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DESIGN OF A SUSTAINABLE WAREHOUSING

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Abstract: For logistics systems, sustainable engineering is critical. This research provides a long-term solution to firstly labour turnover and absenteeism issue that was at an every other warehouse. The issue is because of changing variability of worker demand across time, activities and mainly when we see seasonality in operations, resulting in labour surpluses in some periods and shortages in others. Warehouses schedule picker/associates/labour for numerous activities, at any point of time considerable manpower surpluses or, in some cases; shortages are being experienced by warehouse managers. Secondly if we talk about handling of different activities like of warehouse operations, storage, distribution and economical aspects like cost of distribution, energy efficiency, special activities (those activity performed which is generally not routine activity and also not mentioned in client agreement), there are numerous sustainability aspects to consider and by this research study we can gain and insight about how to execute different activities by coordination in sustainable way.

There are many warehousing companies that wants to execute sustainability practices but as always on the ground situation is dynamic and complex enough for companies to attain sustainability easily by mere board room planning so it is difficult not impossible to adhere to top management decision to follow sustainability to a 100% hit. There should be high level of experience on part of warehousing managers to accomplish sustainability practices as well as operational goals, agendas of the warehousing companies and to adopt in their current business environment, particularly when they execute client warehousing needs such as warehousing and distribution.

Keywords: Sustainable warehouse, Sustainability, Warehouse design**.**

1. INTRODUCTION

A warehouse plays a vital role in context of storage, inbound, outbound and distribution operations. By merely thinking and planning to work on the basis of sustainability the on the ground situation are not always, though future economic viability of company depends on it. Sustainable practices is having high impact particularly on economic (compensation, expenditure, vendor pavements etc) and social sustainability (cultural, employee welfare and environmental) as part. The main challenge in following sustainable practices as there is constant fluctuations and variations in demand and supply in the market of these a company can do a best by absorbing the consequences of changing market dynamics. We cannot at any moment deduce that at what percentage or by what numerical

difference that how much there would be gap in demand and supply though some situations have best observed seasonality but still knowing this is not an conclusive task. It is best shown these days when there is a large gap in demand. These days warehousing companies are paying more and more attention to sustainability issues like increasing utilities cost as the operations are scaling by the time and recently activities are being scrutinized by looking to their environmental sustainability of bearings.

As defined by the Brundtland definition sustainable development is “development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). Three of the pillars of sustainability are environment, society and economy (Glavic & Lukman, 2007). We can see many ways in which we can handle our warehousing fulfilment needs in a more sustainable and that too when we can put operations scaling as a factor. In this thesis we have shown that there are numerous ways that is examined, adjusted and evaluated on several criteria. If we fail to efficiently utilise these said resources then we are not able to coordinate operations in a sustainable way. In outbound operations picking is extreme Intensive process that consumes a lot of energy, capital and human resources; its impact on the sustainability of the entire warehouse is very high. An efficient use of resources is a prerequisite for sustainable order picking and thus for sustainable warehousing (Andriansyah et al, 2009). Numerous articles cover scheduling, routing, and other optimization methods. Use of mobile resources in the warehouse. In this thesis our main focus would be on minimizing our operational expenditure, plugging leakages which incur and create an obstacle in running operation in a sustainable manner, exploring various way to implement cost-saving ideas, minimizing

2. LITERATURE REVIEW

This study can be positioned within the study dealing with workforce planning Problems, activity planning problems, and resource sustainability. Sustainable warehousing is one of the key elements in sustainable supply chain storage. Sustainable warehouses include activities such as terminals and warehouses Location, proper storage and disposal of dangerous goods, donation of surplus or Training for remanufactured inventory and safe forklift operation to the community (Carter and Jennings, 2002). Modern storage activity, on the other hand, includes many implementations that actually create value. Examples of these implementations include disassembly, integration, delay, cross ship, final assembly, and packaging activities (Bowersox, 2002). In real life, most storage and transportation companies consider little about the environmental impact of their business and do not understand the social impact of their business. Sustainable warehousing businesses need to not only consider economic factors such as rent and operating costs, but also weigh the social and environmental impacts that occur on and around the warehousing premises (Tan et al., 2010). Shift Planning addresses the issue of choosing from a pool of potentially large candidates. Assign employees to each shift to meet demand and shift to work together.” Within the selected shift the position of the break it will be considered unless modified. Problems are usually displayed with a specific number of evenly spaced daily planning periods. Given the number of workers available, the goal is usually to find a schedule that minimizes understaffing and overstaffing. As natural resources are contested, it is important that the concept of "doing more with less effort" applies throughout the product life cycle. In many cases, it is not immediately clear whether sustainability will help achieve this goal. Reducing the intensity of materials and energy in goods and services, reducing the spread of pollution, improving the recyclability of materials, extending the life of products and maximizing the sustainable use of renewable resources are all sustainable. It will be an important driving force for the

possibilities. Investing in sustainability will take much longer, but future benefits in terms of economics and environmental protection will be enormous Mosovsky J, Dickinson D, Morabito J (2000).

