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Editorial

Good teaching emanates from Research. The teachers' love for research and their experience in research are vital for the growth of the institution. Any institution is judged by the level and extent of the research work it accomplishes. This sets in a regenerative cycle of excellence. Experience of research leads to quality teaching and quality teaching imparted to the young in turn enriches the research. The campus dynamics needs such type of research teaching research environment.

Technology is the non-linear tool available to humanity, which can affect fundamental changes in the ground rules of economic competitiveness. Science is linked to technology through applications. Technology is linked to economy and environment through manufacture of knowledge products. Economy and environment are linked to technology, which promotes prosperity to the society. We have to use innovation to generate high value added products for becoming a global player. The foundation for academic excellence is the research.

Let us take would like to give, how you young friends can become a great inventors or discoverers. What is the unique nature of thinking minds of discoverers and inventors of the world. "Inventions and discoveries have emanated from creative minds that have been constantly working and imaging the outcome in the mind. With imaging and constant effort, all the forces of the universe work for that inspired mind, thereby leading to inventions or discoveries". Now there are three unique friends to make you great; they are great books, great human beings and great teachers. Teachers should have the capacities to nurture the "creative minds" and "imagining minds".

So this conference has been designed to stimulate the young minds including Research Scholars, Academicians, and Practitioners to contribute their ideas, thoughts and nobility in these disciplines of engineering. It is a pleasure to welcome all the participants, delegates and organizers to this International Conference on behalf of IRAJ Research Forum and ITR family members. This conference has received a great response from all parts of the country and abroad for the presentation and publication in the proceedings. I sincerely thank all the authors for their valuable contribution to this conference. I am indebted towards the Reviewers and Board of Editors for their generous gifts of time, energy and effort for the Conference.

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TO ASSES SERUM ALKALINE PHOSPHATASE LEVEL IN CHRONIC KIDNEY DISEASE PATIENTS

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Abstract - The study was conducted on 120 normal patients and 120 CKD patients attended to the OPD/IPD of SMI Hospital, Dehradun. The various biochemical investigations (Serum Creatinine, Serum Uric acid, Blood Urea and Alkaline phosphatase) of these patients were assessed. In our study Serum Creatinine, Serum Uric acid, Blood Urea and Alkaline phosphatase levels were significantly higher in study group than control group.

Keywords - Chronic Kidney Disease, Serum Creatinine, Serum Uric Acid, Blood Urea and Alkaline Phosphatase

I. INTRODUCTION

Chronic kidney disease (CKD) appears to be a worldwide health concern(1). Chronic renal failure (CRF) is a progressive illness caused by the kidney's inability to maintain normal low levels of protein metabolism products such as urea, hematocrit, sodium, water, potassium along with normal blood pressure and acid-base balance(2). Changes in lifestyle and renal disease pathogenicity may be contributing to the present stage of CKD. Decades back, glomerulonephritis was a key factor in the development of renal disease (1). Infections are no longer as common as they formerly were as a cause of renal disease. Furthermore, recent evidence shows that hypertension, progressive nephritic syndrome, diabetes mellitus, chronic hypertension, long-term polycystic kidney disease, and chronic pyelonephritis are the leading causes of kidney disease globally(3, 4 & 5). Hepatic cells and bones synthesize alkaline phosphatase as well intestine; kidney and leukocytes synthesize alkaline phosphatase in small amount(6).

Alkaline phosphatase is a marker for bone disorders and markedly in patients with chronic renal failure(7).

II. AIMS AND OBJECTIVES

The aim of our study was to estimate serum creatinine, blood urea, serum uric acid and serum alkaline phosphatase in chronic kidney disease patients.

III. OBJECTIVES

- To estimate Serum Creatinine, Blood Urea and Uric Acid in CKD patients.
- To estimate Serum Alkaline Phosphatase in CKD patients.

IV. MATERIAL AND METHODS

A hospital based retrospective case control study was conducted on patients attended the medicine OPD and Emergency of Shri MahantIndresh Hospital, Dehradun for period of 12 months. A total no of 120 CKD Patients and 120 normal subjects in the age group 20-90 years were selected randomly for the study. Exclusion criteria was Dehydration, Smokers, on drugs, alcoholic, Diuretics, CVD, Pregnancy etc. and age less than 20 and more than 90 years. All the 240 subjects (120 controls and 120 cases) were analyzed for serum creatinine, blood urea; serum uric acid and serum alkaline phosphatase were estimated on a fully automated analyzer (Vitros-5600). All the parameters were statistically analyzed by SPSS software and used descriptive analysis for all the parameters.

V. OBSERVATIONS AND RESULTS

The various biochemical investigations of these patients were observed.

Parameter	Study Group (n=120)	Control Group (n=120)
	MEAN±SD	MEAN±SD
Age (in Years)	55.96±16.79	51.25±16.69

Table-1: Comparison of age (in years) in study group and control group.

Table 1 is showing the comparison of age in cases and normal subjects. In our study case's age mean value is 55.96 and normal subject's age mean value is 51.25.

SEX	Study Group		Control Group	
	No of Patients	%age	No of Patients	%age
Male	65	54.10 %	58	48.33 %
Female	55	45.90 %	62	51.67 %
Total	120	100 %	120	100%

Table-2: Gender distribution of CKD patients in study group and control group.

Table 2 is showing gender distribution of cases and normal subjects. In our study male percentage is 54.10% and female percentage is 45.90 % in cases and 48.33 % male and 51.67% female in normal subjects.

Parameter	Male Cases(120)	Female Cases(120)
	MEAN±SD	MEAN±SD
Age (in Years)	56.32±17.76	55.49±15.60

Table-3: Comparison of age (in years) in males and females of study group.

Table 3 is showing comparison of age in males and females of cases. In our study male's age mean value is 56.32 and female's age value is 55.49.

Parameter	Study Group (120)	Control Group (120)	t value	p value
	MEAN±SD	MEAN±SD		
Creatinine	5.44±3.99	0.79±0.25	9.23	<0.05*
Urea	108.24±59.23	23.79±11.82	11.19	<0.05*
Uric Acid	7.36±3.05	5.37±1.90	4.74	<0.05*
ALP	132.53±82.99	95.77±41.86	3.31	<0.05*

Table 4- Comparison of the various biochemical parameters in the study and control group. (* all the parameters were showing statistically significant result)

Serum Creatinine, Blood Urea and Serum Uric Acid and Alkaline Phosphatase levels in the CKD patients were significantly higher than the control group.

VI. DISCUSSION

In our study we observed the value of serum Creatinine is level (5.44 ± 3.99 mg %) was significantly higher in cases as compared to control group. Mittal A et al., also described almost similar results with a significant increase in mean serum creatinine was 4.6 ± 1.18 mg%, Divya Pandya et al.; observed mean value 7.19 ± 4.77 mg%, and Freethi R. et al.; observed mean value 4.90 ± 2.23 mg %¹⁰ was

significantly higher in cases as compare to normal subjects.

Blood Urea level (108.24 ± 59.23 mg %) were significantly higher in cases as compared to control group. Mittal A et al., described almost similar results with a significantly higher level of blood urea was 136.03 ± 74.6 mg %⁸, and Divya Pandya et al.; observed mean value 112.66 ± 43.52 mg%⁹ was significantly higher in cases as compare to normal subjects.

Serum Uric Acid level (7.36 ± 3.16 mg %) in the CKD patients were significantly higher than normal subjects. Jung Tak Park et al; observed mean value 7.6 ± 1.8 mg/dl mg%¹¹ and Toyama et al, observed mean value 6.0 ± 1.3 mg%¹² was significantly higher in cases as compare to normal subjects.

In our study we observed the mean value of serum Alkaline Phosphatase is 132.53 ± 82.99 U/L was significantly higher than the control group. Srinivasan Beddu et al; reported mean value 119 ± 1.7 U/L⁶ was significantly higher in cases and Freethi R. et al; observed mean value 94.01 ± 15.10 U/L¹⁰ was not significant in cases as compare normal subjects.

VII. CONCLUSION

In our study, we tried to prognosis role of alkaline phosphatase level with renal markers such as creatinine, uric acid and blood urea in the patients of CKD. From the findings of the study, it is evident that the Serum alkaline phosphatase level is significantly higher in study group as compare to normal subjects and ALP has positive relation with Serum creatinine; blood urea and serum uric acid.

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TO ASSES CSF GLUCOSE, MICRO-PROTEIN AND CSF ADA LEVELS AND CLINICALLY IMPORTANCE FOR TUBERCULOUS MENINGITIS IN CHILDREN

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Abstract - Meningitis is inflammation of the meninges which affect the dura matter, pia-matter and arachnoid membranes of the brain. The patients with tuberculous meningitis were about 59 and patients with non-tuberculous meningitis were 20. The study was about to assess levels of CSF Glucose, Micro-Protein and CSF ADA and their role as biomarkers in tuberculous meningitis. Our study showed that CSF glucose level was not significant, but CSF micro protein and CSF ADA level was significant in cases as compared to control group.

Abbreviations: CSF-cerebral spinal fluid, ADA- adenosine deaminase.

Keywords - Tuberculous Meningitis, CSF Glucose, Micro-Protein, CSF ADA

I. INTRODUCTION

Tuberculous meningitis is caused by *Mycobacterium tuberculosis*. It is infection of the meninges, which envelop the central nervous system. Tuberculous meningitis is the most persistent form of central nervous system tuberculosis. The cases of pulmonary tuberculosis is 5% and peak incidence is in children under 4 years of age (1 &2). Tuberculous meningitis (TBM) continues to be the most common manifestation of neuro-tuberculosis in children (3). The sub-acute-meningiticillness can be difficult to distinguish from other causes of meningoencephalitis. TBM is classified into three grades of severity according to the British Medical Research Council TBM grade. Grade 1 TBM is defined as a Glasgow coma score (GCS) of 15 with no focal neurology, Grade 2 TBM as a GCS of 15 with a focal neurological deficit, or a GCS of 11–14 and Grade 3 TBM is defined as a GCS of ≤10. The importance of this classification system is that it enables stratification of patients and is useful to predict prognosis (2). Some children may present with ‘tuberculous encephalopathy’ with disseminated tuberculosis but without clinical or CSF evidence of meningitis (4). In recent years, an elevated CSF adenosine deaminase (ADA) activity has been shown to be a promising test for the differentiation of patients of TBM. The results were less reliable in children. As a marker of cellular immunity, ADA activity is found to be elevated in those diseases in which there is a cell-mediated immune response. Raised levels of enzyme have been found in tuberculous pleural (5), peritoneal and pericardial fluids and cerebrospinal fluid (CSF) of patients with TBM. In view of these observations ADA activity was estimated in CSF of children with tuberculous meningitis, partially treated meningitis, Aseptic meningitis & pyogenic meningitis to assess its

diagnostic value for TBM and to correlate with stages of TB and clinical parameters of CMI response to tuberculous infection (6).

II. AIMS AND OBJECTIVE

Aim

To asses CSF Glucose, Micro-Protein and CSF ADA levels and clinically importance for Tuberculous Meningitis in Children

Objective

Primary objective:

1. To estimate CSF Glucose and Micro protein in tuberculous meningitis patients.
2. To estimate CSF ADA levels and its role in tuberculous meningitis

Secondary objective:

3. To distribute cases according to age
4. To distribute cases according to gender
5. To distribute of the subject's age according to CSF ADA Activity
6. Comparison between CSF glucose, μProtein and CSF ADA in total case and total control.

III. MATERIAL AND METHODS

The study was conducted in the Department of Biochemistry, at Shri MahantIndresh hospital attached to the Shri Guru Ram Rai Institute of Medical and Health Science, Patel Nagar, Dehradun, Uttarakhand, India.

Source of data:-Total Patients – 79 {including cases (59) and control (20)}

The samples were taken from the patients who visited at SMI Hospital Dehradun. Subjects were recruited

according to simple random sampling method that met the selection criteria. The persons of all the age groups from 1 month to 10 years were taken. Both the gender was included in the study.

Inclusion criteria

- Patients with physical findings of tubercular meningitis in CSF.
- Patient who had tuberculosis or history of tuberculosis
- Includes patients of both the genders and age group of 10 and below years

Exclusion criteria

- Patients >10 years
- Those who are not willing to participate

IV. METHODS

- CSF glucose was estimated by GOD/POD method by VITROS 5600 fully automated Integrated System.
- Micro-Protein was estimated by pyrogallol red method (For the quantitative determination of Microprotein in Urine and CSF).
- CSF ADA was estimated by MICROEXPRESS ADA-MTB method (Colorimetric Method).

V. RESULT

The evaluation of the data of subjects indicated that the enrolled subjects were distributed according to different trends. They were distributed according to age, gender, activity of ADA, glucose and micro protein levels in CSF test group.

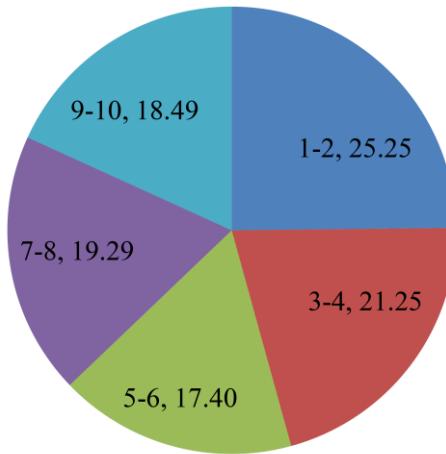
Age Distribution

Age distribution	CASES[59]	
	No of patients	Percentage (%)
1-2 YEARS	34	57.62 %
3-4 YEARS	9	15.25%
5-6 YEARS	6	10.16%
7-8 YEARS	4	6.77 %
9-10 YEARS	6	10.16 %

Table. 1: age wise distribution.

Sex distribution	Cases[59]	
	No of patients	Percentage (%)
Male	40	67.80
Female	19	32.20%
Total	59	100%

Table. 2: Sex distribution



Graph Chart 1: Distribution of the subject's age according to CSF ADA Activity.

PARAMETER	CASES MEAN±SD	CONTROL MEAN±SD	P Value	Significance
CSF (glucose)	49.63±24.57	56.45±30.25	0.31	Not significant
μ PROTEIN	229.89±209.05	71.85±61.88	0.001	Significant
CSF ADA	26.81±21.29	4.13±3.10	0.001	Significant

TABLE-4: Comparison between CSF glucose, μProtein and CSF ADA in total case and total control.

Table 4 is showing comparison between cases and control group. CSF glucose mean \pm SD value was 49.63 ± 24.57 ; micro-protein mean \pm SD value was 229.89 ± 209.05 and CSF ADA mean \pm SD value was 26.81 ± 21.29 in cases. CSF glucose mean \pm SD value was 56.45 ± 30.25 , micro-protein mean \pm SD value was 71.85 ± 61.88 and CSF ADA mean \pm SD value was 4.13 ± 3.10 in normal subjects.

V. DISCUSSION

In the present study was observed that maximum number of tubercular meningitis patients were in third decade i.e. age group 1-2 years represented by 57.62 %, 3-4 years represented by 15.25%, 5-6 years represented by 10.16%, 7-8 years represented by 7.7 % and 9-10 years represented by 10.16%. In the study of A. Pan had total of 62 subjects, of them 43 were boys and 19 were girls. The mean age of children was 4.15 years in TBM (6). In the study of Bindu TH et al. had 55 patients, Out of fifty-five patients 32 patients fulfilled the criteria were labeled as tubercular while other 23 patients were labeled as non-tubercular. The mean age of children is 4.36 years (7).

CSF glucose:

In our study we observed the value of CSF glucose is 49.63 ± 24.57 mg/dl in study group and 56.45 ± 30.25 mg/dl in control group. The CSF glucose level is not significant in cases as compared to control group. O. P MISHRA ET AL (8) was observed 37.9 ± 18.3 , A. Pan et al. (6) 45.92 ± 1.91 , Bari Siddiqui MA and AddankiYohoshuva (10) 33.656 ± 20.185 which is also similar to our study.

CSF protein:

In our study we observed the value of CSF micro protein is 229.89 ± 209.05 mg/dl in study group and 71.85 ± 61.88 mg/dl in control group. The CSF protein is significant in cases as compared to control group. O. P MISHRA ET AL (8) was reported 210.7 ± 144.5 , A. Pan et al. (6) 207.37 ± 14.89 , Bari Siddiqui MA and AddankiYohoshuva (10) 368.875 ± 494.808 which was statistically significant.

CSF ADA:

In our study we observed the value of CSF ADA is 26.81 ± 21.29 05IU/L in study group and 4.13 ± 3.10 IU/L in control group. The CSF ADA is significant in cases as compared to control group. In the study of Rajendra Prasad et al. (11) observed mean value of CSF ADA was 6.43 ± 1.93 , O. P MISHRA ET AL. (9) reported as 9.4 ± 5.4 , Dr (Mrs) S.V.Rana (12) was found 18.22 ± 3.35 , A. Pan et al.

(6) was also observed 11.38 ± 0.77 which is statistically significant.

VI. CONCLUSION

The present study was planned to study the diagnostic utility of cerebral spinal fluid Glucose, micro-Protein and CSF ADA in tuberculous meningitis. As few studies have been conducted to evaluate the role of CSF ADA levels for the diagnosis of TBM, we tried to estimate ADA levels in CSF in TBM and to find out its role as a sensitive, accurate, rapid, and affordable diagnostic tool that will work in resource-limited settings in confirming the tubercular etiology in cases of meningitis at early stage.

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SUSTAINABILITY IN HEALTHCARE SUPPLY CHAIN THROUGH THE LEAN AND RESILIENT METHOD

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Abstract –

Purpose

This paper aims to determine the impact of lean and resilient practices on the sustainability of supply chain management in the healthcare sector. The relationship between sustainability (economic, environmental, and social), lean and resilient factors is being analyzed to apprehend the dependency on each other. The integration of environmental and social aspects with economic considerations, known as the triple-bottom-line (TBL) has gained relevance for managerial decision-making in general and supply chain management (SCM) in particular. This process will help the healthcare professionals to take accurate decisions to focus on the most significant factor that influences the sustainability of Healthcare's Supply Chain management.

