construction technology	Conventional
Sustainable technologies implemented	Roof-top solar powered, In-house ZLD plant for water recycling.
Construction typology	Industrial shed roofing for factory building with maximum daylight utilization from the G.I roofing materials
Industrial identification	Nucleated Dyeing unit

Tab -4: Construction configurations of MITHRA dyeing processing

8.5. NAADHAN AND CO

Naadhan and Co. is a domestic retailer of recycled cotton garments at 15 Velampalayam in Tirupur. This company provides job orders for all nucleated units involved in the OYE knitting garment manufacturing process, such as spinning, knitting, dyeing, printing, embroidery, stitching, checking, ironing, and packing, in different units and stocks the final finished garments within the office to cater to their delivery of business through platforms like AJIO, MYNTRA, etc. This kind of nucleated business unit is also popularly found in the cities of textile industry developing regions possessing a need for vehicular transportation, causing carbon emissions on a large scale.

Construction technology	Conventional
Sustainable technologies implemented	Nil
Construction typology	RCC built-up structure only for the admin activities of the business
Industrial identification	Nucleated domestic manufacturer and retailer of open end yarn fabric.

Tab -5: Construction configurations of NAADHAN and CO

8.6. MAHINDRA GLOBAL CITY

Mahindra Global City at Chengalpattu in Chennai is an industrial township organized on 15,000 acres, which includes 1,000 acres of reserved forests consisting of 7 lakes within the complex. This study was carried out to analyze the area allocation provided for housing units such as villas and apartments. From the study, it is clear to state that 62% are for individual villas and 38% are for high-rise developments for housing communities. This Mahindra global city is provided with efficient water and energy conservation technologies to cater to their needs for electricity and water. This city is also provided with a bio-gas plant to generate CNG (compressed natural gas) fuel for transportation. This project was also awarded gold certification from the IGBC (Indian Green Building Council).

8.7. COMPARITIVE ANALYSIS OF THE CASE STUDIES

Key specifications	Anugraha fashion mills pvt.ltd.,	KPR mills pvt.ltd.,
Vertical integration in textile manufacturing process	Excluding dyeing unit	Excluding dyeing unit
Site area	35 acres	65 acres
Building typology	G+3 industrial shed roofing for factory developed sites	G+3 industrial shed roofing for factory developed sites
Sustainability in practice	Solar power generation, bio-gas plant for cooking gas, in-house ZLD plant for water recycling, vertical integration minimizing carbon emission through transportation.	Wind power generation ,in-house ZLD plant for water recycling, vertical integration minimizing carbon emission through transportation.

Tab -6: Comparitive analysis of vertical integration in ANUGRAHA and KPR mills pvt.ltd.,

9. Final proposal for PM MITRA PARK at VIRUDHUNAGAR with sustainable and modern prototype of technologies

9.1. PROPOSED SITE

The state government of Tamil Nadu, on behalf of providing industrial development in the southern regions, had its proposal with the SIPCOT land area of 1054 acres at E. Kumaralingapuram in Virudhunagar district. There are no further delays in the land acquisition process as the land is already pre-owned by the state government of Tamil Nadu for industrial development purposes. This PM Mitra Park at Virudhunagar will be funded with approximately INR 500 crore from the Central Government of India for the development of the textile industry.

9.2. PROPOSAL

9.2.1. EFFICIENT LAND ALLOCATION

The area allocation is as per the norms of DTCP (directorate of township and city planning) and CBR (combined building rules) for efficient utilization of the available land of 1054 acres. This 1054-acre area is provided with a green belt of 116.51 acres of xeriscaping, which requires less water for irrigation purposes, industrially developed sites at 508.17 acres, individual housing units at 40 acres, and high-rise housing units at 25 acres, along with 15 acres for hostel facilities for the workmen, a bio-gas plant at 25 acres, roads at 94.32 acres, 100 acres for logistics parks, 40 acres for other sewage and waste water treatment plants, 20 acres for multi-specialty hospital, 40 acres for commercial spaces, and 50 acres for ZLD treatment plant, including man-made ponds to collect surface run-off water with rain and storm water management facilities.