(Uysal and Tosun, 2012) had found and had set standards for sustainability model mentioned below:-

• Cost: Cost is one of the factors that greatly affect the location of the facility. Cost criteria are evaluated taking into account labour costs, shipping costs, fees and land costs.

• Manpower: This standard defines the level of qualified manpower at a location and the degree of availability of such manpower.

• Transportation: DM considers ease of transportation, traffic density, and distance from alternative camp to main camp.

• Environment: CO2 minimization and other environmental guidelines are taken into account in the decision-making process.

• Geographic location: This criterion defines the availability of space that changes depending on the structure of the alternative area.

Sustainability in an organisation is driven by various factors. The magnitude by which a company faces up to the drivers and issues of sustainability may vary depending on the size, location and number of supply chain players involved (Krishnan et al., 2012). The advent of extreme climate change and global warming has spurred governments to enact laws on the environmental and social impacts of organisations and industries. The aim is to effectively control pollution and reduce the resultant environmental damages Sathiendrakumar, R. (2003).

Research Reliability and Validity the concepts of reliability and validity are increasingly used in today's qualitative analysis. In a qualitative study, Anderson, C. (2010), "validity refers to the honesty and authenticity of the study data, and reliability refers to the reproducibility and stability of the data." To do so Triangulation is used to ensure the effectiveness of components and elements. Altrichter, H. (1993) states: Triangulation "provides a more detailed and balanced picture of the situation." According to O`donoghue, T. (2003), triangulation is "a method of cross-checking data from multiple sources.

3. METHODOLGY

Based on the literature review, identified various factors and elements of a sustainable warehouse. Discussion with industry experts, and proposed a conceptual model of a sustainable warehouse.

4. PROPOSED SUSTAINABLE WAREHOUSE DESIGN

we have taken certain areas where we can conduct and conclude this conceptual study and we can see that to make a warehouse truly sustainable these areas has to be explored by the researchers and managers and these areas in themselves are major areas in which after considerable amount of deliberation the areas categorised and mentioned can make a warehouse sustainable.

SUSTAINABILITY WAREHOUSING AREAS

1. **Warehouse management system**
2. **Mechanical handling equipment**
3. **Warehouse facility design**
4. **Inventory management**
5. **Warehouse staff**
6. **Warehouse operations**
7. **On site facilities**
8. **Warehouse layout**

All these factors are briefly described and discussed as these are all together helps warehousing model to achieve an optimal sustainability goal. Please find below all the factors mentioned above briefed in detail:-

Warehouse Facility Design

Warehouse facility design is an area where warehousing managers can do intensive study in a way to research for re-structuring existing warehouse design or to design a warehouse keeping in mind the sustainability goals for future. We have argued and discussed in this paper what would be the essential factors to be applied in the warehouse facility design so that it contributes to the overall sustainability goals.

Sustainability factors for facility design are mentioned below:

• **Renewable power resources**: This detail is important and strategic in nature as when a question arises that how we have to power are warehouse without incurring a costly power utility bill.

Things that we need to evaluate and study before selecting any of the above mentioned energy sources:-

- Operational viability
- Cost saving when we compare it to non-renewable energy assets

- Compliance norms
- Regulatory requirements
- Safety
- Infrastructure installation cost and space taking especially in warehouses as space utilisation and optimization is critical as available space for inventory is source of income for the warehouses
- Operability, reliability and dependability

• **Daylight usage:** Sunlight is the most abundant sources of energy on our planet. The sun not only provides a renewable energy source to power a warehouse but it also has a usage of illuminating a warehouse in the day light time. We need not to power on various lighting or illuminating appliances during the day light timings which would be between 5:00 am to 6:00 pm a hour can be adjusted depending upon the season.