Methodology

The healthcare sector and its supply chain were chosen as lean and resilient practices have proven to be effective in this industry. To identify the relationships between lean and resilient supply chain practices and their impact on the three different dimensions of sustainability, a methodology based on the Interpretive Structural Modelling (ISM) approach is used.

Findings

The results show a synergistic effect between lean and resilient practices. The former practice acts as a driving force for the latter practice. Therefore, lean practices, especially the use of electronic data interchange, have had a direct and indirect impact on supply chain sustainability.

Research limitations

The relationship between lean and resilient practices in the healthcare sector has been studied. Different sectors may produce different results because the factors considered important in each sector may differ, as well as the methodology in which each process is implemented.

Originality

The current relationship between lean and resilient supply chain practices and their impact on sustainability is highlighted in this study. In addition, several healthcare experts have been approached to provide their perspectives on various parameters. These data are then entered into the ISM model to assist experts in making better decisions.

Keywords - Sustainability, Supply Chain Management, Lean Supply Chain Management, Resilient Supply Chain Management, Healthcare Sector, Interpretive Structural Modeling (ISM), Covid-19

I. INTRODUCTION

The healthcare industry, also known as the medical industry, is a business that provides products and services to patients in need of curative, preventive, rehabilitative, or palliative care. To meet individual and collective health needs, the modern health sector is divided into many sub-sectors, relying on an interdisciplinary team of trained medical professionals and associates. It has grown into one of India's largest sectors in terms of income and employment. The competitive advantage lies in the large pool of well-trained medical professionals. A recently announced financial budget allocated ₹86,200.65 crores to healthcare in 2022-23. That's about 16.59% more than last year's estimate of ₹73,931.77 crores. Increasing civilization's illness, increasing demand for affordable healthcare systems due to rising healthcare costs, technological advances, the emergence of telemedicine, the rapid penetration of health insurance, and e-health with tax benefits and

incentives are driving the healthcare market in India. The country has also made huge capital investments in advanced diagnostic facilities and has become one of the major destinations for high-end diagnostic services that serve a large number of people. Also, consumers of medical services in India are becoming more aware of their medical needs.

Healthcare is the necessity of life thereby, assessing the character of a healthy and resilient supply chain can help a nation develop ideas to combat the healthcare crisis. Healthcare has been one of the most important industries and saving lives is essential for any government, but the healthcare supply chain has been severely impacted over the past two decades by several disasters. Recently the healthcare sector has been significantly affected by the world's most contagious disease Covid-19 which has led to a long-term strain on the healthcare supply chain (HCSC) and resulted in a lack of basic healthcare facilities. It has become apparent that supply chain disruptions

and increased usage has led to a lack of medical supplies needed to provide proper care to patients. The healthcare supply chain is responsible for delivering high-quality products and efficient services to patients as quickly as possible at the lowest possible cost and time. Healthcare costs can be high, and they appear to be increasing all the time. Hospitals are looking for places within the healthcare supply chain where response times may be shortened, and demand can be satisfied consistently. In this paper, we are focusing on lean and resilient supply chain management.

Lean supply chain management focuses on efficient, streamlined operations, as well as the elimination of non-value-added time and redundant procedures that add no value to the product or service delivered to customers. It also prioritizes dependability and predictability over flexibility and adaptability. The strategy is to plan everything ahead of time to deal with any unforeseen situation like COVID-19. It aims to reduce the number of defective goods to zero, reduce waste, and increase efficiency.

Resilience is defined as a system's adaptive ability to respond to disruptions more effectively or even gain an advantage during disruptive events. The ability to respond to unexpected interruptions caused by unexpected events and recover from them by maintaining operations at the desired level of connectedness and control is defined as supply chain resilience.

Sustainable Development means the integration of Triple Bottom Line i.e., environmental, social, and economic development of mankind without causing any harm to the environment. It is important for the performance of businesses and their supply chains. The concept of sustainable development has evolved over the past thirty years. It is based on the strong pillars of social progress, economic stability, and environmental conservation. It is perhaps the only social development tool where all three of these work in unison. This makes sustainable development a very subtle way of achieving progress. Organizations are held accountable for their activities that have an impact on the environment, society, and economy of their enterprises as well as those of their supply chain partners. As a result, sustainability in the operations of businesses, as well as in the supply chain, has emerged as a hot topic and a promising research subject. Adoption of sustainability practices not only improves the environmental and social performance of enterprises and their supply chains but also allows them to gain a new set of skills that can help them gain a competitive advantage by taking on new projects. Through this paper, we aim to propose the need for sustainable development in supply chain management of the healthcare sector for a better society, economically, socially, and environmentally.

II. LITERATURE REVIEW

Supply Chain Management

Supply Chain Management (SCM) is a widely accepted and practiced concept in many industries as they understand the need for demand integration, coordination, and supply relationships management. As a result, there is a huge amount of literature available on SCM which addresses the contemporary issues in a variety of industries and sectors including the manufacturing industry (Ogunlela and Lekhanya, 2016; Njoku and Kalu-Alexanda, 2015), automotive industry (Bhattacharya et al., 2014), agriculture sector (Ferry et al., 2007), oil and gas (Abduljabbar and Tahar, 2015), construction and project management (Benton and McHenry, 2010), and also the small and medium-sized industries and tech start-ups (Jitesh et al., 2012). The performance of the supply chain is influenced by managing and integrating the key elements of information into the company's supply chain (Sufian, 2010; Gunasekaran and Ngai, 2004). Effective SCM has been becoming increasingly important to build and sustain competitive advantage in the products and services of the business. It is important to adopt an appropriate SCM strategy to compete at a supply chain level and this strategy needs to be integrated and coordinated throughout the supply chain to extract the performance out of all the supply chain members (Green Jr. et al, 2008; Cohen and Roussel, 2005; Wisner, 2003). The adopted strategy should suit both the product as well as the marketplace (Mason-Jones, 2000; Lewicka, 2011). Considering the nature of demand for the product, either functional or innovative, of an organization is the first step in developing a supply chain strategy (Fisher, 1997).

Healthcare Supply Chain

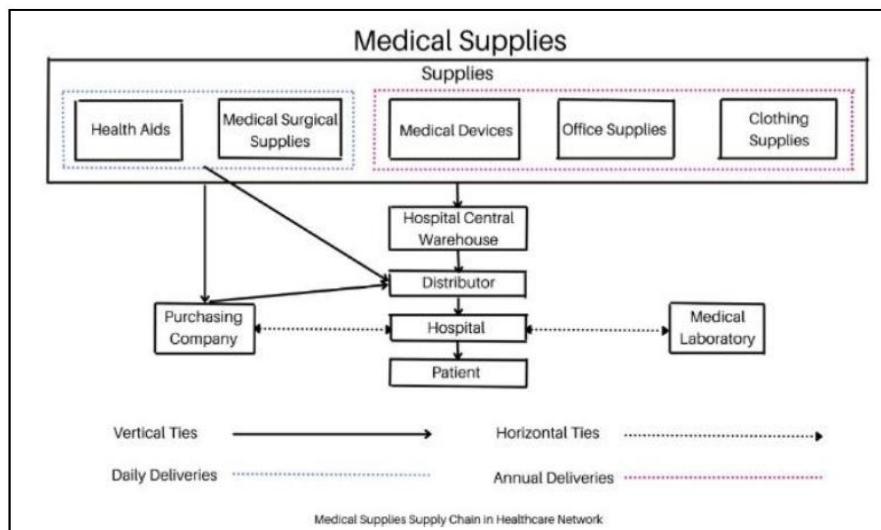
The Healthcare supply chain can be classified into three interdependent groups: 1) consumables and medical-surgical supplies, 2) pharmaceuticals and drugs, and 3) medical equipment and or medical devices. The consumables supply chain has a lot of factors and has a low allowable, 14-16 days of delivery time. The participation of governmental institutions, regulatory agencies, alliances, or group purchasing organizations, and health management insurance are an addition to the complexity of the healthcare supply chain. The multiple factors in the medical supply chain result in irregularities or unwillingness to share economic, environmental, or societal information giving rise to problems associated with demand amplification or Bullwhip effect (Mason-Jones; Towill, 2000); it is a major setback in the supply chain sustainability. A literature review study uses content analysis that focuses on improvement in hospital supply chain performance to give important insights about the pharmaceutical supply chain concept (Narayana et al., 2014). Another study took into consideration the empirical tests to

evaluate the performance of hospital supply chain (Chen et al., 2013); a research model was used after considering performance factors of hospitals, these factors were considered in terms of IT integration in hospitals, suppliers, the flow of information and the trust; these factors are interrelated, so their effect is very important in the hospital supply chain.

Sustainable Healthcare Supply Chain Management

Environmental (pollution, carbon emission, global warming, greenhouse effect), ethical and social issues have received tremendous attention globally over the past few years (Bjørn and Hauschild, 2013; Ellen McArthur Foundation, 2012). The continuous increase in the interest in social and environmental issues is greatly inspired by the idea of Sustainable Development which is “development that meets the

needs of the present generation without pulling down the needs of the future generation” (UN General Assembly, 1987). After the pandemic hit, many organizations responded by implementing business continuity plans and by conducting risk assessments to stabilize their supply chains. Many organizations responded by diversifying their product portfolio and using their existing resources to make new products; others utilized 3D printing technology to make products closer to demand to make their supply chains more responsive; while still others put emphasis on bringing production facilities back onshore or use nearshoring (M. Landry, 2020). Local and State governments are generally well equipped to identify the most affected groups and respond to their needs, circumstances, and preferences in a more targeted and agile fashion. (B. Burstrom and W Tao, 2020).



Dim	Code	Performance Measure	References
Economic	EM1	Decrease in cost for materials purchasing	Green et al. (2012), Prajogo et al. (2016), Zhu et al. (2008)
	EM2	Decrease in cost for energy consumption	Green et al. (2012), Zhu et al. (2008)
	EM3	Decrease in fee for waste treatment	
	EM4	Decrease in transportation cost	Chan and Qi (2003), Gunasekaran et al. (2001, 2004)
	EM5	Decrease in production cost	Chan and Qi (2003), Gunasekaran et al. (2001, 2004), Prajogo et al. (2016)

Environmental	ER1	Reduction of air emissions	Green et al. (2012), Zhu et al. (2008)
	ER2	Reduction of wastes	
	ER3	Decrease of frequency for environmental accidents	Green et al. (2012), Zhu et al. (2008)
	ER4	Increase of recycled materials	Green et al. (2012), Zhu et al. (2008)
	ER5	Decrease of energy consumption	Aras et al. (2010)
Social	SA1	Increase in worker's motivation and participation	Gurumurthy and Kodali (2009), Martínez-Jurado and Moyano-Fuentes (2014), Treville and Antonakis (2006)
	SA2	Decrease in working environment stress	Martínez-Jurado and Moyano-Fuentes (2014)
	SA3	Increase in safety and healthy working environment	Giannakis and Papadopoulos (2016), Martínez-Jurado and Moyano-Fuentes (2014), Vinodh et al. (2011)
	SA4	Increase in worker's skills and training	Gurumurthy and Kodali (2009)
	SA5	Increase in worker's retribution	Aras et al. (2010), Giannakis and Papadopoulos (2016), Gurumurthy and Kodali (2009)

Table – I (Sustainable Factors)

Lean and Resilient Methods

A Lean organization is focused on delivering the highest quality in the shortest possible time while minimizing waste throughout the process (waste is classified as any resource that is not being used the right way). At first one may think that minimizing waste means reducing inventory, but time, effort and

people are also resources that need to be used properly. Analyzing how people spend and how much time they spend is an important step in reducing waste. We can apply Lean principles to supply chain planning, with the primary goals of reducing costs and improving customer service.

ID	Lean Factors	Description	References
LE1	Supplier Selection Evaluation and Monitoring	Factors to be considered while selecting a supplier are: - 1. Strict Selection Process. 2. Supplier Evaluation and Certification. 3. Whether the supplier is following sustainable protocols for raw material	Azevedo et al. (2012), Azevedo et al. (2016), Cabral et al. (2012), Campos and Vazquez-Brust (2016), Jajja et al. (2016), Jasti and Kodali (2015), Kou and Lee (2015), Maleki and CruzMachado (2013), Qrunfleh and Tarafdar (2013), Shah and Ward (2007), Simpson and Power (2005), So and Sun (2010), So (2010), Wiengarten et al. (2013)
LE2	Suppliers and company involvement in New Product Development (NPD):	A buyer-supplier relationship focused on quality, directly impacts the buyer's operational effectiveness and the quality of the final product. In these scenarios, suppliers are involved from the beginning of the project instead of being subcontracted with already parts. High level of risks and shared benefits and joint discussion towards cost savings because of frequent participation of suppliers and company from an early stage in the process.	Cabral et al. (2012), Campos and Vazquez-Brust (2016), Jasti and Kodali (2015), Kou and Lee (2015), Maleki and Cruz-Machado (2013), Qrunfleh and Tarafdar (2013), Shah and Ward (2007), Simpson and Power (2005), So and Sun (2010), So (2010), Wiengarten et al. (2013)
LE3	Communication and Information Exchange between suppliers and company	The primary objective of the lean supply chain is to develop people and develop structures processes to minimize wasteful activities. Frequent communication and information sharing between suppliers and companies. Exchange of technical assistance, knowledge transfer, and lean training are frequent between the parties. Adoption of multifunctional supplier-company equipment. Frequent feedback on results derived from lean, such as delivery time, quality indicators, inventory details, etc.	Cabral et al. (2012), Campos and Vazquez-Brust (2016), Jasti and Kodali (2015); Kou and Lee (2015), Madu and Kuei (2014), Maleki and Cruz-Machado (2013), Qrunfleh and Tarafdar (2013), Shah and Ward (2007), Simpson and Power (2005), Singh and Pandey (2015), So and Sun (2010), So (2010), Wiengarten et al. (2013)

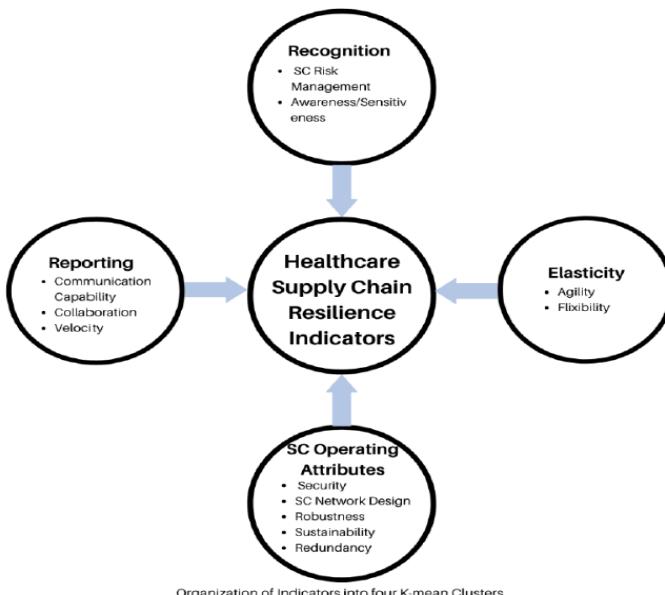
LE4	Use of Electronic Data Interchange	To share the hardware, software, and network tools that facilitate the electronic integration of the supply chain, avoid creating multiple purchase orders, storing outdated and unnecessary documents, etc. The use of e-business systems and sharing information allows better integration of production planning and scheduling to improve operational efficiency and increase the efficiency of information and material flows. This process will help to reduce paper waste. It facilitates a contactless process that aligns with Covid-19 protocols.	Anand and Kodali (2008), Azevedo et al. (2012), Campos and VazquezBrust (2016), Chen et al. (2013), Gorane and Kant (2016), Hong et al. (2010), Jasti and Kodali (2015), So and Sun (2010), So (2010)
LE5	Just-In-Time Delivery	Frequent deliveries of small quantities from suppliers to production line, avoiding storing more than what is required by the customer at various stages of the supply chain. This is done by calculating lead time, best and worst time, percent-on-time delivery.	Agus and Hajinoor (2012), Anand and Kodali (2008), Azevedo et al. (2012), Azevedo et al. (2016), Cabral et al. (2012), Campos and Vazquez-Brust (2016), Govindan et al. (2015, 2014), Jasti and Kodali (2015), Maleki and Cruz-Machado (2013), Shah and Ward (2003, 2007), Wiengarten et al. (2013)
LE6	Production pull systems	Controlling the flow of resources by replacing only what the customer has consumed, thus eliminating the waste as well its sources; contributes to the reduction of inventory in the supply chain. This in turn reduces space and extra money required.	Agus and Hajinoor (2012), Anand and Kodali (2008), Azevedo et al. (2016), Campos and Vazquez-Brust (2016), Crute et al. (2003), Jasti and Kodali (2015), Marodin et al. (2016), Perez et al. (2010), Shah and Ward (2003, 2007)

LE7	Value stream mapping (VSM)	Visual tools like IoT can be used to represent the flow of information and material from the supplier to the customer. This supports the lean supply chain and identifies potential opportunities for continuous improvements to eliminate lean supply chain wastes.	Campos and Vazquez-Brust (2016), Chen et al. (2013), Hines and Rich (1997), Seth et al. (2008), Singh and Pandey (2015), Taylor (2005), Wee and Wu (2009)
LE8	Supplier training lean initiatives	Processes to enable an exchange of experiences and to propose goals to extend lean manufacturing practices. This training matrix can be used by companies working with their suppliers to create lean capabilities and to determine the number of employees who have undergone lean and/or Six Sigma training.	(Campos and Vazquez-Brust (2016), Lopes de Sousa Jabbour et al. (2014), Stewart et al. (2010))

Table – II (Lean Factors)

Operational risk and disruption can threaten multiple areas of the supply chain. As we saw at COVID-19, global disasters can have widespread global impacts on supply chain logistics, suppliers, and workers. Other supply chain disruptions can occur in the form

of unexpected competition, sudden market trends, or rapid changes in customer purchasing behaviour. Resilience is defined by the ability to withstand or avoid the effects of supply chain disruptions and the ability to recover quickly from disruptions.