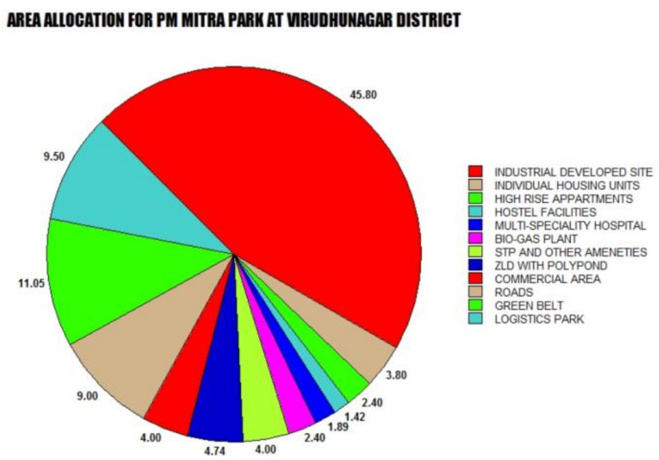

Fig -1: Area allocation proposal for effective and efficient utilization of the industrial textile township development

9.2.2. PROTOTYPE FOR BUILT-UP STRUCTURES

A prototype for the built-up structures is suggested with pre-cast technology for industrially developed sites and high-rise and mid-rise housing and hostel facilities, along with commercial and hospital spaces, and other amenities in the area of conventional construction for areas allocated for individual villa housing plots. This 40-acre area allocated as individual plots for villas will initially cater to a temporary pre-cast batching plant to fabricate the pre-cast elements necessary for the construction of the pre-cast structures. The industrial development sites are provided in 508.17 acres to provide a uniform specification for built-up structures, of which 496.25 acres are to be specified with precast industrial shed roof buildings in the allocated plots for each unit, while 11.92 acres of site are provided for mid-rise vertical development structures to cater to the industrial needs for the production of textile garments. On considering the previous studies on textile integrated private units, the construction time has an overrun of longer than expected due to inadequate manpower and machinery resources, leading to delays in the completion of the project through conventional methods, so this suggested prototype could enhance uniformity in the project along with the value for money in its quality.

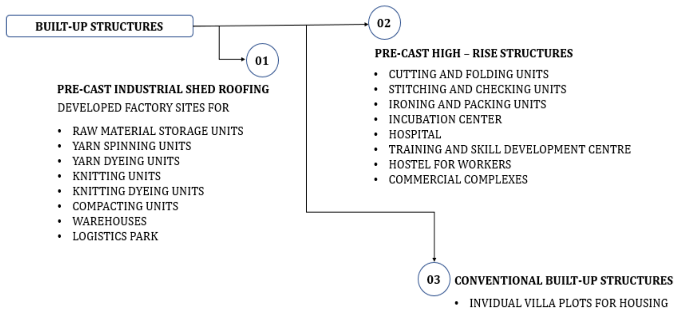

Fig -2: Prototype and it's built-up structures for different purpose buildings within the PM MITRA PARK AT Virudhunagar district in TAMILNADU

9.2.3. WATER LESS DYEING AND ZLD TREATMENT PLANTS

ZLD (zero liquid discharge) plants have now become a mandatory process to be licensed to provide dyeing services in the textile industry in India. On average, 1kg of fabric requires 250 litres of water for the process of dyeing in the textile industry. These dyeing units are termed to require a huge amount of water amongst other processes in dyeing. This dyeing effluent water is being treated in the ZLD plants and is being recycled and reused for dyeing and landscape purposes. Apart from the innovation of other research and developments in the textile industry, an important masterpiece could be the invention of waterless dyeing machines. The water-less dyeing process is a new technology in the process of dyeing fabric or yarn without the use of water. This water-less dyeing machine uses liquid carbon dioxide heated in a controlled environment to probably minimize the larger needs of water for the process of dyeing in the textile industry.