Discussing about interior of the warehouse, the designing of insides of a warehouse should be in a way that it acts like a catalyst in providing luminosity and illumination inside the warehouse facility below are mentioned some measures to do that:-

- Install Skylights on roof: Skylights are an amazingly effective way of pulling in natural light.
- Adding reflective features inside warehouse
- Without compromising security of the warehouse, walls could be replaced with fibber sheet or glass blocks but it should be at a certain height and protected with iron mesh for security purpose
- Usage of glass or reflective tiles in warehouse
- Application of high gloss paint on walls
- Applying lighter and brighter interior paints on roof and wall
- Interior sun shades that blocks glare and regulates distribution of sunlight inside the warehouse

• **Artificial lights scheme:** In summary, a thorough analysis is needed to determine the lighting needs of different areas of the warehouse weather inside the premises or outside taking into account peak and off-peak hours, the amount of daylight available have to be taken for consideration.

• **Temperature control:** The temperature inside the warehouse must be favourable and in conformance with the warehouse personnel as the ambient temperature has direct impact on the productivity of the warehouse staff working on the ground. Excessive heat, cold, humidity could hamper workforce productivity and can even affects workforce heath as unpleasant temperature inside the warehouse could also lead to faint, tiredness, drowsiness of the warehouse staff. The temperature control or say what temperature ought to be depends upon factors as follows:-

- Temperature outside the warehouse.
- What type of inventory is stored?
- Ambient temperature without control inside the warehouse.
- Weather conditions.
- Temperature according to the comfortability of the warehouse staff.

- What type of machines (service inventory) is there in warehouse and there operability, machines tends to break down due excessive heating and heat generated from the use of mechanical handling equipment such as forklifts, etc.
- Location and orientation of the warehouse.
- The type of insulation used in the walls, and the volume and thermal mass of the installation.
- Humidity.

Water usage: Brown and green roofs, roof drainage technology, water irrigation technology, and state-of-the-art sanitation can also be used to save water. In addition, by considering an air cooling system, you can avoid the water consumption of refrigeration compressors, chillers and steam boilers.

• **Noise Pollution:** Steps to prevent noise pollution in warehouse:

- using quieter equipment or a different, quieter process;
- engineering/technical controls to reduce at source the noise produced by a machine or process;
- using screens, barriers, enclosures and absorbent materials to reduce the noise on its path to the people exposed
- The use of rooftop greening to attenuate sound transmission

Biodiversity: it refers to various forms of organisms that exist in a particular location, such as natural vegetation, forests, animals, microorganisms, waterways, and ecosystems. Biodiversity is needed to sustain life on Earth. Also, environmentally friendly companies will be more motivate the employee.

Warehouse layout configuration

The warehouse layout plays an important part in warehousing sustainability as the layout determines the operational efficiencies and effectiveness that can be achieved.

A warehousing layout is having a significant impact on the following things:-

- Storage space and costs
- Flexibility of storage operation
- Inventory optimization
- Product flow (from ready to dispatch to put-away)
- Workforce productivity : the more streamlined the layout is the more productivity could be expected from workforce
- Ease in movement of material handling equipment without any obstacles
- Locating of inventory for dispatch
- Making locations for product put-away
- Ease in pallet relocation
- Ease in movement of product as a single unit load on a single pallet as the movement on a single pallet save time and workforce engagement

- Locating of particular inventory for dispatch
- Passage or say aisle design optimization can lead to storage of more inventory in a limited space
- Responsiveness to customer orders
- Reduction in costs
- Staff safety

• **Storage system:** a warehousing storage system is a process which specifies that how economically ,safely inventory can be retained, maintained, retrieved and put-away could be done. The main purpose of a storage system is to maintain inventory optimally by keeping following material and structural constraints in mind:-

- Nature of material
- Material shape and size
- Storage capacity
- Simple access
- Room usage
- Class base storage
- Racks, pallets and shelfs

Aisle passage way design: Passage design plays an important role in vehicle route and picking optimisation. Width of the passage is important as in vehicle route optimisation and strategy we have to see following things for sustainability:-

- Aisle orientation
- Length, width of the passage
- Travel time
- Congestion:
- Safety
- Space utilization

Functional structure: there are various functional areas in the warehouse as follow:

- Acceptance area
- Storage area
- Picking area
- Receiving area
- Quality check area
- Dispatch area
- Damage area
- Hold area

Inventory management

- Keep track of your inventory and offers centralized view of stock
- Controlling of costs by making stock reports for analysis of your inventory
- Prevent stock out situation and meeting customer expectations
- Helps in managing and planning inventory storage
- Reduces the time for managing inventory by keeping records in place
- Protects from fluctuations in demand and supply
- Reduces the risk of excess or shortage of inventory
- Check loss of materials due to pilferage, theft and handling damage
- Minimizing administrative work load
- Facilitates accounting activity
- Reduces the risk of loss

Warehouse management helps maintain the optimal level of inventory that can be met fluctuating customer demand.