ID	Resilient SC practices	Description	References
RE1	Use of information control systems	Technology can be used to detect and monitor disruptions so that decisions could be taken for unforeseen situations like the Covid-19 pandemic, earthquakes, extreme weather conditions at any point in the supply chain.	Birkie (2016), Chowdhury and Quaddus (2015), Elzarka (2013), Guojun and Caihong (2008), Pettit et al. (2010) (2013), Rice and Caniato (2003), Romano et al. (2013), Stecke and Kumar (2009), Tang (2006), Tukamuhabwa et al. (2015)
RE2	Flexible supply base	The firm should have a flexible group of suppliers to mitigate challenges in its material procurement in case of a supply chain disruption.	Azevedo et al. (2016), Chopra and Sodhi (2004), Govindan et al. (2014), Guojun and Caihong (2008), Hasani and Khosrojerdi (2016), Iakovou et al. (2007), Kamalahmadi and MellatParast (2016), Rajesh et al. (2015), Spiegler et al. (2012), Stecke and Kumar (2009), Tang (2006)
RE3	Resilient transparency	Emerging technologies can be used to improve visibility, collaboration, coordination, and understanding between suppliers and healthcare firms when a supply chain disruption happens.	Azevedo et al. (2016), Birkie (2016), Chowdhury and Quaddus (2015), Christopher and Peck (2004), Elzarka (2013), Govindan et al. (2015, 2014), Hohenstein et al. (2015), Iakovou et al. (2007), Pettit et al. (2010, 2013), Ponomarov and Holcomb (2009), Rajesh et al. (2015), Scholten et al. (2014), Soni et al. (2014), Soni and Jain (2011), Spiegler et al. (2012), Stecke and Kumar (2009), Tang (2006), Tukamuhabwa et al. (2015)
RE4	Safety stock	The firm maintains excess capacity in the production storage,	Azevedo et al. (2016), Chopra and Sodhi (2004), Chowdhury and Quaddus (2015),

		handling, and/or transport to absorb the effects of supply chain disruption.	Christopher and Peck (2004b), Correia et al. (2017), Elzarka (2013), Hasani and Khosrojerdi (2016), Hohenstein et al. (2015), Iakovou et al. (2007), Juttner et al. (2003), Pettit et al. (2010) (2013), Rajesh et al. (2015), Rice and Caniato (2003), Romano et al. (2013), Soni et al. (2014), Spiegler et al. (2012), Stecke and Kumar (2009), Tang (2006), Tukamuhabwa et al. (2015)
RE5	Security measures	Set of rules targeted at reinforcing supply chain security against deliberate disruptions like terrorist attacks, intrusions, etc	Hasani and Khosrojerdi (2016), Stecke and Kumar (2009), Tukamuhabwa et al. (2015)
RE6	Contingency planning	Supply chain partners implement a contingency plan which includes a wide range of actions aimed at identifying and minimizing the effects of potential supply chain risks throughout the entire process from manufacturing to distribution	(Birkie (2016), Hohenstein et al. (2015), Kamalahmadi and Mellat-Parast (2016), Pettit et al. (2010) (2013), Tukamuhabwa et al. (2015))
RE7	Disaster recovery plan	The supply chain partners can carry out a disaster recovery plan to counteract when disruption takes place; this includes a wide range of actions aimed at restoring the normal activities in the supply chain as soon as possible.	Birkie (2016), Pettit et al. (2010, 2013), Romano et al. (2013)
RE8	Alternative transportation routing	Alternative transportation routes should be planned and programmed to avoid any delay in deliveries in case of a supply chain disruption.	Azevedo et al. (2016), Chowdhury and Quaddus (2015), Govindan et al. (2015) (2014), Kamalahmadi and Mellat-Parast (2016), Pettit et al. (2013, 2010), Rajesh et al.
			(2015), Rice and Caniato (2003), Romano et al. (2013), Spiegler et al. (2012), Stecke and Kumar (2009), Tang (2006), Wang et al. (2016)

Table – III (Resilient Factors)

III. METHODOLOGY

We have focused on supply chain management in the healthcare sector, where it is important to achieve lean and resiliency for smooth operations. To do this, we analyzed the combined impact of lean and resilient SCM practices on SC sustainability. In the healthcare sector, resilience is of great importance not only in the production settings but also in the supply chain function. In addition, the lives of patients are at greater risk in this type of supply chain, and in this sector, it is imperative to find ways to reduce this risk through lean and resilient supply chain management. After analyzing the health sector, we saw the need for more sustainability studies in this area. In addition, the healthcare industry is committed to reducing the environmental impact of all aspects of the production of pharmaceuticals and medical supplies such as surgical instruments. Therefore, the health sector was selected to research the relationship between lean SC practices and resilience and their impact on sustainability. Pre-examination of industry practices and measures as shown in Tables I to III, a total of 16 lean and agile SC practices and 15 sustainability

measures were identified in the literature review. This number should be conveniently reduced for two reasons. On one hand, it is necessary to determine which of these practices and measures are appropriate in the field under study and therefore necessary to achieve the objective of the paper. On the other hand, it is necessary to reduce the complexity of the resulting model to make it easier for the managers to take decisions and to derive useful information from the model. Too much complexity can hide important relationships and effects in the model and make it impractical. For that purpose, six senior experts were chosen to identify which of those practices and measures are relevant in the healthcare sector. A questionnaire was created in the five-point Likert scale to measure the importance of each practice and their performance measure in the healthcare sector, and also their degree of implementation in the sector. Finally, personal interviews were conducted to collect experts' opinions. Those practices were selected that had both an importance and a degree of implementation greater than the global mean value; these are shown in Tables IV and V.

Practices	Grade of Implementation	Importance
LE1	4.5	4.67
LE2	3.67	4.17
LE3	4.5	5
LE4	4.33	4.83
LE5	4.67	4.83
LE6	4.5	4.67
LE7	4.17	4.67
LE8	3.17	3.33
RE1	4.67	4.83
RE2	4	4.67
RE3	4.67	4.33
RE4	4.17	4.33
RE5	4.17	4.33
RE6	4	4.17
RE7	4.33	5
RE8	4.83	5

Table IV (Lean and Resilient SC practices)

Measure	Implementation	Importance	Quadrant
EM1	4.5	4.83	High
EM2	4.67	4.33	High
EM3	4.5	4.67	High
EM4	4.33	4.67	High
EM5	3.83	4	Low
ER1	4.5	4.83	High
ER2	4.5	4.83	High
ER3	4.5	4.67	High
ER4	4.5	4.5	Low
ER5	4.5	4.83	Low
SA1	3.83	3.67	Low
SA2	3.67	4	Low
SA3	4.33	5	High
SA4	3.67	3.5	High
SA5	3.17	3.33	Low

Table V (Sustainability performance measures)

Research design

This research design follows Interpretive Structural Modelling (ISM). This was selected as ISM supports the objective of this research paper that includes modelling the relations between lean and resilient practices and their combined effect in all the three dimensions of SC sustainability.

This method has several challenges that had to be overcome. Firstly, the pre-test revealed the model might contain 153 potential relationships.

$$NPR = \frac{\sum_{i=1}^n S_i \times (\sum_{i=1}^n S_i - 1)}{2}$$

where NPR which is the total number of potential relationships between pairs of elements, and S_i represents element i^{th} in the model. ISM has proved to be an excellent mechanism for converting very complex systems into visible and well-defined hierarchical problems showing direct and indirect relationships between elements (Attri et al., 2013; Diabat et al., 2014). Second, with the aim of guaranteeing the robustness of the model and generality of its results across the entire healthcare manufacturing SC, this had to successfully aggregate knowledge of a heterogeneous group of experts. ISM used a structured and iterative learning process to aggregate represent knowledge of the experts about a set of elements that define a system and how these elements are related to each other. One of its main characteristics is that when experts receive feedback reports, they can modify their answers. The ISM approach does not offer experts the possibility of modifying their former opinions in order to reach a consensual model, but the final result will represent all their inputs in an aggregated manner. Finally, managers, stakeholders and other agents in the society might have difficulties understanding these complex models and thus making appropriate decisions. Cognitive maps also produce a static model based on the knowledge of the experts where nodes are connected directionally by links. As compared to cognitive maps, ISM holds the strength of converting the mental models into structured hierarchical models. The method allows to impose order on the complexity of the causal relationship represented in the diagram (Sage, 1977). The role of each element in the system can therefore be more easily interpreted. For the complex problem considered here, a high number of interlinked practices may be influencing sustainability. The direct and indirect links between them describe this problem far more precisely than the individual practices taken in isolation or ill-structured models. ISM will thus provide insights into findings of these relationships. This would also assist managers to spot patterns within the diagram and help them make informed decisions based on the dimension that they want to improve. This method has been successfully adopted to achieve a more sustainable SC in various sectors (Diabat et al., 2014).

Sample selection

ISM models are built based on opinions of experts. Previous ISM studies consulted a panel of experts having recognized knowledge in their domain (Attri et al., 2013). These comprised a lower number of participants as compared to empirical studies. Improper selection of experts would risk the validity of the research. To ensure this, the group of participants should comprise of 5 – 10 experts (Kapse et al., 2018). The composition of the panel of experts is also important and as a result multiple choices were considered. It is recommended to have a diverse group of experts (López and Ishizaka, 2017), thereby reducing the number of participants required. Finally, 6 experts pertaining to different manufacturing plants in the sector were selected and agreed to participate in the present study. The main selection criteria were current position, academic background and experience in lean management and resilience. We also selected the participating experts based on the level of their organizations in the SC. All the levels in the Healthcare manufacturing industry were represented. The number of participants on every level were around the same. The final ISM will be representative of the entire SC in the sector.

Structural self-interaction matrix (SSIM)

The ISM model represents a finite set of n elements in a system represented by $S = (s_1, \dots, s_i, \dots, s_n)$. The SSIM is built up based on the relationships of any pair of elements (s_i and s_j) representing that s_i drives s_j . Experts were asked to fill out pairwise relationships among units of the system in an 18×18 SSIM. Considering this in mind, we have provided them with the following four symbols:

V: element i drives element j ;

A: element j drives element i ;

X: elements i and j are mutually dependent on each other

O: elements i and j are independent of each other;

A total of 6 SSIM were gathered from experts that were combined by a simple averaging process to obtain the final SSIM.

Final Reachability Matrix

The SSIM is reborn into a binary matrix by work V, A, X and O by one and zero. For a much better understanding, the subsequent guideline for translating symbols into binary digits are given:

- if the (i, j) entry within the SSIM is V, the (i, j) entry within the reachability matrix become one and therefore the (j,i) entry becomes 0.
- if the (i, j) entry within the SSIM may be a, the (i, j) entry within the reachability matrix becomes zero and therefore the (j,i) entry becomes 1.
- if the (i, j) entry within the SSIM is X, the (i, j) entry within the reachability matrix becomes one and therefore the (j,i) entry becomes 1; and

- if the (i, j) entry within the SSIM is 0, the (i, j) entry within the reachability matrix becomes zero and therefore the (j, i) entry becomes 0.

The final reachability matrix was obtained by applying the transitivity property. this suggests that if s_i results in s_j , and s_j results in s_k , then s_i ought to cause s_k .

Level partitions

This step consists in segregating the ultimate reachability matrix obtained higher than into completely different levels. First, the reachability and antecedent set for every part (i.e., s_i) were known. These area unit delineate by (1) and (2), respectively:

$$R(s_i) = \{s_j \in S / e_{ij}=1\} \cup \{s_i \in S\}, \quad (1)$$

$$A(s_i) = \{s_j \in S / e_{ji}=1\} \cup \{s_i \in S\}, \quad (2)$$

The intersection set of every part is computed as follows:

$$I(S_i) = R(s_i) \cap A(s_i), \quad (3)$$

The table shows simply the intersection sets for every part within the system. part is premeditated within the high position of the school of thought model (level I), if $R(s_i) = I(s_i)$ so is separated out from the remaining elements' sets. This method is recurrent to assign parts in Level II, these then being deleted. This unvarying method finishes once each part has been already assigned to grade.

ISM digraph

An initial digraph is formed based on each element's level partition and the reachability matrix's conical form. Each element is represented in its respective level, as well as relationships between them, to create the original diagraph.

	LE1	LE3	LE4	LE5	LE6	RE1	RE3	RE7	RE8	EM1	EM2	EM3	EM4	ER1	ER2	ER3	SA3	SA4	Driving Power
LE1	1	1	0	1	1	0	1	0	1	1	0	0	1	0	0	1	0	9	
LE3	0	1	0	1	1	0	1	1	0	0	0	0	1	0	1	1	0	8	
LE4	0	1	1	1	0	1	1	1	1	0	0	0	1	0	0	1	0	9	
LE5	0	0	0	1	1	0	0	0	0	1	0	1	1	1	1	0	0	6	
LE6	0	0	0	1	1	0	0	0	0	0	1	0	1	0	1	0	1	6	
RE1	0	1	0	1	1	1	1	1	1	1	0	0	1	1	1	1	0	12	
RE3	1	1	0	1	1	0	1	1	1	1	0	1	0	1	1	0	0	12	
RE7	1	0	0	1	0	0	1	1	0	0	0	0	0	0	0	1	0	5	
RE8	0	1	0	1	1	0	1	1	1	0	0	0	1	1	0	1	0	9	
EM1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	
EM2	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	4	
EM3	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	4	
EM4	1	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	5	
FR1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	6	
ER2	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	5	
ER3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	3	
SA3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3	
SA4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	4	
Dependence Power	6	6	1	9	7	2	7	6	5	4	4	4	4	13	7	11	12	6	2

Table VII (Final reachability matrix)

Level	Reachable set	Antecedent set	Intersection	Variable
9th	LE1	LE1, RE3, RE7, EM1, EM4, ER1	LE1,	LE1
7th	LE3, RE3, RE7	LE1, LE3, LE4, RE1, RE3, RE8	LE3, RE3	LE3
10th	LE4, RE1	LE4	LE4	LE4
6th	LE5, ER1	LE1, LE3, LE4, LE5, LE6, RE1, RE3, RE7, RE8	LE5	LE5
5th	LE5, LE6	LE1, LE3, LE5, LE6, RE1, RE3, RE8	LE6, LE5	LE6
9th	RE1	LE4, RE1	RE1	RE1
8th	LE1, RE3, RE8	LE1, LE3, LE4, RE1, RE3, RE7, RE8	RE3, LE1, RE8	RE3
7th	LE1, RE3, RE7	RE8	RE7, RE3	RE7
8th	RE3, RE8	LE1, LE4, RE1, RE3, RE8	RE8, RE3	RE8
1st	LE1	LE1, RE1, RE3, EM1	LE1	EM1
5th	EM2	LE5, RE3, EM2, EM4	EM2,	EM2
2nd	EM3, ER1, ER2	LE6, EM3, ER1, ER2	EM3, ER1, ER2	EM3
1st	LE1, EM2, EM4, ER1, ER2	LE1, LE3, LE4, LE5, LE6, RE1, RE3, RE7, RE8, EM2, EM3, EM4, ER1, ER2	EM4, LE1, EM2, ER1, ER2	EM4
6th	LE1, ER1	LE5, RE8, EM3, EM4, ER1, ER2, ER3	ER1	ER1
4th	ER1, ER2	LE3, LE5, LE6, RE1, RE3, EM2, EM3, EM4, ER1, ER2, SA4	ER2, ER1	ER2
3rd	ER1, ER3,	LE1, LE3, LE4, RE1, RE3, RE7, RE8, EM2, ER2, ER3, SA3, SA4	ER3	ER3
1st	ER3, SA4	LE6, RE1, ER1, ER3, SA3, SA4	ER3, SA4	SA3
5th	SA4	SA3, SA4	SA4	SA4

Table VIII (Level partitions in the ISM Model (reduced version))

Following that, the model's transitiveness was removed, and each ID node was replaced with its appropriate description. Finally, the model was examined for conceptual flaws. Figure 1 shows the final diagram.

IV. RESULTS

Analyzing the aggregated ISM based model:

The final ISM model contains 5 lean, 4 resilient and 9 sustainable factors representing the social, environmental, and economic dimensions. Looking at the figure 1 SA3 and EM1 are disconnected from the remaining elements. EM1 i.e., decrease in cost for materials purchasing and SA3 i.e., increase in safety and healthy working environment are the least important factors as they are present on level 1. We see from the level partition diagram that LE4 i.e., use of electronic data interchange is the most important factor as they are present on level 10 and drives other factors. Figure 1 also states that LE4 leads to RE1, which in turn will facilitate RE3 and so on. LE4 may thus lead to any element in the ISM model, either by direct influence or by indirect impact. From level 9 to 11, other factors have been represented from lean and resilient practices. They have a big driving power associate degree thus lean practices exert an influence on the remaining components – resilient practices, economic performance measures, environmental performance lives and social performance measure. The ISM also reflects that any lean practice will help to improve the SC sustainability in its economic, environmental, and social dimensions. Therefore, sustainable SCM demands the best efforts in lean implementation.

Resilient practices mainly fall under Level 7 and Level 8, this highlights those lean practices are related to resilient practices, the former activating the latter. Nevertheless, resilient practices do not prompt lean practices. Regarding the influence of RE3, RE7 and RE8 on SC sustainability, these impact the environmental dimension in disparate ways.

Level 5 and Level 6 locates significant factors in Lean, social, environmental, and economic factors which affects sustainability in supply chain which are particularly interrelated with each other. These factors mainly affect the environmental factor in Level 4.

The aggregated ISM model represents economic performance measures mainly from levels 5 to 6. EM2, EM3 were found to have a significant influencing power to affect the environmental and social performance measures. As a result, managers should focus their efforts on achieving economic SC sustainability because this may lead to improvements in environmental and social sustainability. ER3 facilitates EM3 which leads to SA3, thus environmental sustainability may lead to social sustainability as well. Finally, EM1 and SA3 are located at the top level and so does not have any

influence capacity on the remaining measures. SA3 and EM1 are also the sustainability performance measure least affected by lean and resilient practices and it therefore has a limited impact on social SC sustainability.