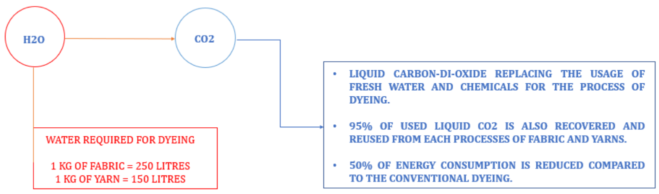

Fig -3: Alternative suggestion for the process of dyeing in the textile manufacturing process.

This proposal for dyeing units is provided to meet a fabric production capacity of approximately 6250 MT/month.

As 1 MT = 1000 kg, and 6250 MT = 62,50,000 kg,

On an average of 24 working days, 260 MT (i.e., 2,60,000 kg)

Water required for dyeing 1kg of fabric is 150–350 litres, taking 250 litres as an average. These dyeing units require 6,500,000 litres of water per day. This water requirement could be mitigated by providing dyeing units with water-less dyeing technologies and utilizing fresh water for drinking and other irrigation facilities.

9.2.4. WATER CONSERVATION THROUGH EFFICIENT STORM AND RAIN WATER MANAGEMENT SYSTEM

Surface run-off water is being collected from the roofs and terraces of the built-up structures and roads through the drains to the water storage tanks that are provided as man-made ponds within the site to cater to the storage necessities of the water for later utilization. Providing prototype accessory roads within the complex with drains could be a suggestion to collect surface runoff water from the roads.

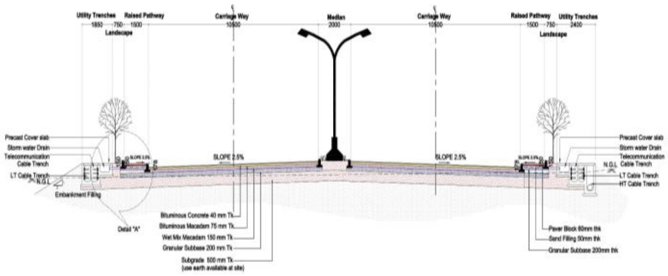

Fig -4: Prototype of main access road with 21M width with trenches for High tension and Low tension cables with telecommunication trench and trench for storm water drain collected from the roads provided with 2.5% slope to the raised pathway.

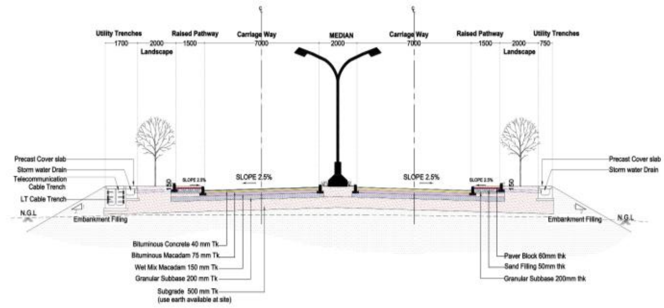

Fig -5: Prototype of main access road with 14M width with trenches for Low tension cables with telecommunication trench and trench for storm water drain collected from the roads provided with 2.5% slope to the raised pathway.

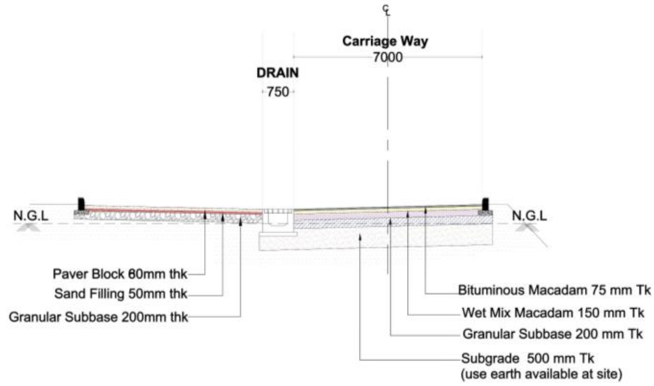

Fig -6: Prototype of service access road with 7M width with trench for storm water drain collected from the roads and the parking area provided with 2.5% to the drain.