• **Inventory optimization:**

Factors that need to be balanced for achieving optimal inventory levels

- Inventory visibility
- Replenishment cycle
- Storage costs
- Customer sales returns management
- Accurate forecast data
- Available storage space

All of these competing factors need to be balanced to achieve optimal inventory levels.

The one stop solution and the most beneficial is to implement warehouse management system.

• **Inventory accuracy:** maintain inventory accuracy is beneficial for getting real time stock levels and planning and storage management could be done by maintaining inventory accuracy.

Things that helps to maintain inventory accuracy

- Inward-outward movement report also known as consignment tracking report
- Warehouse management system
- Stock counting
- Dispatch or inward intimations like bills or shipping documents

Warehouse theft and waste management and loss:

Factors that are prevalent in this context as follow:-

- Warehouse security systems and devices like cctv, alarms, security guards
- Regular inventory audits to check shortages, excesses and damages
- Warehouse security sops
- Waste management
- Insurance of materials and warehouse

Warehouse worker management framework

The following are some points which to be taken for consideration while planning operational strategy for warehouse worker management:-

Employee training:

Advantages

- Higher productivity
- Increased employee retention
- Less accidents
- Low supervision
- Achieving sustainability in working of a warehouse worker

Work-life balance

Advantages

- Increased productivity
- Low employee turnover
- High rate of employee engagement
- Development of positive behaviour towards work
- More employee participation
- Positive approach towards sustainability goals of warehouse

Shift management

Advantages

- Working flexibility
- More operations capacity handling
- Avoidance of rotational shifts
- Schedule consistency
- Backup in case of absenteeism
- Flexible working hours
- Can lead to growth in operational capacity of warehouse
- Worker attentiveness

- Well-being of worker mental heath

Workplace safety and security

Advantages

- Less illness cost
- Sense of security in working at warehouse
- Leads to increased productivity
- Less employee turnover
- Improved health and wellbeing

Optimal storage equipment

Advantages

- High degree of inventor control
- Complex activity can be performed by employee
- Improvement in product flows and reduction of tat duration

Material Handling Equipment

MHE helps in warehousing operations in following ways:-

- Material relocation inside the warehouse
- Maximized load handling
- Time saving in transferring of materials
- Safe handling as per nature of material
- Reduces manual load of pickers
- Minimizing TAT for put-away and dispatch

MHE helps a warehouse in achieving requisite levels of effectiveness with efficiency. Different types of material handling equipment are used by a warehouse as shown in the illustration below:-

- MHE sources of energy
- MHE upkeep and service: maintenance and upkeep of MHE should be on three following basis:-
- Preventive maintenance
- Timely maintenance
- Corrective maintenance
- Vehicle Training

Warehouse Processes

Warehouse procedures refer to a wide range of physical actions that occur on a daily basis in the warehouse. Offloading, receipt, put-away, storing, pallet movement, pallet management, reworking, picking area replenishing, case picking, extraction, loading, returns handling, inventory counting, and so on are all examples.

- Inbound processes
- Storage processes
- Picking processes
- Outbound processes

On-Site Amenities

The warehouse needs to support employee welfare and help manage any emergency situations

- Washroom
- pantry
- Emergency room
- Cross-docking facility
- Recycling infrastructure

System for Warehouse Management

A warehouse management system (WMS) is critical for running a world-class sustainable warehouse. It manages the storage and movement of goods in a warehouse, as well as all associated transactions such as receiving, transporting, stocking, and picking.

• Performance measurement: Keeping track of all key metrics (KPIs) for measuring performance is among the core functions of WMS.

5. CONCLUSION

This study is an important step in making warehouse sustainable development a reality. It has both practical and academic value because the advantages can be realised by both distribution network managers and researchers. It clearly demonstrates that measures to achieve sustainable development goals are not incompatible with economic benefits. As a result, socio - environmental advancements can be seen as having both short - range and long profitability. Furthermore, it is not better to follow all best practise activities at once because this process must evolve over time. As a result, the selection of best practises derived from this research can be used as a road map for establishing future aims and objectives. The primary objective of this study was to assess each element's 'primary impact,' rather than its implicit and secondary effects. As a result, most of these elements may have an impact on

other aspects of sustainability that have already been identified. It is suggested that this model be further investigated and improved through much more qualitative approach, with the goal of eventually extending it to a quantitative approach.

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