We see from the level partition diagram that LE4 i.e., use of electronic data interchange is the most important factor as they are present on level 10 and drives other factors. On the other hand, Hence, Electronic data interchange should be considered the most significant factor in the supply chain management of healthcare sector.

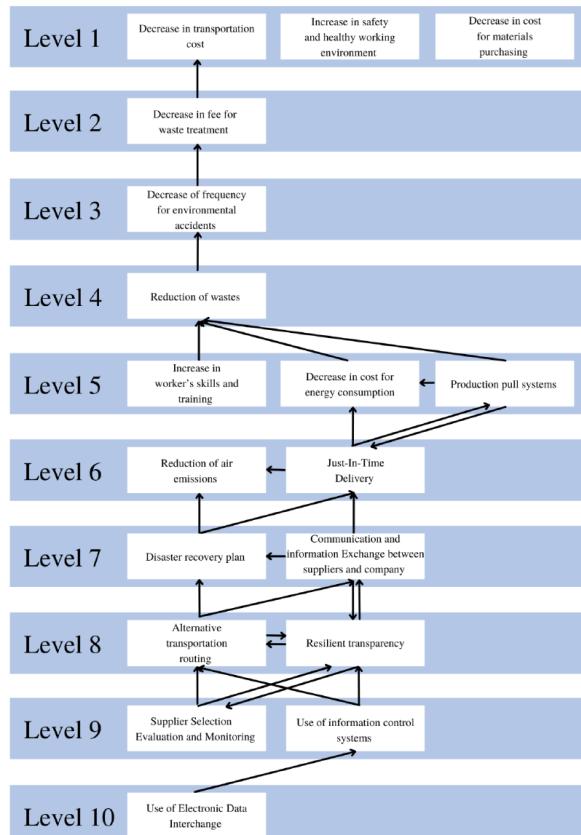


Figure 1 (Aggregated ISM based model)

V. CONCLUSIONS

Theoretical implications

This is the joint influence of lean and resilient strategies on sustainability where the measures have been modelled from an academic standpoint. As a result, our study adds to earlier studies linking operational lean and resilience approaches to SC (Birkie, 2016). The creation of linkages between multiple lean and resilient strategies and sustainability measures through a single systemic framework is a major contribution of this research. The ISM technique was used to accomplish this. The three sustainability dimensions were put into an ISM model. Both lean and resilience strategies aid in the development of more sustainable SCs, yet their effects are somewhat different. All performance measures examined in the economic, environmental,

and social dimensions may be affected by lean approaches. Resilient SC practises, on the other hand, have a limited influence on social sustainability. The relationship between lean and resilient paradigms is another result of this study: its findings show that lean and resilient practises are intertwined, with the former leading to the latter. As a result, the lean methods investigated may have an impact on SC vulnerability. This study makes a significant contribution by considering a larger number of practises in each paradigm to better reflect the existing relationships between practises. It's possible that this was overlooked previously.

Implications for managers and policymakers

The conclusions of this study have a few major practical and political implications for increasing SC sustainability in the healthcare industry. Managers have the option of implementing a set of lean and resilient practises that will improve SC sustainability. The study emphasises how economic, environmental, and social sustainability may be attained more efficiently in this way. These insights can also help policymakers design particular policies and activities to make the healthcare supply chain more sustainable. Implementing lean and resilient SC practises is the most straightforward way to achieve economic sustainability. If a management wishes to considerably increase economic sustainability, he or she should adopt suitable supplier selection, assessment and monitoring, as well as supplier involvement in NPD and training. When effectively applied, these methods can assist minimise waste disposal expenses and, as a result, production costs. All SC dealers will share a similar culture of lean thinking and risk management, which will support these gains. With this in mind, policymakers should work to promote knowledge transfer and best practises through collaborative research and development projects.

Lean and resilient SC techniques can also help to increase environmental sustainability. Managers should employ electronic data interchange or effective supplier selection, evaluation and monitoring strategies in this manner, as well as good communication and information sharing with their suppliers, to reduce the consumption of hazardous/toxic materials. This decreases itself, in turn, has evidenced to cause the reduction of liquid wastes. On the other hand, Just-In-Time delivery practices cause the reduction of solid waste attributable to lower lot size and inventory levels. Each training in lean initiatives and a correct supplier choice, evaluation and monitoring have shown a decrease in the frequency of environmental accidents. The impact of those practices may be strengthened with a lot of restrictive legislation concerning treatment and disposal of solid and liquid wastes. Additionally, scientists in universities and analysis centres ought to participate within the development of

advances for reducing these wastes and therefore the consumption of hazardous/toxic materials.

In contrast, the results show that it is difficult to achieve social improvements through a lean and resilient SCM. The only social improvement that can be achieved through lean or resilient initiatives is increasing worker's training and skills. The factor healthy work environment is unlikely to be improved by a lean or resilient SCM. Therefore, if a manager wishes to improve social sustainability directly, use of information control systems and resilient transparency are the practices that should be implemented. All SC partners, as well as public safety officers, are encouraged to quickly resume normal operations in SC after a disruption and avoid as much as possible if there is any impact on society.

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VIRTUAL LABORATORIES FOR PULSE WIDTH MODULATION AND TEMPERATURE SENSOR READING USING PYTHON BASED DESKTOP APPLICATION

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Abstract - In this paper, a desktop application-based virtual laboratory has been developed to perform laboratory experiments. Here two applications have been developed for virtual laboratory execution

- (i) Pulse Width Modulation and
- (ii) Temperature Sensor Reading. These virtual experiments can easily performed at home using any PC or laptop by downloading the application. In the applications, there are various provisions for the parameter selection to change the inputs of the experiments. The desktop applications have been developed in Python language.

Keywords - Desktop Application, Numpy, Matplotlib, Scipy, Python, PWM, TMP36, 555IC

I. INTRODUCTION

In the Pandemic situation caused by COVID-19, the students, as well as the teachers, are confined at home. Classes are going on virtually but it is quite difficult to perform the practical laboratory experiments in such a way. Therefore an initiative has been taken to create a Virtual Lab to perform laboratory experiments at home such that the students can have both technical and practical knowledge. Many institutions have created their virtual labs [1-3] and they can be accessed easily from their websites. Getting inspired by their initiative we have also started to design our own virtual labs. But the difference is that it is in the offline mode which means one can perform the experiments without any internet connection. The work is totally new to the best of the knowledge of the authors and therefore can't be compared with other similar works.

II. DESKTOP APPLICATION

The application has been developed in Python Programming language. Here we have used a well-known library “Tkinter” to create the user application. To create the user interface at first we have to import the class “from tkinter import *” to include all existing methods.

a) PWM Experiment

In this experiment, we produce a Pulse Width Modulated Wave(PWM) using the well-known “555 Timer” integrated circuit. The circuit diagram has been drawn in the paint app and it has been included in the main application as a file dialog. The code “from tkinter import filedialog as fd” indicates the inclusion of the image as file dialog in the main application. The image is included either in a canvas or in a label. Here we have included the image in the

label. The image file is at first taken from the file dialog box using the code “fg=fd.askopenfilename()”. This image file is included in the label as a photo image with the following code “fig=PhotoImage(file=fg)”. Next to create the application, a window is created with the following codes “tk=Tk()”, “tk.title(“Pulse Width Modulation using 555 Timer”)” and “tk.geometry(“1200x700”)”. The first code is to create the class, the second code is to create the window title and the third code is to assign the size. Then a label is created with the following code “Label(master object,figure=fig).grid(row=value,column=value)” where the figure is displayed.“tk.mainloop()” maps the application interface in the main loop. In this application, we aim to design a pulse width modulator circuit using 555 timer IC. In the 555 timer circuit, a square wave can be generated with the time-period given by the following equation.

$$T = 0.69 \times (R_1 + 2 \times R_2) \times C \quad (1)$$

Here the high and the low time intervals can be expressed with the following equations as follows.

$$T_{HIGH} = 0.69 \times (R_1 + R_2) \times C \quad (2)$$

$$T_{LOW} = 0.69 \times R_2 \times C \quad (3)$$

There is another term in PWM which is very important and that is the duty cycle. Duty cycle can be defined as follows.

$$\begin{aligned} \text{Duty Cycle} &= \frac{T_H}{T} \times 100\% \\ &= \frac{0.69 \times (R_1 + R_2) \times C}{0.69 \times (R_1 + 2 \times R_2) \times C} \times 100\% \\ &\times 100\% = \frac{(R_1 + R_2)}{(R_1 + 2 \times R_2)} \times 100\% \end{aligned}$$

To achieve a perfect square wave, R_2 is taken to be far greater than R_1 i.e. $R_2 \gg R_1$. But in PWM, we need to vary the pulse width. Therefore R_1 needs to be varied.

Therefore in the application, there is a provision for varying R_1 .

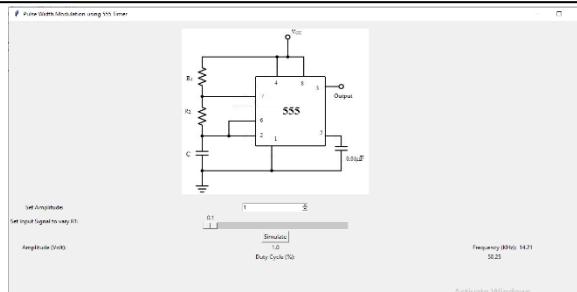


Fig. 1: Application window for PWM experiment

In the application window, there is a slider by which R1 can be varied. To create a slider, the following code can be written “`sld=Scale(tk,from_=0.1,to=10,resolution=0.1,variable=x,length=300,orient=HORIZONTAL)`” and “`sld.grid(row=2,column=1)`”. The first code creates a scale (slider) with the starting value (“`from_=0.1`”) 0.1 and the ending value (“`to=10`”) 10 with an increment of 0.1 (“`resolution=0.1`”). A variable “`x`” has been taken which is of double type (“`x=DoubleVar()`”). It takes the value after each sliding. The option “`length`” gives the size of the slider. There is another option “`orient`” which sets the alignment of the slider (horizontal or vertical). The second code is to set the position of the slider onto the application window. There are various layouts for positioning: (i) Grid layout, (ii) Box layout. Here grid layout has been used.

To set the amplitude, a spinbox has been used. The spinbox can be created with the following codes “`spb1=Spinbox(tk,from_=1,to=10)`” and “`spb1.grid(row=1,column=1)`”. The first code creates a scale (slider) with the starting value (“`from_=1`”) 1 and the ending value (“`to=10`”) 10. The second code is to set the position of the slider onto the application window. Here also grid layout has been used.

To simulate the waveform, there is a button. The following code can create the button “`Button(tk,text="Simulate",command=simulate).grid(row=3,column=1)`”. The button caption can be set by the option “`text`”. The button triggers the command which calls the method “`simulate()`”. Inside the “`simulate()`” method, the calculation for the pulse width is performed and the waveform is generated. To generate the waveform, three libraries are needed “`numpy`”, “`matplotlib`” and “`scipy`”. “`numpy`” is used to create the timing array for the waveform plotting. “`scipy`” is used to generate the square wave based on the timing array created by the “`numpy`” library. Finally, “`matplotlib`” is used to plot and show the waveform. Figure 1 shows the application window for the virtual lab. Figures 2 and 3 show the application window before and after the simulation. At first, the amplitude and the resistor value (R1) is set. Then the “`Simulate`” button is pressed which generates the waveform. Figure 3 shows the waveform window after the simulation. It is generated using the “`matplotlib`” library.

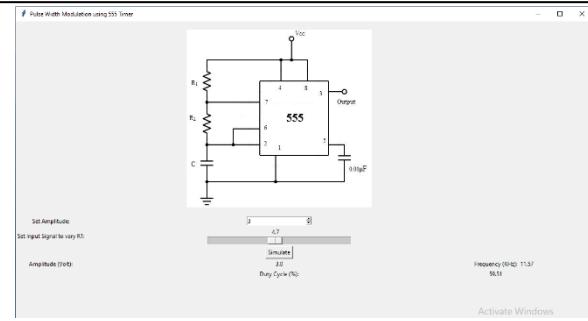


Fig. 2: Results (amplitude, frequency, and duty cycle) display inside the application after simulation (after the button is pressed)

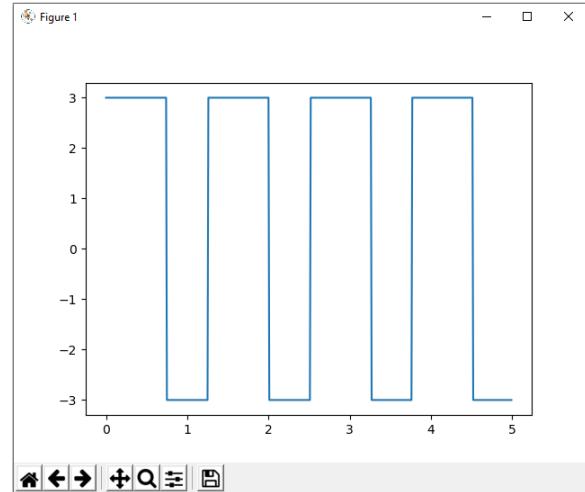


Fig. 3. PWM waveform

b)Temperature Sensor Reading Experiment using TMP-36 Sensor

In this experiment, we can measure temperature using a TMP36 sensor. The circuit diagram has been drawn in the paint app and it has been included in the main application as a file dialog. The code “`from tkinter import filedialog as fd`” indicates the inclusion of the image as file dialog in the main application. The image is included either in a canvas or in a label. Here we have included the image in the label. The image file is at first taken from the file dialog box using the code “`a=fd.askopenfilename()`”. This image file is included in the label as a photo image with the following code “`fig=PhotoImage(file=a)`”. Next to create the application, a window is created with the following codes “`tk=Tk()`”, “`tk.title("Temperature measurement using TMP36 temperature sensor")`” and “`tk.geometry("1200x580")`”.

The first function is to get the output pin voltage in the multimeter screen, the second function is to get the pin reading, calculated temperature and inference on the microcontroller screen based on preferred temperature unit, the fourth function is to reset the value of the input slider and clear all screens to default. Then two canvases are created where the output pin voltage (in multimeter screen) and analog pin reading &temperature reading (in microcontroller screen) are displayed. “`tk.mainloop()`” maps the application interface in the main loop. In this

application, we aim to measure surrounding temperature using a TMP36 sensor.

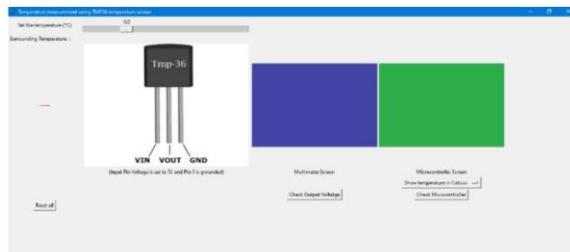


Fig. 4: Application window for Temperature sensor reading experiment

In this application, the pin voltage is measured by the following equations.

$$\text{analogread} = ((t \div 100) + 0.5) \times 1024$$

$$\text{pin_volt} = (((t \div 100) + 0.5) \times 1024)$$

And the output temperature is measured by the following equation:

$$\text{analogread} = (\text{float}(t) \div 100) + 0.5) \times 1024 \div 5$$

$$c = (((\text{analogread} \div 1024) \times 5.0) - 0.5) \times 100$$

$$f = (((c \times 9.0) \div 5.0) + 32.0)$$

Here ‘t’ is the value set by the user using the slider which we get by using ‘t=x.get()’.

Next the inference is generated based on the calculated temperature and the selected temperature unit. The function uses “clicked.get()” to get the preferred temperature unit and then it compress the temperature to room temperature which is 27 °C or °F and gives the difference.

The output pin voltage, pin reading, temperature and the inference are displayed using canvases in the application interface.

In the application window, there is a slider by which the surrounding temperature can be set to manually select the background temperature. To create a slider, the following code is used “sld=Scale(tk,from_=-40,to=125,resolution=0.1,variable=x,length=400,orient=HORIZONTAL)” and “sld.grid(row=0,column=1)”. The first code creates a scale (slider) with the starting value (“from_=-40”) and the ending value (“to=125”) with an increment of 0.1 (“resolution=0.1”). A variable “x” has been taken which is of double type (“x=DoubleVar()”). It takes the value after each sliding. The option “length” gives the size of the slider. There is another parameter “orient” which sets the alignment of the slider (horizontal or vertical).

There are three buttons given in the application. The following code ‘btn1=Button(tk, command=use_multimeter).grid(row=7,column=2)’ is used to create a button ‘btn1’ which is used to check the output voltage calling the ‘use_multimeter’ function. Similarly, ‘btn2’ is used to check the output temperature calling the ‘use_microcontroller’ function. The button ‘btn3’ is a reset button used to can be reset the input value to 0 and clear all other set values. Two canvases are created in the application which is used to display the output. For creating Canvas, the following code is used: “multimeter=Canvas(tk,height=200,width=300,bg="#4244A4").grid(row=3,column=2)” and “lcd=Canvas(tk,height=200,width=300,bg="#2EAD4B").grid(row=3,column=3)”. The Multimeter Canvas is used to print the output pin voltage and the LCD canvas is used to print the output temperature.

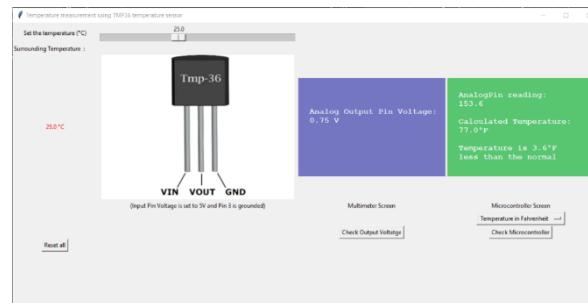


Fig. 5: Results of the above experiment

III. CONCLUSION

In this paper, we designed a virtual platform for PWM waveform generation and temperature sensor reading using TMP-36. The desktop applications were developed to create the virtual laboratory experiments. Moreover, the reading of the experimental data was displayed on the applications’ screen. The applications were developed in python with the help of a predefined library. The work was totally new to the best of the knowledge of the authors and so could not be compared with any other existing works.