On considering the annual rainfall recorded in the previous year in the Virudhunagar district of 724mm from the rooftops and terrace areas of the built-up structures, the surface runoff water could also be collected in the storm drains and deposited in the man-made poly ponds within the industrial complex for further utilization.

ANNUAL RAINFALL	**724 MM**
WATER CATCHMENT AREA	30,00,000 SQ.M (APPROX.,)
WATER HARVESTMENT	2,17,20,00,000 Litres/annum

Tab -7: Harvestment of surface run-off water catchment

9.2.5. ON-SITE SOLAR ROOF TOP

This larger industrial development could also be provided with 75% rooftop solar panels for power generation for industrial roofed structures and 50% rooftop solar panels on the terraces for power generation to minimize the carbon emissions from the combustion of fossil fuels, coal, etc. Providing roof-top solar panel panels could probably meet half of the energy consumption necessary for the overall operations of this textile industrial development.

The area required for the installation of a 1 MWp solar plant is 75,000 sq. ft. with a power generation capacity of 3,500–4,500 units per day. The projected approximate roof and terrace area of the industrial complex is around 1,456,673,300 sq. ft., which excludes the other services provided in the roof and terrace areas of the built-up structures that can be provided with solar panels to generate electricity.

Hence,

Available roof area / area required for 1 MWp solar plant = solar roof top panel installation capacity

1,45,67,300 / 75,000 = 194.23 MWp, with a power generation of 3,30,000–4,50,000 units/day.

This prototype could mitigate the carbon emissions from coal power generating stations. The carbon emissions from utilizing coal could be 950 GMS per KWp, and hence for 330 KWp, the carbon emissions will be 3,13,500 kg/day. This carbon emission could be mitigated through the solar-powered industrial development in Virudhunagar district in Tamil Nadu.

APPROXIMATE ROOF AREA	1,45,67,300 Sq.ft.,
AREA FOR 1MWp SOLAR	75,000 Sq.ft.,
SOLAR ROOF-TOP CAPACITY	194.23 MWp

Tab -8: On-site solar power generation from the rooftops of the industrial shed roof structures and terrace of the slabbed roof structures within the textile park.

9.2.6. CONVEYOR SYSTEM FOR TRANSPORTATION OF GOODS FROM EACH PROCESS INVOLVED IN THE PROCESS OF TEXTILE MANUFACTURING

This suggestion could be an innovation in the process of vertical integration in a textile manufacturing region to mitigate the vehicular transportation necessary to transport the finished goods from each process involved in the manufacturing process of the textile garments. This supply chain in the manufacturing processes could be connected with a conveyor system for transportation of the finished goods from each process. This conveyor system could also minimize the emission of carbon dioxide through vehicular transportation.

9.2.7. BIO-GAS PLANT

This textile township development with housing and hostel facilities tends to emit large quantities of food waste that could be collected every day. This food waste could also be recycled on site with the installation of a bio-gas plant to provide bio-gas, which could be an alternative suggestion to using CBG (compressed bio-gas) cylinders instead of LPG (liquified petroleum gas) cylinders.

9.2.8. IBMS INTEGRATION

Integrating the textile township development with intelligence building management facilities could make the process of monitoring and managing the services and facilities more conservative. This installation cost could be higher, but providing artificial intelligence services could be more effective for facility management of the textile complex.

10. RESULTS

Implementation of the suggested prototype results in better utilization of land area and service efficiency in energy and water consumption and management within the textile complex. This could also support mitigating the emission of carbon within the textile complex. A proper vertical integration of the textile complex through sustainable and modern prototype technologies could also enhance the seamless flow of operations with a better outcome in the quality of finished textile products. This sustainable production could also probably attract foreign buyers to provide job orders for their development in the production of their products in an environmentally friendly manner. This vertical integration can also support the nation's goal of becoming a net-zero carbon emitter by 2070.