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FIELD SCREENING OF SORGHUM GENOTYPES FOR RESISTANCE TO SHOOT FLY, *ATHERIGONASOCCATA* AND STEM BORER, *CHILOPARTELLUS*

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Abstract - Sorghum [Sorghum bicolor(L.) Moench] locally known as Jowar is the fifth most important cereal crop in the world after wheat, rice, maize and barley. In India it has positioned third after rice and wheat. Among the biotic factors about 150 insect pests have been reported in different agro ecosystem of sorghum crop. Out of them sorghum shoot fly, *Atherigonasoccata*Rondani (Diptera: Muscidae) and stem borer, *Chilopartellus*Swinhoe (Lepidoptera: Pyralidae) are the major insect pests which severely devastate to sorghum crop. Shoot fly is the most destructive one and causes severe damage in the early seedling stage at 7-30 days after seedling emergence. The present investigation was conducted on screening with nineteen advanced breeding lines of sorghum in randomized block design (RBD) with three replications against the shoot fly and stem borer during rabi season at Regional Agricultural Research Station, Vijayapur, Karnataka, India. Results on shoot fly revealed that the highly susceptible genotype was reported to SPH 1864 (36.9eggs/ 5 plants and 9.3% dead heart). Whereas, genotypes SPH 1899 and CSV 22 were found to be resistant with significantly minimum number of eggs (14.7/ 5 plants) and dead heart (6.7%). During the investigation, stem borer incidence was negligible with maximum in SPH 1864 genotype (4.8%) and minimum dead heart per cent caused by stem borer was genotype SPH 1898 (2.3%).

Keywords - Screening, Sorghum, Shoot Fly, Stem Borer

THE MOST PROMINENT ART GALLERIES IN DELHI

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Abstract -

In an increasingly technological age, fewer galleries are exhibiting artworks of these artists, especially such as Shilpa Gupta, Jitish Kallat, Nalini Malani, Bharati Kher, Anish Kapoor, Arpita Singh, and Jiten Thukral & Sumir Tagra artists. There is little recognition of newer media, such as installation art and video art, and more attachment to conventional attributes of art such as craft, skill, technique and material. This study begins by outlining the evaluation of the art galleries, including Delhi; in the research, the growth of the art galleries stretched across multiple sites and was dedicated to emerging forms of visual communication and artistic expression. Secondly, focused on the five most prominent galleries, i.e., National Gallery of Modern Art, Kiran Nadar Museum of Art, Vadehra Art Gallery, Nature Morte and Latitude 28, wherein galleries focus on new ways of visual dialogue, promote and discover the modern generation of present-day artists. Data collection methods are visiting various galleries, experiencing, observations and document analysis.

Keywords - Art Gallery, Prominent Gallery in Delhi, New Media Gallery, Art Galleries in Delhi, Galleries Across the Sites

I. INTRODUCTION

The origin of the gallery in Delhi goes back to the late nineteenth century, although references to an art gallery can be found in ancient Indian literature. Delhi has been one of the world's oldest inhabited cities for as long as anybody can remember. And hence it reasons out well that why it's every corner talk about history which with the coming years have been given a modern touch. What has remained unaltered today is the art that has long been a part of the city's centre and now has a home in one of Delhi's many art galleries.

The National Gallery of Modern Art and the Lalit Kala Academy were among the first cultural institutions to be established in Delhi. Now what the capital city has in the form of popular art galleries represent not only the coming age artists showcasing Contemporary Indian art but also the talented creators of ancient times. That being said, art galleries that we now have are much more than what they used to be before; they are the hub of fairs, art events and exhibitions that pull in travellers, hence acting as a major source of tourism in Delhi.

The gallery's displays featured a diverse group of artists, ranging from traditionalists to cutting-edge modernists. The art market in India has altered dramatically over the last two decades. The expansion of galleries throughout the 1990s, and especially in the twenty-first century, demonstrates the market's transformation.

India is a country that brings forth a rich heritage of art and culture. For ages, universities like Taxila, Ujjaini and Nalanda have veered the course of the Indian art movement. There are various institutes and galleries in India which proclaim their richness in art and their dominance over various styles and genres. This modern art movement in the early 20th century

was pioneered by Rabindranath Tagore's Vishwabharati in Shanti Niketan. Later, various art schools and galleries contributed to this art movement, one of them being the 'National Gallery of Modern Art'.

The National Gallery of Modern Art was first set up in Delhi, which has a collection of paintings great artists, including Jamini Roy, Rabindranath Tagore, Raja Ravi Verma, Nandalal Bose, Amrita Shergill, Thomas Duellin etc. These art galleries, located around the city, are the greatest venues to appreciate the city's magnificent blend of history and modern contemporary art.

II. ART GALLERY IN DELHI

Delhi's artistic infrastructure was developed post-1947 by the efforts of the Delhi Shilpi Chakra (an artist group); Delhi has an ever-changing roster of paintings and exhibitions in its galleries. These exhibitions feature everything from abstract art to sombre urban studies.

National Gallery of Modern Art

The National Gallery of Modern Art was founded in 1954 is the only institution of its kind in the country representing evolution and pictorial transformation in visual arts over the last more than 150 years. NGMA functions as a subordinate office under the superintendence and administrative control of the Ministry of Culture.

The NGMA's principal goals are to increase public awareness and comprehension of the visual and plastic arts in general and encourage the development of modern Indian art in particular. In 2009, the NGMA celebrated the opening of its New Extension Wing in New Delhi, which more than doubled the museum's display area.



National Gallery for Modern Art, Delhi, Rederived from: <https://lbb.in/delhi/national-gallery-of-modern-art-new-delhi/>

Delhi's National Gallery for Modern Art (NGMA) preserves and presents contemporary Indian art from the last century and a half. Starting in 1954, the premier gallery contains well over 10,000 works by artists who changed the artistic landscape of India. Galleries include collections of individuals and themes, such as works of Rabindranath Tagore, Amrita Sher-Gil, an entire gallery on Tanjore and Mysore traditions of painting, another gallery collection commissioned by the British East India Company, and Modern Art Sculptures, to name a few. International Exhibits, Miniature Paintings, Print Photographs, Paintings by prominent Indian painters such as Rabindranath Tagore, Abstraction in

Contemporary Indian Art, Modern Sculptures are all things to look forward to.

Kiran Nadar Museum of Art

The Kiran Nadar Museum of Art was established in 2010 by avid art collector Kiran Nadar. The museum is one of the first private museums to display modern and contemporary works from India and the subcontinent. The collection here consists of a number of 20th-century Indian painters, as well as works of younger contemporary artists. KNMA's programming focuses on promoting art and pedagogy through workshops, symposiums and public programmes and organising exhibitions and walkthroughs.



Kiran Nadar Museum of Art, New Delhi, Photo Courtesy: Kiran Nadar Museum of Art

The Kiran Nadar Museum of Art is India's first private museum dedicated to modern and contemporary art. A. Ramachandran, Arpita Singh, FN Souza, Jamini Roy, Anish Kapoor, Jogen Chowdhury, M F Husain, Manjit Bawa, N S Harsha, Krishen Khanna, and Ram Kumar are among the artists featured in themed exhibits.

Vadehra Art Gallery

Vadehra Art Gallery is one of the oldest art galleries in the city, with a collection spanning over four generations. Established in 1987, the gallery was

conceptualised out of a need to build an institution serving as a platform to connect artists with art lovers. The gallery's collection includes works by MF Husain, SH Raza, Tyeb Mehta, Arpita Singh, Ganesh Pyne, Anjolie Ela Menon, Atul Dodiya, Shilpa Gupta, Nalini Malani, Atul Bhalla, among others. The gallery often displays its collections in museums, as well as international platforms, in turn helping contribute to the exposure of Indian art globally. The gallery's diverse collection is sure to lure art aficionados as well as casual visitors who wish to know more about the Indian art landscape.



Vadhera Art Gallery, New Delhi. Retrieved from: <https://www.destimap.com/index.php?act=attraction&a=Vadhera-Art-Gallery%2C-New-Delhi%2C-India>



Nature Morte

Peter Nagy, the owner of the New Delhi, based gallery Nature Morte, represented the top 20

contemporary Indian artists and opened the gallery in 1997. In 2008 Nature Morte opened a branch of the gallery in Berlin.



Nature Morte Gallery, New Delhi. Retrieved from: <https://www.architecturaldigest.in/story/nature-morte-opens-two-new-galleries-in-delhi/>

Nature Morte was launched in 1982 in New York before being closed and reopened in 1997 in New Delhi as a commercial gallery by Peter Nagy. The art gallery is noted for fostering conceptual installation and lens-based techniques, as well as focusing on challenging and experimental art genres. Nature Morte, in addition to promoting internationally acclaimed artists, organises initiatives and shows with international artists visiting India, integrating their work with that of Indian artists to develop multicultural exchanges and viewpoints. Anita Dube, Mithu Sen, Jitish Kallat, Bharti Kher, Mona Rai, Pushpamala N, Imran Qureshi, Raqs Media Collective, Seher Shah, Thukral & Tagra, and Asim Waqif are among the artists who are represented. Nature Morte is unquestionably a must-see for

anyone interested in seeing important experimental artists.

Latitude 28

Latitude 28 was created as an art gallery and idea incubator, with curatorial projects, lectures, artist talks, and walkthroughs facilitating the exchange of ideas. Bhavna Kakar, the gallery's founder and director, runs the gallery, which is named for its location. Young artists have the opportunity to exhibit their work with stalwarts of Indian art at Latitude 28. It offers artists and audiences a lateral perspective on contemporary artistic production in relation to its past. Its approach towards supporting emerging, exciting contemporary practice makes this gallery an important stop to witness experimental new practices in the city.



Latitude Art Gallery, New Delhi. Retrieved from: <https://magicpin.in/blog/contemporary-art-galleries-in-delhi/>



Palette has prided itself to present different mediums of artistic expression ranging from the traditional to the experimental. Oils, watercolours, video, photography and performance art have all found a home at the gallery.

III. METHODOLOGY

Some of the Galleries were visited to collect the information, and some information about galleries was collected with the help of electronic media such as the Internet and other sources from Magazine and Literature Review. There are various galleries in Delhi, but only five art galleries were finally selected based on their popularity and their collection of work to collect the information for the study. During the research, collects the information of galleries space, its collection, the exhibitions, meeting place for artists and gallery events. The selected art galleries were the National Gallery of Modern Art, Kiran Nadar Museum of Art, Vadehra Art Gallery, Nature Morte and Latitude 28.

IV. DISCUSSION

The great collections were already built-in Delhi after the 1990s. Galleries are now taking part in art fairs all around the world, exposing them to global trends. In the spirit of the times, gallery owners are more willing to show video and performance art. For example, in KNMA, the participating artists presented blurred visions of broaching life through their films, videos, and kinetic objects that were displayed in the museum's black boxes, illuminating the need for a rewiring of the world. The major artworks are displayed in galleries like installation art, video, performance art and photography, but there are fewer artworks of new media.

V. CONCULSION

Art galleries are the places to go to see the newest tendencies, themes and media. The galleries thus have a very important function. Not only do gallery owners seek to sell works to prestigious collectors, but they also aim to build networks with galleries internationally, with curators and critics, and in every respect to serve as the advisers or managers for the artists and to promote them and their work.

Online sites are becoming as important and popular as gallery locations in this age of digitalisation. Gallerists are investing in websites because they allow them to reach a larger audience not just in India but also throughout the world.

Galleries in New Delhi, Mumbai and Kolkata show ready-mades, sculptures, installation, videos, photos and other experimental artistic expressions, although oil on canvas is still the most common medium displayed in the many galleries throughout the country.

Art galleries, such as Religare Art Vadehra Art Gallery, have recently organised their area around erecting book shops, cafes and art shops within their grounds in order to draw more visitors.

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RURAL WOMEN EMPOWERMENT IN INDIA: CHALLENGES, NEEDS AND INITIATIVES

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Abstract -

Women's Empowerment has been an issue of immense discussions and contemplation over the last few decades world-wide. This as an agenda has been on top of the lists of most government plans & programs as well. Women empowerment in India is the most effective tool for development as these days; women across the world are actively working as a leader and surpassing others in all the spheres of life. Women empowerment in rural areas has been pointed out as an indispensable condition to reduce poverty and enhancing rural development in developing country like India. Although women make up half of the Indian population, their participation in various activities is not the same as men even today. Without the participation of women in the development process, society as a whole cannot be said to develop sufficiently. In recent decades the topic of women's empowerment in rural areas has become acute, especially, in developing countries like India. Rural women are key agents for achieving the sustainable development of India. The present study attempts to analyze the women empowerment in rural India. This paper reveals issues, problems, needs and necessity of rural empowerment in India. It is also tried to exhibit the facts about various programmes conducted by the Government of India to improve the women empowerment and it illustrates the fact clearly that empowering the women is key not only to the well-being of individuals, families and rural communities, but also to overall development of the country.

Keywords - Rural Women Empowerment, Rural Development, Issues, Needs

I. INTRODUCTION

The Indian Constitution provides for the principle of gender equality in its preamble, and women's equality is provided as a fundamental right. The constitution places obligations on the state to foster the same as part of its fundamental duty and to provide a definitive direction through well-thought-out policies and directions. However, there is still a long way to go even after more than seventy years of independence. Each day, the media is full of stories of atrocities against women. These issues are concentrated more in areas and communities that still accept the age-old concept of male superiority. The social and economic structure in rural India has not changed much over the years. Underemployment, casteism, and lack of education have a major role to play in the marginalization of women, particularly in rural areas. Women are the victims of social, political, religious, and economic subordination and deprivation in Indian society. Also they are treated unequally and cannot participate in democratic activities equally with men. Democracy becomes meaningless and paralyzed unless fifty per cent of its population participates in the democratic decision making processes and joins in the economic, social, and political activities. The gender disparity, especially in rural India, is a glaring and grim reminder to the still rampant problem of gender discrimination. Women still have issues concerning financial exclusion and the lack of education opportunities, medical care, sanitation facilities, and more.

In rural India, many important characteristics, such as equity and inclusiveness, have been ignored for many

decades. Even though women constitute nearly half of the total population in India, they are often excluded from the politics and public representation. Therefore, to make democracy sustainable it is necessary that both women and men should take part in the development activities. To address the issue of women's equality and uplift their social status, the Government of India has made a concerted effort by way of laws, plans, and programs in various spheres, with the realization that the way forward is to shift the focus from welfare to development. Thus women's empowerment has gained recognition as the core issue in uplifting the status of women.

II. THEORETICAL FRAMEWORK

'Empowerment is the process of increasing the authority and responsibility of individuals or groups to make choices and to transform those choices in to desired actions and outcomes.'

Empowerment is not a technocratic goal—it is a wholesale political commitment. Achieving it requires a long-term process in which all cultural, social, political and economic norms undergo fundamental change. It also requires an entirely new way of thinking—in which the stereotyping of women and men no longer limits their choices, but gives way to a new philosophy that regards all people as essential agents of change that views development as a process of enlarging the choice of both sexes, just not one.

The term women empowerment is all about authority, or the power embarked on women sharing

indistinguishable rights. The term refers to the liberation of women from socio-economic restraints of reliance. Women comprise around 50% of the country's population, and a bulk of them stays economically dependent on each other without employment. In the age of feminism, a small portion of women in India are freed and can employ their free will and are permitted to carve out their lives the way they want. But there is a considerable division of the women in this nation who require optimistic support. In most Indian villages and semi-urban cities, women are still denied fundamental education and are never authorized to continue higher education despite amassing the understanding required.

Empowerment means women must exercise full participation in decision-making process in all walks of life, and full participation with men in all walks of life, and fully participating with men in finding equitable and practical solutions to issues in family and in society. Apart from this empowerment includes women right to have control over and decide freely and responsibly on matters related to their sexuality, including sexual and reproductive health, free of coercion, discrimination and violence. Equal relationships between women and men in matters of sexual relations and reproduction including full respect for the integrity of the person, require mutual respect, consent and shared responsibility for sexual behaviour and its consequences.

III. REVIEW OF LITERATURE

Ayyappadas (2016) enumerates the problem faced by women entrepreneurs. The chief and most troublesome of which is the marketing problem, where men play a dominant role. Particularly, the rural women are worship though they possess indigenous knowledge, talent, potential and resources. But they are bountifully deprived of the legitimate and justifiable opportunity to prove their mettle. The proper choices of business, lack of technical skill and absence of training programs and other problems for women entrepreneurs.

Nethravathi (2014) points that indefatigable courage of women has embolden them to break open the age old confinement of four walled houses and their metamorphosis from mute and passive spectators into active participants in the familial / societal / national activities has been duly recognized as a result of which they are assigned positions in entrepreneurship which are hitherto the exclusive property of males and their entry into business world has positively profited the national economy as it is kept active and vibrant.

Reddy (2014) praises the role of these women entrepreneurs in spreading the spirit of freedom among women. Besides being self-employed themselves, they generate employment opportunities to other women too, to make them economically

independent which is the first step towards women emancipation just like a candle which lights other candles to spread light these women are not satisfied with themselves alone empowered. They extend a helping hand to the lives of them to advice in life.

Manisha and Frehama (2014) elimination of gender discrimination through women empowerment is not a national phenomenon but a global one. Endorsing this view Vike and Kale 2014 proceeds further and assert that the increased frequency and magnitude of participation in the modern technology based entrepreneurship world ensure sustainable development of national economy. Citing the examples from other countries includes the developed nations.

H. Subrahmanyam (2011) compares women education in India at present and Past. Author highlighted that there has a good progress in overall enrolment of girl students in schools. The term empower means to give lawful power or authority to act. It is the process of acquiring some activities of women.

M. Bhavani Sankara Rao (2011) has highlighted that health of women members of SHG have certainly taken a turn to better. It clearly shows that health of women members discuss among themselves about health related problems of other members and their children and make them aware of various Government provisions specially meant for them.

Doepke M. Tertilt M. (2011) Does Female Empowerment Promote Economic Development? This study is an empirical analysis suggesting that money in the hands of mothers benefits children. This study developed a series of non cooperative family bargaining models to understand what kind of frictions can give rise to the observed empirical relationship.

Duflo E. (2011) Women's Empowerment and Economic Development, National Bureau of Economic Research Cambridge The study argues that the inter relationships of the Empowerment and Development are probably too weak to be self sustaining and that continuous policy commitment to equally for its own sake may be needed to bring about equality between men and women.

Sethuraman K. (2008) The Role of Women's Empowerment and Domestic Violence in child Growth and Under nutrition in a Tribal and Rural Community in South India. This research paper explores the relationship between Women's Empowerment and Domestic Violence, maternal nutritional status and the nutritional status and growth over six months in children aged 6 to 24 months in a rural and tribal community. This longitudinal observational study undertaken in rural Karnataka, India included tribal and rural subjects.

Venkata Ravi and Venkatraman (2005) focused on the effects of SHG on women participation and exercising control over decision making both in family matters and in group activities.

IV. OBJECTIVES OF THE STUDY

1. To identify the Problems and challenges in the Path of Women Empowerment.
2. To know the need and necessity of Women Empowerment.
3. To analyze the ways for Empowerment of rural women.
4. To study the Government Schemes For Women Empowerment.

V. RESEARCH METHODOLOGY

This paper is basically descriptive in nature. In this paper an attempt has been taken to analyze the empowerment of rural women in India. The data used in it is purely from secondary sources according to the need of this study.

VI. RURAL WOMEN EMPOWERMENT IN INDIA

Women empowerment in India is heavily dependent on many different variables that include geographical location (rural/urban), educational status, social status (caste and class) and age. Policies on women empowerment exist at national, state and local levels in many sectors including health, education, economic opportunities, gender based violence and political participation. The scope and coverage of the schemes launched has been expanding that include initiatives for economic and social empowerment of women and for securing gender equality.

According to Census-2011, India has reached the population of 1210 million, as against 301 million in 1951, of which 58,64,69,174 (48.5 %) were females. The population of India accounted for 17.5% of the total world population and occupied second place. The sex ratio was 930 in 1971 and it has increased to 940 according to 2011 Census. The female literacy also increased from 18.3% in 1961 to 74.0% in 2011 and a decrease in male-female literacy gap from 26.6% in 1981 to 16.7 per cent in 2011.

As per Census 2011, literacy rate at all India level is 72.98% and literacy rate for females and males are 64.63% and 80.9% respectively (Ministry of Statistics and Program Implementation, 2017). During the last decade, highest improvement in literacy rate has been observed among rural females (24%). The gap in literacy rates of males and females is low in the States of Meghalaya, Kerala and Mizoram (less than 5 percentage points) and high in the States of Rajasthan, Jharkhand, Dadra & Nagar Haveli, Jammu & Kashmir, Uttar Pradesh, and Chhattisgarh (20 percentage points or above) with Rajasthan being the highest. During 2014 -15, the Gross Enrolment Ratio (GFR) at Primary level for females and males are 101.4 and 98.9 respectively; at middle class level the corresponding figures are 95.3 and 87.7; at higher secondary level, the status is at 65.8 and 63.8

respectively (Ministry of Statistics and Program Implementation, 2017). In 2014-15, there are 93 girls per 100 boys in primary class, 95 in middle class, 91 in secondary class and 90 in senior secondary class. The adult literacy rate for females in rural areas is 50.6% vis-a-vis 76.9% in urban areas whereas for males the same in rural areas is 74.1% vis-a-vis 88.3% in urban areas (UN Women, 2012). The work force participation in India is estimated to be 25.51% for females and 53.26% for males. (Ministry of Statistics and Program Implementation, 2017). Worker Population Ratio for females is higher in rural areas (24.8%) than urban areas (14.7%). For males, the ratios in rural and urban areas are 54.3% and 54.6% respectively (Ministry of Statistics and Program Implementation, 2017). Thus, considerable gender gap exists in both rural and urban areas and the gap is higher in urban areas. The average wage/salary received per day by regular wage/salaried employees of age 15-59 years for females is rural: Rs.201.56 and urban: Rs.366.15 which is lower than that of males (rural: Rs.322.28, urban: Rs.469.87) in both rural and urban areas and the gap is more in rural areas. Unemployment Rate (UR) is more for females in both rural and urban areas with the gap very wide for the urban (Ministry of Statistics and Program Implementation, 2017).

VII. CHALLENGES AND PROBLEMS IN WOMEN EMPOWERMENT

There are various issues and problems which women generally face in the society in India which may become hindrances in women empowerment. Some of the problems are mentioned and described below:

1. Selective abortion and female infanticide: It is the most common practice for years in India in which abortion of female fetus is performed in the womb of mother after the fetal sex determination and sex selective abortion by the medical professionals.

2. Sexual harassment: It is the form of sexual exploitation of a girl child at home, streets, public places, transports, offices, etc by the family members, neighbors, friends or relatives.

3. Dowry and Bride burning: It is another problem generally faced by women of low or middle class family during or after the marriage. Parents of boys demand a lot of money from the bride's family to be rich in one time. Groom's family perform bride burning in case of lack of fulfilled dowry demand. In rural areas parents can not afford it even though they have to arrange anyhow.

4. Disparity in education: The level of women education is less than men still in the modern age. Female illiteracy rate is higher in the rural areas. Women education percentage is low in India especially in the rural areas because they are discouraged for higher education like professional and technical education.

5. Violence against women: Women are getting affected by the various violence almost every day which is disrupting the society. Women are being victims of violence at huge level day by day because of increasing crimes against women (according to the report of Crime Record Bureau of the Central Home Ministry). Woman is getting kidnapped at every 44 minutes, raped at every 47 minutes, 17 dowry deaths every day, etc. They may face violence within the family (dowry related harassment, death, marital rape, wife-battering, sexual abuse, deprivation of healthy food, female genital mutilation, etc) or outside the family (kidnapping, rape, murder, etc).

6. Gender discrimination: Women are considered as weaker section of the society than men and given less importance. Girls' children are becoming real victims of the discrimination. There are also discrimination of power and work between men and women because of the patriarchal system families in India. Gender discrimination affects women in the areas like nutrition, education, health, care, decline of female population, job, public life, etc.

6. Problems related to unemployment: Women are getting more problems in searching their suitable work. They become more prone to the exploitation and harassment in the work areas.

7. Child Marriages: Early marriage of the girls by their parents in order to be escaped from dowry. It is highly practiced in the rural India.

8. Inadequate Nutrition: Inadequate nutrition in the childhood affects women in their later life especially women belonging to the lower middle class and poor families.

8. Low status in the family: It is the abuse or violence against women. So women give low preference for achievement or absence of ambition for the achievement

9. Status of widows: Widows are considered as worthless in the Indian society specially in rural areas. They are treated poorly and forced to wear white clothes.

VIII. NEED AND IMPORTANCE FOR WOMEN EMPOWERMENT

In recent times, everyone is pointing on the empowerment of women. It's right to say that women's empowerment has become the necessity of the time. Women should possess liberty, faith, and self-worth to opt for their needs and demands. Discrimination based on gender is useless and is having zero worth by looking at the growth of women in the last few decades. Women are paid less and are treated as a cook and slave in families, and their real potential fails to get highlighted. Rural Women empowerment in India is required to overcome situations of such types and to provide them with their independent role in Indian society. Empowering women is a necessary right of women. They should have proportional rights to contribute to society,

economics, education, and politics. They are approved to gain higher education and receive a similar treatment as men are receiving.

1. Ensures Holistic Development of Society: Rural Women empowerment in India is one of the principal terms for society's overall development. There is nothing erroneous in participating in the development of society. In the world of corporates, women are playing numerous roles such as medical, engineering, and so on. Apart from taking part in the sphere of technology, they are energetically partaking in security services such as police, navy, military, etc. All these before-mentioned services are taking the community to another level.

2. Determine their Intelligence Level: Over the preceding decades, there has been a uniform increase in women's empowerment. Women must possess self-worth, confidence, and freedom to choose their needs and requirements. Classifying the people based on gender is unreasonable, and it has no worth. Still, women are paid less, expected to cook, and restricted by their family members. To overcome these situations and to have an independent role in society, women's empowerment is needed.

Empowering women is the fundamental right of women. They can have equal rights to participate in education, society, economics, and politics. They are allowed to have higher education and treated in the way like men. In this article, you will know about the importance of women's empowerment. So make a halt on this page and read the following content.

3. Economic Benefits: Women Empowerment also leads to more economic benefits not to the individuals but to the society as well. Last days when they stayed at home only and do only kitchen stuffs, nowadays, they roam outside and also earn money like the male members of the society. Women empowerment helps women are independent and also to earn for their family which grows country's economy.

4. Reduction in domestic violence: Women Empowerment helps to decrease domestic violence. Uneducated women are at higher risk for domestic violence than educated women.

5. Reduce Poverty: Women Empowerment help to reduces poverty. From time to time, the money earned by the male member of the family is not adequate to meet the demands of the family. Then earnings of women help the family to come out of poverty.

6. Know about their intelligence: It is unthinkable to understand and analyze the way of living of women by peeking at them. You can foresee their level of intelligence by way of moving toward the problems and in the solution-finding. In the contemporary era, women are nicely versed in unraveling technical troubles. Women's empowerment plays a vital role in these cases. Without women empowerment in India, you won't be able to determine and understand the intelligence of

women. Therefore, making existence in work is particularly important and an advantageous one. You can present any gift to give recognition to their work.

7. Make Equally competent and intelligent to men: Women are equally competent. Nowadays, women are even ahead of men in many socio-economic activities.

IX. WAYS TO EMPOWER WOMEN

- Changes in women's mobility and social interaction
- Changes in women's labour patterns
- Changes in women's access to and control over resources and
- Changes in women's control over Decision making
- Providing education
- Self employment and Self help group
- Providing minimum needs like Nutrition, Health, Sanitation, Housing
- Other than this society should change the mentality towards the word women
- Encouraging women to develop in their fields they are good at and make a career

X. GOVERNMENT INITIATIVES

There are multiple government schemes to support and guide the rural women through various entitlements, which has also helped them to come together to form Self Help Groups (SHGs). Schemes like Pradhan Mantri Mudra Yojana supports more than 50 million small business owners, a majority of whom (78 per cent) are women. These SHGs with enterprising women help a community at large to explore business ideas, gain access to resources (human, intellectual and financial) to begin their venture and explore means to expand these as well. Mahila Shakti Kendra is another scheme that aims to empower rural women with opportunities for skill development, employment, digital literacy, health and nutrition.

The National Policy for the Empowerment of Women in 2001 laid out goals and guiding principles for the empowerment of women:

- (i) Creating an environment through positive economic and social policies for full development of women to enable them to realize their full potential;
- (ii) The de-jure and de-facto enjoyment of all human rights and fundamental freedom by women on equal basis with men in all spheres – political, economic, social, cultural, and civil;
- (iii) Equal access to participation and decision-making of women in social, political and economic life of the nation;
- (iv) Equal access of women to healthcare, quality education at all levels, career and vocational

guidance, employment, equal remuneration, occupational health and safety, social security and public office, etc.

- (v) Strengthening legal systems aimed at elimination of all forms of discrimination against women;
- (vi) Changing societal attitudes and community practices by active participation and involvement of both men and women;
- (vii) Mainstreaming a gender perspective in the development process;
- (viii) Elimination of discrimination and all forms of violence against women and the girl child; and
- (ix) Building and strengthening partnerships with civil society, particularly women's organizations.

Laws Related to Women Empowerment

- The Maternity Benefit Act 1961
- The Dowry Prohibition Act, 1961
- Indecent Representation of Women (Prohibition) Act, 1986
- The Commission of Sati (Prevention)Act, 1987
- Protection of Women from Domestic Violence Act, 2005
- Equal Remuneration Act 1976
- The Employees' State Insurance Act, 1948
- Relevant provisions of Code of Criminal Procedure, 1973
- Family Courts Act, 1984
- The Indian Succession Act, 1925
- The Medical Termination of Pregnancy Act 1971
- The Child Marriage Restraint Act, 1929
- The Hindu Marriage Act, 1955
- The Indian Divorce Act, 1969

The Centre would implement an umbrella scheme for protection and empowerment of women at an estimated expenditure of Rs.1800 crore during the 12th Five Year Plan. The Union Ministry of Women and Child Development has moved a proposal for this scheme to the Expenditure Finance Committee (EFC).

- Protection of Women from Domestic Violence (PWDV) Act, 2005.
- National Mission for Empowerment of Women (NMEW)
- Projects of One Stop Crisis Centres (OSCCs) in urban areas
- Schemes for Economics Empowerment
 - Swa-Shakti
 - Swayamsiddha
 - Swawlamban Programme
 - Support to Training and Employment Programme (STEP)

Support Service

- Construction of Working Women Hostels
- Creches

- Relief, Protection and Rehabilitation to Women in Difficult Circumstances-Swadhar, Compensation to Rape Victims.

Institutional Services

- State Homes
- Service Homes
- Working Women's Hostels
- Vocational Training Centres
- Regional Tailoring Centres
- Craft Training Centres
- District Crafts including Tailoring Centres
- Women Technical Training Institute (WTTI)
- Centrally Sponsored Schemes
- 1. Integrated Rural Development Programme (IRDP)
- 2. Training for Rural Youth for Self-Employment TRYSEM)
- 3. Development of Women and Children in Rural Areas (DWCRA)
- Integrated Rural Development Programmes (IRDP)
- Training for Rural Youth Self-Employment (TRYSEM)
- Development of Women and Children in Rural Areas (DWCRA)
- Mahila Samridhi Yojana (MSY)
- Indira Mahila Yojana (IMY)
- Rashtriya Mahila Kosh (RMK)
- Swarnajayanthi Gram Swarozgar Yojana (SGSY)
- The Velugu Programme
- Indira Kranti Patham

The efforts of government and its different agencies are ably supplemented by nongovernmental organizations that are playing an equally important role in facilitating women empowerment. Despite concerted efforts of governments and NGOs there are certain gaps. Of course we have come a long way in empowering women yet the future journey is difficult and demanding

XI. CONCLUSION

From the study it is found that there many hindrances in rural women empowerment like gender discrimination, education, participation in economic activities, decision making, low sense of achievements and others. It is observed that India has enacted many constitutional and legislative provisions for empowerment of women. Many development schemes especially for women have also been launched for improving their fortune. Such measures have started giving positive outcomes relating to women's problems. But the position of

women in our country still leaves much to be desired. Top priority should be given in our developmental plans for improving female literacy and creating skills and capability among women for enabling them to stand on their own feet.

Empowerment of women could only be achieved if their economic and social status is improved. This could be possible only by adopting definite social and economic policies with a view of total development of women and to make them realize that they have the potential to be strong human beings. Thus, the attainment in the field of income / employment and in educational front, the scenario of rural women empowerment seems to be comparatively poor. The need of the hour is to identify those loopholes or limitations which are observing the realization of empowerment of women and this initiative must be started from the women folk itself as well as more importantly policy initiative taken by the state and society.

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TECHNO-ECONOMIC PERFORMANCE ANALYSIS FOR HOSPITAL WASTEWATER TREATMENT TECHNOLOGIES

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Abstract - This paper evaluates the techno-economic feasibility of three hospital wastewater treatment technologies (Catalytic Wet Air Oxidation, Fenton and Photo-Fenton) in reducing the concentration of pharmaceutical grade chemicals compared to the business as usual of their direct release to the following three environmental streams – wetland, river, sea. A shadow pricing modelling methodology is applied for estimating the environmental damage costs for the selected pharmaceutical chemical released to the three environments. Its implementation is demonstrated through a case study for a typical hospital in Turkey, with a hospital capacity of 750 beds and an average hospital effluent flow rate of 300 L/day. The following four scenarios are considered – A) environmental levy for direct release without any treatment, B) environmental levy + shadow pricing of the avoidable environmental cost for direct release without any treatment, C) includes operating costs of the scoped technological intervention and environmental levy on residual untreated effluent release, D) includes shadow pricing of the avoidable environmental cost for direct release of the residual effluent in addition to all costs in Scenario C. The shadow price of estimated annual environmental costs for 100% direct release (Scenario B), was found to be the highest for the wetland environments (largely attributed to the accumulation of the contaminants in stagnant water), followed by river and sea. Among the three treatment technologies, homogenous Fenton appears to offer the most cost-effective intervention, with a return on investment of 346%, 262% and 12% and Internal rate of return of 84%, 64% and 3%, respectively for release to the wetland, river, and sea environments.