CONCLUSION

The application of an integrated textile complex is a profitable process to be incorporated in the manufacturing of textile garments. This vertical integration mitigates the delays in delivery of the job orders in each process due to the involvement of a third party for the production process, which involves a lot of vehicular transportation with the loading and unloading of the finished materials from each process. By providing vertical integration, the buyers feel secure in their job orders without delays in delivery of the final finished products that are to be exported. This careful vertical integration of all sustainable and modern prototype technologies with their proven benefits could add value to the international competitors of the nation in the textile manufacturing and export markets globally.

RECOMMENDATIONS

Several recommended prototypes can be provided for the vertical integration of the textile complex, such as roof-top solar power generation, Man-made poly pond to cater to water needs met through the collection of surface run-off water from the roofs, terraces, and roads; ZLD plant for treating, recycling, and reusing the effluent water from the dyeing units; Dyecoo's water-less dyeing proposal to mitigate the large water necessity for the manufacturing of dyeing yarns and fabric, Xeriscaping to provide less water for their irrigation purposes; a conveyor system mitigating the usage of vehicles for transportation of finished goods from each manufacturing process involved in the textile industry to have a seamless flow of operations leading to better outcomes for their finished final products;

REFERENCES

[1] Samit Chakraborty, "A detailed study on environmental sustainability in knit composite industries of Bangladesh", https://www.researchgate.net/publication/311881677

[2] Arindam Basu, "Sustainability in Textiles and Apparel industry", https://www.researchgate.net/publication/343064583

[3] Catarina costa, Carla J Silva, Nuno g. Azoia, Eduardo F. Marques, "Textile Industry in a changing world: Challenges of Sustainable development", https://www.researchgate.net/publication/346420826

[4] Rinsey Antony, "Eco friendly Textiles," https://www.researchgate.net/publication/327498497

[5] Md. Touhidul Islam, "Sustainable Textile Industry: An overview", https://www.researchgate.net/publication/361851233

[6] Sarif Patwary,"Clothing and Textile Sustainability: Current state of Environmental Challenges and the Ways Forward", https://doi.org/10.31881/TLR.2020.16

[7] Sohel Rana, Shabaridharan Moorthy, Subramani Pichandi, Amitava Bhattacharyya,"Carbon Footprint of Textile and Clothing Products", https://www.researchgate.net/publication/276193965

[8] Walter Leal Filho, Maria Alzira Pimenta Dinis, Hilde Heim, Haruna Musa Moda,"An overview of the contribution of the textiles sector to climate change", https://www.researchgate.net/publication/363270376

[9] Abu Shaid, Md. Showkat Osman, Md. Abdul Hannan, M. A. Rahman Bhuiyan,"Direct Reusing of Textile Watsewater in Scouring-Bleaching of Cotton Goods Devoid of Any Treatment", International Journal of Engineering Research and Development, e-ISSN: 2278-067X, p-ISSN : 2278-800X, www.ijred.com , Volume 5, Issue 8 (January 2013), PP.45-54

[10] Toral Shindhal, Parita Rakholiya, Sunita Varjani, Ashok Pnadey, Huu Hao Ngo, Wenshan Guo, How Yong Ng, Mohammad J. Taherzadeh,"A critical review on advances in the practices and perspectives for the treatment of dye industry wastewater", BIOENGINEERED 2020, VOL. 12, NO. 1, 70-87, https://doi.org/10.1080/21655979.2020.1863034

[11] Rachana S. Harane, Ravindra V. Adivarekar,"Sustainable processes for pre-treatment of cotton fabric", Harane and Adivarekar Textiles and Clothing, Sustainability (2016) 2:2, DOI 10.1186/s40689-016-0012-7

[12] F. Orts, A.I. del Rio, J. Bonastre, F. Cases,"Study of the reuse of Industrial Wastewater After Electrochemical Treatment of Textile Effluents without External Addition of Chloride", www.electrochemsci.org