Keywords - CWAO; Ecosystem Degradation; Fenton; Hospital Effluent; Shadow Pricing; Techno-Economic

I. INTRODUCTION

Hospitals around the world use a large variety of pharmaceuticals in a range of medical practices, which are often discharged untreated through the hospital drainage system into the surrounding aquatic environment with severe ecological and human health consequences [1]. Typical hospital wastewater comprises of pharmaceutical effluent from different groups, such as antibiotics, anti-tumour drugs, anaesthetics and contrast media from X-ray imaging[2]. Water reuse of treated wastewater in Europe considered to be around 1,100 million m³/year, while the EU aims to increase this to achieve around 6,000 million m³/year of treated wastewater [3]. The lack of hospital wastewater treatment plans and strategies puts developing countries particularly at risk of the most highly contaminated environments, arising mainly from untreated pharmaceuticals in the wastewater[4], with the cost of environmental and social damage being accounted for. Releasing the untreated wastewater with high pollutant concentration to any of the eco-systems, wetland, river, or sea where it damages the environment and humans' health directly and where the affects give rise to severe both long and short-term damage as it transports through the environment[6][7][8]. Over the last three decades the scientific community significantly increased its focus on developing more environmentally friendly technologies that reduces the damage done to the environment while building sustainable communities

[9]. Within the European context the Water Framework Directive (WFD) is the main legislative instrument for water protection and requires member states to ensure water bodies (freshwater and coastal marine) achieve good ecological status by 2015[10]. On December 2019, an EU Water Legislation - Fitness Check concluded that water legislation is broadly fit for purpose, with room for improvement related to investments, implementation, integrating water into other policies, chemical pollution, administrative simplification and digitalisation. The fitness check is a comprehensive policy evaluation of:— the Water Framework Directive (WFD)— the Environmental Quality Standards Directive (EQSD)— the Groundwater Directive (GWD)— the Floods Directive (FD). It assesses whether the Directives are fit for purpose by examining their performance against 5 criteria set out in the Commission's Better Regulation agenda: effectiveness, efficiency, coherence, relevance and EU added value. On 26 July 2021, the EU Commission launched an online public consultation to seek views on the upcoming review of the lists of pollutants occurring in surface and ground waters and corresponding regulatory standards[11]. The fact that the WFD's objectives have not been reached fully yet is largely due to insufficient funding, slow implementation and insufficient integration of environmental objectives in sectoral policies, and not due to a deficiency in the legislation. As for future challenges, this fitness check finds that the Water Framework Directive is sufficiently prescriptive with

regard to the pressures to be addressed, and yet flexible enough to accommodate emerging challenges such as climate change, water scarcity and pollutants of emerging concern (e.g. micro-plastics and pharmaceuticals). A key area where there is room to improve and to achieve better results is on chemicals. Modern technologies in wastewater treatment have been introduced to minimize pollution and to develop sustainable practices in hospital wastewater where Catalytic Wet Air Oxidation (CWAO), Fenton and Photo-Fenton have shown the most effective removal rate whilst employing safe environmental practices [12][13][14]. Shadow pricing methodology has been adopted to evaluate the cost of undesired released outputs from different production activities where they impact the environment and has no market value [15][16][17][18]. It represents the cost of damage to the environment by accounting for the external effects that could impact the environment. This approach provides a means to environmentalists/ecologists and economists to understand the benefits of developing environmentally friendly intervention that can reduce the damage [19][20]. This paper presents an evaluation of the techno-economic feasibility of different hospital wastewater treatment technologies in reducing the concentration of pharmaceutical grade chemicals compared to the business-as-usual of their direct release to the following three environmental streams – wetland, river, sea. Three proposed technologies are considered - Catalytic Wet Air Oxidation (CWAO), Fenton and Photo-Fenton. A shadow pricing methodology is applied for estimating the environmental damage costs for the selected pharmaceutical chemical released to the three

environments in £/mg. Its implementation is demonstrated through a case study for a typical hospital in Turkey, with a hospital capacity of 750 bed and an average hospital effluent flow rate of 300 L/day.

II. MATERIAL AND METHODS

Based on literature data, seventy-nine pharmaceuticals, including mostly parent compounds and some of their transformation products, were subjected to wastewater treatment. Among the three treatment technologies considered, Catalytic Wet Air Oxidation (20 bar of pressure using 1.0 g L⁻¹ of platinum and multi-walled carbon nanotubes (Pt/CNT, 3% wt.), an intensified Fenton performed at 70°C and Photo-Fenton (150 W medium pressure mercury lamp with wavelengths shorter than 313nm cut out) were respectively effective for reducing the effluent concentration with 85%, 99.8% and 94.5% removal efficiency, with the corresponding operational cost of £5.67, £0.72 (including cost of sludge removal) and £8.81 per m³ effluent loading. It is noteworthy that for the case study,

2.1 Techno-economic Analysis

The capital [29] and the operational costs[20] for the three treatment technologies are based on literature [21] and include the energy required either to heat or pump, the cost for sludge management and the operational cost of the catalyst used, with all costs converted from Euro to Sterling using a conversion rate of 1 Euro = £0.85. Table 1 outlines the cost differences in between the three technologies used.

Treatment Technology	One-off Capital cost*[28](£)	Annual Operational Cost [21](£/m ³)
CWAO	300,000	5.67
Fenton	500,000	0.72
Photo Fenton	800,000	8.81

Table 1 Assumed costs for the three treatment technologies applied

*Designed treatment capacity 1,100m³/day with reactors, pumps, and installation.

2.2 Environmental Analysis

Dedicated wastewater treatment plants for hospital effluent require greater level of treatment of the pharmaceuticals disposed to the system [31]. Shadow Pricing modelling[32]describes a methodology based on the estimation of shadow prices for the pollutants removed in a treatment process. This value represents the environmental benefit (avoided cost) associated with undischarged pollution. The comparison of these benefits with the internal costs of the treatment process will provide a useful indicator for the feasibility of wastewater treatment projects. In this study, the shadow prices of the pharmaceuticals in each

ecosystem used the reference prices for treated wastewater effluents, provided by Hernández-Sancho et al.[33], as follows: 0.9 €/m³ for wetlands, 0.7 €/m³ for rivers and 0.1 €/m³ for sea. From this the shadow price for five main pharmaceutical elements (Trimethoprim TMP, Acetaminophen ACM, Ibuprofen IBP, Naproxen NAP, Carbamazepine CBZ) released to the three eco-systems (Wet Land, River, Sea) was calculated [34]. The calculated prices reflect the cost of damage to the eco-system arising from the release of the pharmaceutically contaminated wastewater, as shown in Table 2.

Chemical released	Pharma category	Environmental costs (£/mg)		
		Wetland	River	Sea
Trimethoprim, TMP	Antibiotic	£0.34	£0.26	£0.03
Acetaminophen, ACM	Analgesic	£108.97	£84.75	£12.07
Ibuprofen, IBP	Anti-inflammatory	£9.35	£7.23	£1.02
Naproxen, NAP	Analgesic	£2.89	£2.21	£0.34
Carbamazepine, CBZ	Antiepileptic	£0.51	£0.43	£0.09

Table 2 Shadow price values for environmental damage from release of the scoped pharmaceuticals to different ecosystem environments[33]

2.3 Effluent loading

Table 3 gives the assumed concentrations released into the environment for TMP, NAP and CBZ are based on published data for the Wastewater Treatment

Plant in Varese Olona, Italy[33], whereas for ACM and IBP the concentrations are based on hospital untreated wastewater samples [34].

Analyte	Concentration (µg/L) [Ref source in brackets]
Trimethoprim TMP	4 [33]
Acetaminophen ACM	34.00 [34]
Ibuprofen IBP	165.50 [34]
Naproxen NAP	94 [33]
Carbamazepine CBZ	8 [33]

Table 3 Analyte concentrations of hospital wastewater

The amount and composition of wastewater treated was modelled using literature data, primarily the average flow rate for a hospital in developing countries between 0.2-0.4 m³/per bed per day for a hospital capacity of 750 Beds[35].

2.4 Scenarios

The following four scenarios are considered – A) accounting for environmental levy for direct release without any treatment, B) accounting for environmental levy + shadow pricing of the avoidable

environmental cost for direct release without any treatment, C) accounting for the cost of operating the scoped technological intervention and environmental levy for the release of residual untreated effluent, D) accounting for the cost of operating the scoped technological intervention, environmental levy for the release of residual untreated effluent + shadow pricing of the avoidable environmental cost for direct release of the residual effluent.

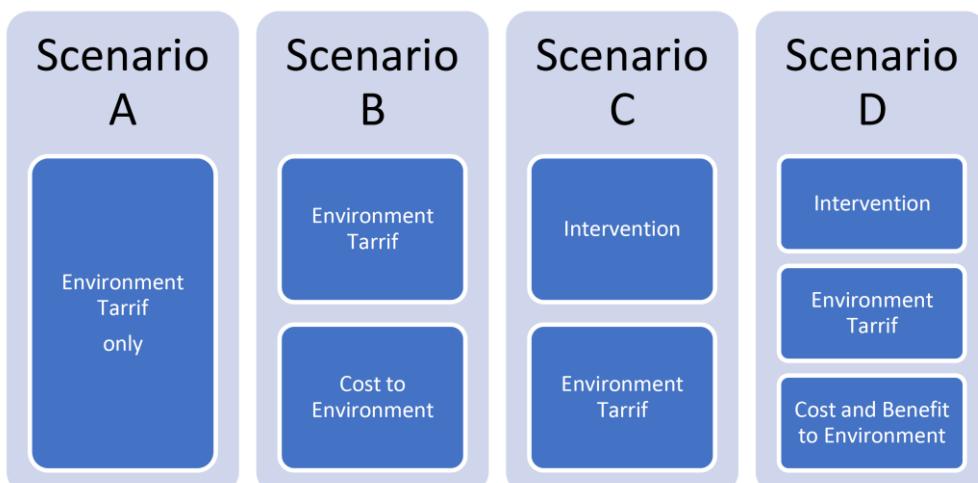


Figure 1. Complexity of the four scenarios evaluated.

III. RESULTS AND DISCUSSION

The total annual flow of the hospital wastewater for the case study is estimated to be 109,500 m³. Based on the assumptions applied in Table 3, this corresponds to a total annual loading of the scoped pharmaceuticals of 33,452 mg. All three proposed technologies show high removal rates for this pharmaceuticals, albeit with varying degree of relative differences (as shown in Table 4). In the case of CWAO, with the removal rate of 85%, this technology is estimated to treat approx. 28,434

mg/year, leaving 5,018 mg/year untreated (assumed to be released to the environment). This is the highest among all the three technologies considered. For Photo-Fenton, with a relatively higher removal rate of 94.5%, the corresponding estimates of untreated waste is 1,840 mg/year. On the hand, for the Fenton technology, with the highest removal rate of 99.8 %, the estimated treated loading is 33,385 mg/year and only 67 mg/year of the untreated residual loading of the pharmaceuticals is released to the environmental stream.

Flows	CWAO	Fenton	Photo-Fenton
Total flow m ³ /year	109,500	109,500	109,500
Total Pharmaceutical mg/year	33,452	33,452	33,452
Total treated pharmaceutical mg/year	28,434	33,385	31,612
Total untreated pharmaceutical mg/year	5,018	67	1,840

Table 4 Total treated and untreated pharmaceutical flow

IV. CONCLUSIONS AND RECOMMENDATIONS

This paper applied a shadow pricing methodology for estimating the environmental damage costs for the selected pharmaceutical chemical released to different natural environments. Its implementation is demonstrated through a case study for a typical hospital in Turkey. The environmental damage from the untreated released pharmaceutical elements is high. Using technology intervention reduces the cost of damage significantly for all the three technologies used and the three eco-systems released to. While some technologies have high operational cost, which plays a major role in cost effective analysis, our study shows that low operational cost technology such as Fenton with the high removal rate achieve the highest damage reduction to the environment with the lowest operational cost. The use of shadow price methodology to calculate the cost of damage to the natural environment from discharge of pharmaceuticals demonstrates clear incentive of applying technological intervention to treat them at source. However, this warrants more detailed investigation of the real-world costs, including the unaccounted cost and damage to the environment, which was not scoped in this study.

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DESIGNING OF MICROSTRIP PATCH ANTENNA USING ARTIFICIAL NEURAL NETWORKS AND ANTENNA TOOLBOX

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Abstract - This paper provides microstrip patch antenna design using artificial neural networks with enhanced back-propagation algorithm for calculating the design parameters, as the dimensions of the antenna is the major limitation in any application. The antenna dimensions are calibrated using MATLAB R2021a with the help of mean square value which is generated using the algorithm. The antenna is designed and simulated using the antenna toolbox and HFSS v15. The performance of the antenna is compared in both the simulation softwares in the frequency ranging 1GHz to 5GHz with a critical frequency of 2.5GHz. The antenna is tested for return loss, VSWR, gain, impedance and radiation pattern with FR4_Epoxy, Rogers RT_Duroid 5880TM, Rogers RO 003TM and Rogers RO 3003TM as substrates . The Back Propagation training algorithm is incorporated in the calculations to minimise the errors and computational time. The dimensions obtained using ANN are simulated using MATLAB with the help of an antenna toolbox as well as HFSSv15.

Keywords - Microstrip Antennas, Artificial Neural Networks, Back Propagation, MATLAB, Antenna Toolbox, HFSS

I. INTRODUCTION

A low profile antenna with compact size, shape, weight, cost, performance, easy installation and conformal in nature is very much in demand for applications such as vehicular communication [1], missile technology [2], satellite communication, personal area network, Wi-Fi, ZigBee, Bluetooth and many more standard communications. Presently many government and private sector applications require these type of specifications as they use 4G and 5G wireless communication and radio communication. To qualify for these types of applications, micro strip patch antennas can be used for communication between the devices, units and cloud. These antennas are low profile in nature, easy to fabricate and can be placed on any surface depending on the application demand. These antennas are inexpensive and versatile and robust in nature for resonating frequencies even at mm frequency. Microstrip patch antenna is also referred to as patch antenna where the shape of the radiating patch can be varied according to the usage such as rectangular, square, triangular, elliptical or any other configuration (such as fractal in nature)[3]. As the dimensions are calibrated for specified frequency, the drawback it possesses is its narrow bandwidth and a lot of side lobes and back lobes. There exists the choice of calibrating the patch dimensions depending on various algorithms, trial-hit process and various online simulators. The advancement towards data science, neural networks and artificial intelligence provides an excellent opportunity to re-calibrate the dimensions of the patch, substrate and other parameters such that the antenna possesses a better resulting performance towards return loss, resonating

frequency, gain and radiation pattern [4].Various artificial neural networks models are developed such that they can provide mean square error, which in turns help to design the antenna with more accurate dimensions. In this work, the analysis problem can be defined as to obtain the resonating frequency for a given dielectric constant, substrate height and impedance of the proposed antenna. In the similar way, synthesis problem can be defined as to obtain the dimensions of the antenna using lower and upper cut off frequency, dielectric constant, substrate height and impedance of the proposed antenna [5]. Back propagation is the most famous algorithm in feed forward neural networks, artificial neural networks and various other applications [6]. These algorithms compute the gradient of the loss function with respect to the weights available in a network. These can be adapted even for multi-layer to minimize the error in obtaining any specific value or calculations. Chain rule is used to compute the gradient at each layer in order to achieve mean square error [7]. Once the error is calculated, it is easy to calibrate or adjust the dimensions of any specific object, in this case the dimensions of patch and substrate of the antenna. Antenna toolbox provides various applications and functions for the design, visualization, simulation and synthesis of both single element and multi element antennas. It also includes a method of moments in order to compute impedance, efficiency, near-field, far field radiation patterns. The toolbox comes with various dielectric materials which support almost all the common substrates of micro strip patch antennas [8]. The range of dielectric constant is in the range of 1.03 to 4.8 with operating frequency up to 40GHz. The toolbox also supports cone antennas, cavity antennas, fractal antennas, reflector antennas and slot

antennas [9]. The visualization of the antenna is carried out for both 2D and 3D for polar and smith plots. The tool box consists of an enormous library of predefined antennas and can also support customized antennas. In this paper, I am designing antennas with various shapes of patch such as rectangular, circular, triangular and square [10].

II. DESIGN PROCESS

In this section, the patch antenna geometry is calibrated with the help of hidden layer and back

propagation. The dimensions are obtained using input variables such as the height of the substrate ($h=1.6\text{mm}$), range of frequency of operation ($f_1=1\text{GHz}$, $f_2=5\text{GHz}$), impedance of the antenna (50 ohms) and dielectric constant for fr4_Epoxy material (4.4). The alternate way is the analysis model, but in this paper the scope is kept only for the synthesis model. The input variables are provided as per the figure 1 in order to achieve the dimensions of the antenna.

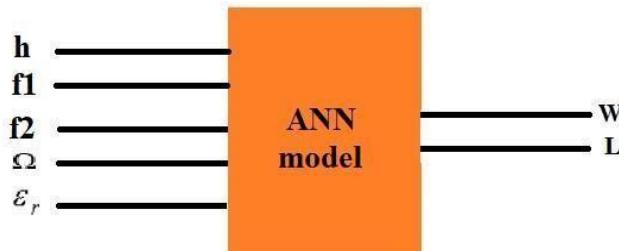


Fig1: The synthesis of microstrip patch using ANN model

The Back Propagation algorithm is used in the ANN model for achieving the mean square error and to provide the accurate dimensions of the antenna [11]. In this algorithm the input layer is fed with all the inputs provided as shown in figure1. The output of this layer is connected to the hidden layer and from the hidden layer it is connected to the output layer which provides the dimensions of the antenna after calculating the mean square error [12]. The network is trained using the gradient descent method and the

error calculated is sent back to the hidden layer as well as the output layer for weight adjustments [13]. The model first uses a forward pass which takes the input, derives the error function and then generates the weights according to the input functions [14]. Upon receiving these weights, a backward pass is used to calculate the error deviation and computes the weight adjustment which is given as feedback to the hidden layer as shown in figure 2[15].

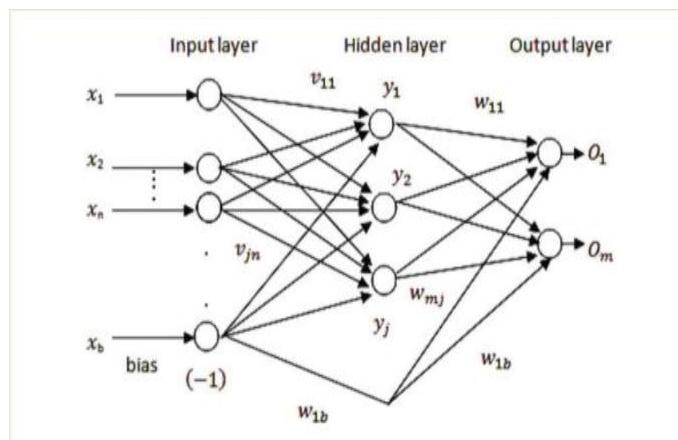


Fig2: Back Propagation Neural Network model

The following are the algorithm steps which are implemented using MATLAB, in order to achieve mean square error at various epochs such that the least mean square value is achieved.

- Step 1: $\eta > 0$, Maximum error E_{\max} is chosen.
- Step 2: Weights are initialized at small random values, $E \leftarrow 0, p \leftarrow 1, k \leftarrow 1$

- Step 3: Now begin the training process. Input is provided to input layer and output is Calculated
- Step4: Calculate the new value of error by using previous value of error, desired output a_k and actual output O_k
- Step 5: Now value of error for both the layer is computed
- Step 6: Now weights of output layer are adjusted

- Step 7: Now weights of Hidden layer are modified
- Step 8: If p is less than P then p = p + 1 and k = k + 1 and go to step 3, otherwise
- return back to step 9.
- Step 9: At last, the sequence of the full training process is finished and the least mean square error is obtained.

The algorithm is configured with 5 input neurons, 10 and 5 neurons in a single hidden layer, and 2 output neurons with learning rate = 0.15, goal = 0.001, and

trained for 500 epochs, 1000 epochs, 1500 epochs and finally for 2000 epochs. The least mean square error is then calibrated and applied for the calculations of antenna such as Patch width, Patch length, Substrate width, Substrate Length, Inset, Inset gap, Radiation width, Radiation Length and Radiation Height, along with Feed length and Feed width. Further the dimensions of each side of square patch, radius of circular patch and each side of rectangular patch are also calculated as shown in the figure 3.

```

all_designs.m | Command Window
Command Window
Rectangle Patch
Patch Width:45.6435 mm
Patch Length:35.4543 mm
Substrate Width:55.2435 mm
Substrate Length:45.0543 mm
Inset:14.1542 mm
Inset Gap:0.2428 mm
Radiation Width:79.858 mm
Radiation Length:69.6687 mm
Radiation Height:26.2145 mm
Feed Width:9.2304 mm
Feed Length:18.4609 mm
Square Patch
Each Side:40.2276mm
Triangle Patch
Each Side:61.1327mm
Circle Patch
Radius:22.696mm

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Fig3: Obtained Parameters of antenna using MATLAB

The following table provides the least mean square error achieved at 500 epochs, 1000 epochs, 1500

epochs and 2000 epochs respectively, using a back propagation algorithm.

No. of Epochs	Least Mean Square Error
500 epochs	0.39691
1000 epochs	0.26804
1500 epochs	0.082474
2000 epochs	0.12887

Table 1: Least mean square error achieved for various epochs

As per table 1, it is very much clear that the minimum mean square error is achieved when the hidden layer is provided with 1500 epochs, and if we increase the number of epochs more than 1500, then there is no significant change, which makes clear that no matter how many epochs we increase, there is no guarantee that the mean square error will further reduce. The achieved mean square error is fed to the antenna toolbox in order to get the dimensions of the antenna for designing of the antenna using HFSS v15. Table 2 provides the comparison of the antenna dimensions without ANN, with 500 epochs ANN, with 1000 epochs ANN, 1500 epochs ANN and finally with 2000 epochs ANN where the most significant measurement is achieved using 1500 epochs as its least mean square error is less compared to other values as per table 1. The comparison has a significant difference between the antenna design without using ANN and that using with ANN. The difference is very minimal between the values achieved using 500 epochs, 1000 epochs, 1500 epochs and 2000 epochs, which states that the number of epochs can be limited up to 2000, as the time taken to calculate increases enormously when the ANN model is trained with more number of epochs. After the dimensions are achieved, the designing of the antenna is done using HFSS as well as using the antenna toolbox. For further understanding the conceptual design and the impact of substrate, the antennas are designed using FR4_Epoxy, Rogers RT duroid 5880TM, Rogers 4003TM and Rogers 3003TM.

Antenna Dimensions	Without ANN	With 500 epochs ANN	With 1000 epochs ANN	With 1500 epochs ANN	With 2000 epochs ANN
Rectangular patch width	45.6435mm	43.1787 mm	43.2045 mm	43.2416 mm	43.2324 mm
Rectangular patch length	35.4543mm	33.4976 mm	33.5228 mm	33.5591 mm	33.55 mm
Square patch side	40.2276mm	38.0313mm	38.057mm	38.0939mm	38.0847mm
Triangular patch side	61.1327mm	57.7951mm	57.8341mm	57.8903mm	57.8762mm
Circular Patch Radius	22.696mm	21.4569mm	21.4714mm	21.4922mm	21.487mm
Substrate width	55.2435mm	52.7787 mm	52.8045 mm	52.8416 mm	52.8324 mm
Substrate Length	45.0543mm	43.0976 mm	43.1228 mm	43.1591 mm	43.15 mm
Inset	14.1542mm	13.3791 mm	13.3872 mm	13.3989 mm	13.3959 mm
Inset Gap	0.2428mm	0.23044 mm	0.23044 mm	0.23044 mm	0.23044 mm
Radiation width	79.858mm	76.1405 mm	76.1659 mm	76.2025 mm	76.1934 mm
Radiation height	26.2145mm	24.9618 mm	24.9614 mm	24.9609 mm	24.961 mm
Radiation Length	69.6687mm	66.4594 mm	66.4842 mm	66.52 mm	66.511 mm
Feed width	9.2304mm	8.7607 mm	8.7605 mm	8.7603 mm	8.7604 mm
Feed Length	18.4609mm	17.5213 mm	17.5211 mm	17.5207 mm	17.5208 mm

Table 2: Comparison of dimensions achieved using with and without ANN

Fig 4 provides the mean square error calculation using MATLAB for 500 epochs, 1000 epochs, 1500

epochs and 2000 epochs using back propagation with one hidden layer.

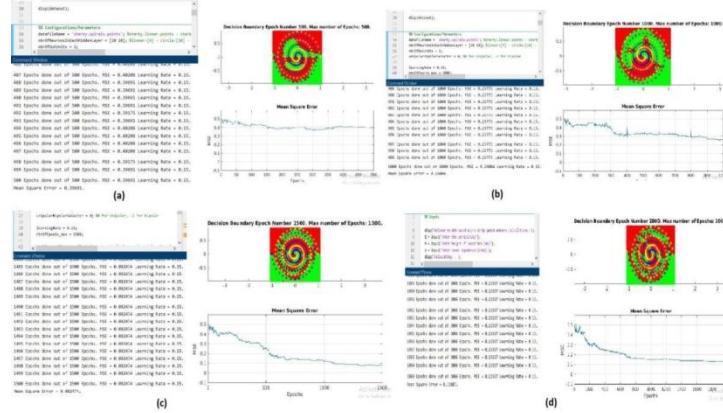


Fig 3: M.S.R of a)500 epochs b) 1000 epochs c)1500 epochs d)2000 epochs

III. RESULTS AND DISCUSSIONS

In this section, I will discuss about the simulations achieved for the Microstrip patch antenna for various shapes of patches such as rectangular, circular, triangular and square using various substrates such as FR4_Epoxy, Rogers RT Duroid 5880TM, Rogers RO 4003TM, Rogers RO 3003TM. The simulation is carried out at the frequency range of 1GHz to 5GHz with centre frequency at 2.5GHz.

Fig 4 provides the simulation carried out using HFSS for various patches with the calibrated dimensions of the antenna using back propagation with the help of least mean square error at 0.082474 with 1500 epochs, as it was the lowest among all other values obtained as per table 1.

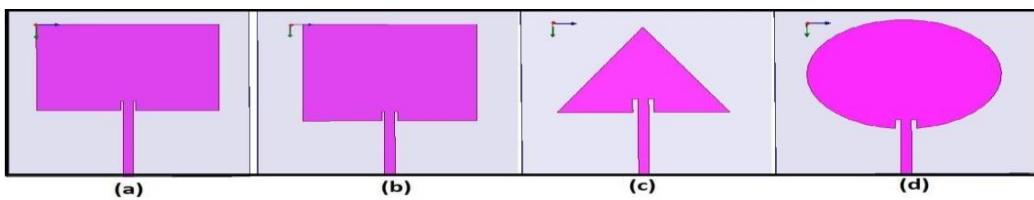


Fig 4: Shapes of Patches used for simulation of antenna using HFSS

The simulation is carried out for return loss, VSWR, gain and impedance matching of the antenna, as these are the most common antenna parameters which are considered to be important when the application based antenna is to be selected [15].

3.1 Rectangular Patch

In this section, I will discuss simulation results achieved using a rectangular patch for all the four substrates used in design. Fig 5 provides the simulation results of return loss.

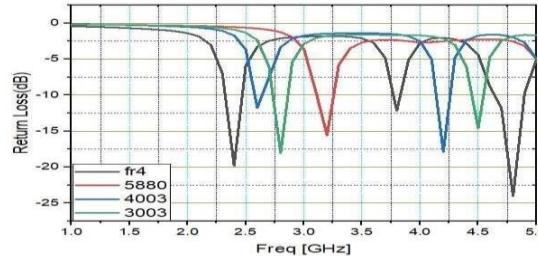


Fig 5: Return loss of rectangular patch with various substrates.

The return loss for FR4 material will be discussed first. The lowest return loss of - 24.03dB is observed at a frequency of 4.8GHz along with two more positions, at 2.4GHz(- 19.81dB) and at 3.8GHz(- 12.16dB). The Rogers RT Duroid 5880™ substrate provided only one resonating point at a frequency of 3.2GHz with return loss of -15.59dB. The Rogers RO 4003™ substrate design provided two resonating points at 2.6GHz and 4.2GHz with return loss of -11.75dB and -17.89dB, respectively. Rogers RO 3003™ substrate provided a dual band with frequencies of 2.8GHz and 4.5 GHz with return loss of -18.04dB and -14.59dB. Depending on the simulation results achieved, FR4 substrate material was found to have a better return loss compared to other three substrate antennas. The second parameter which we will discuss here is about the standing wave ratio with respect to voltage for all the four antennas as provided in fig 6.

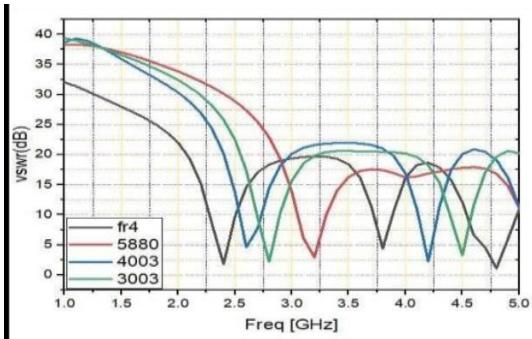


Fig 6: VSWR of rectangular patch with various substrates

As per fig 6, all the substrate antennas provided a similar standing wave ratio with a minimum of 1.58dB for FR4, 2.7dB for Duroid 5880™, 2.35dB for RO 4003™ and 2.47dB for RO 3003™. Fig 7

provides the gain of the antenna with various substrates with rectangular patch and the gain is calibrated with at least a cut off of 3dB or more. The Duroid 5880™ provides a better gain with a maximum of 6.95dB at 3.4GHz and it is maintained at the same gain from 3.4GHz to 3.5GHz. With this we can conclude that the antenna with FR4 material has a gain of -2.75dB at 2.8GHz and has a very good return loss and VSWR.

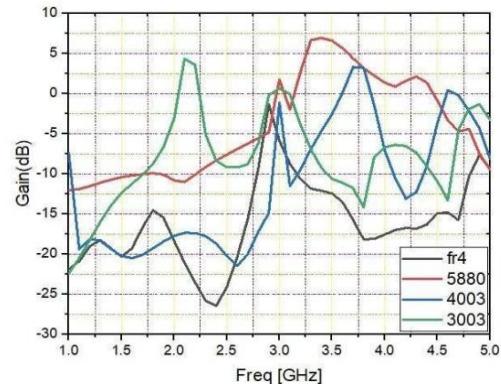


Fig 7: Total Gain of rectangular patch with various substrates

Figure 8 provides the impedance matching of the antennas with various substrates and we can observe that the FR4 material antenna has an average impedance of 49.85 ohms which is near to the perfect impedance of 50 ohms.

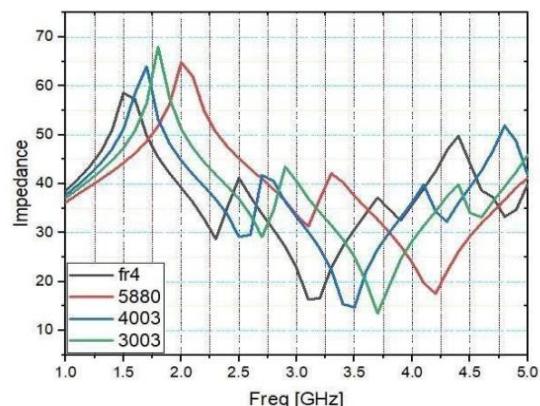


Fig 8: Impedance matching of rectangular patch with various substrates

3.2 Circular Patch

In this section, I will discuss simulation results achieved using a circular patch for all the four substrates used in design. Fig 9 provides the simulation results of return loss. The minimum return loss is achieved using Duroid 5880™, and it is -18.05dB at 3.1GHz and 11.63dB at 5.0GHz. The minimum return loss for FR4 material is observed at two different positions of the antenna, at 2.2GHz (-13.2dB) and at 3.7GHz(-16.73dB). The Rogers RO 4003™ substrate design provided two resonating points at 2.5GHz and 4.2GHz with return loss of -12.42dB and -10.77dB, respectively. Rogers RO 3003™ substrate provided a dual band with

frequencies of 2.7GHz and 4.6GHz with return loss of -14.64dB and -10.48dB.

Depending on the simulation results achieved, Duroid 5880TM substrate material is found to have a better return loss compared to other three substrate antennas.

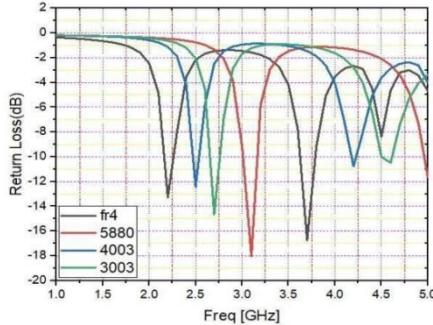


Fig 9: Return loss of circular patch with various substrates.

As per figure 10, all the substrate antennas provided a similar standing wave ratio with a minimum of 2.55dB for FR4, 1.95dB for Duroid 5880TM, 4.35dB for RO 4003TM and 3.87dB for RO 3003TM. These results are better compared to a rectangular patch as the circular patch has better voltage standing wave ratio.

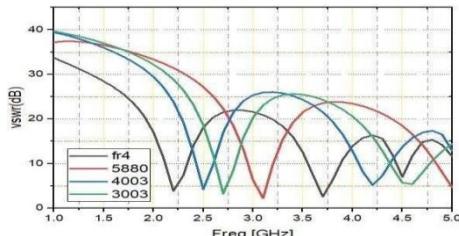


Fig 10: VSWR of circular patch with various substrates

Fig 11 provides the gain of the antenna with various substrates with circular patch and the gain is calibrated with at least a cut off of 3dB or more. The Duroid 5880TM provides a better gain with a maximum of 2.45dB at 3.0GHz. With this we can conclude that the antenna with Duroid 5880TM material has a gain of 2.45dB at 3.0GHz and has a very good return loss and VSWR.

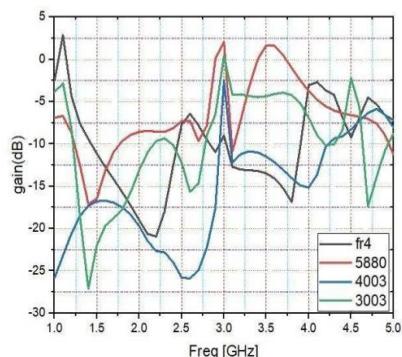


Fig 11: Total Gain of circular patch with various substrates

Fig 12 provides impedance of antenna with four substrates. From here it can be observed that RO Duroid 880TM has an average impedance of 53.8 ohms which is near to the perfect impedance of 50 ohms.

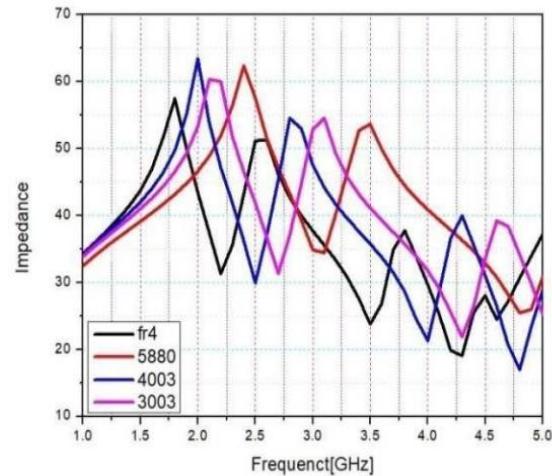


Fig 12: Impedance matching of circular patch with various substrates

3.3 Triangular patch

In this section, I will discuss simulation results achieved using a triangular patch for all the four substrates used in design. Fig 13 provides the simulation results of return loss. The minimum return loss is achieved using RO 3003TM and it is -12.65dB at 3.0 GHz and it is a single band. For FR4, two values were obtained, -7.1dB at 2.7 GHz and -6.5dB at 4.8 GHz.

The substrate Duroid 5880 showed one value at -10.76dB at 3.7 GHz. The RO 4003 substrate did not perform well for the triangular patch.

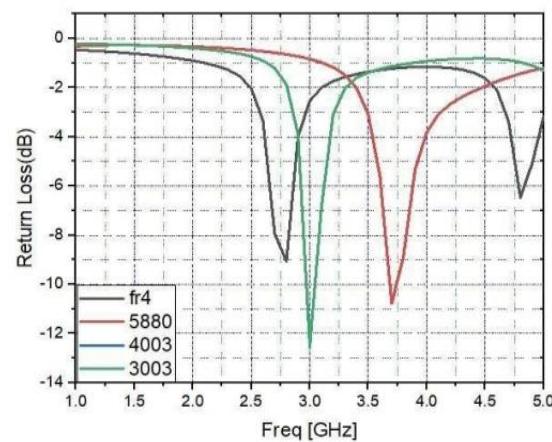


Fig 13:Return loss of triangular patch with various substrates

The second parameter to be discussed is VSWR. As per Fig 14, the antenna with RO 3003 substrate has least VSWR of 3.8dB, for FR4 it is 7.1dB and for Duroid 5880TM the value is 5.0dB.

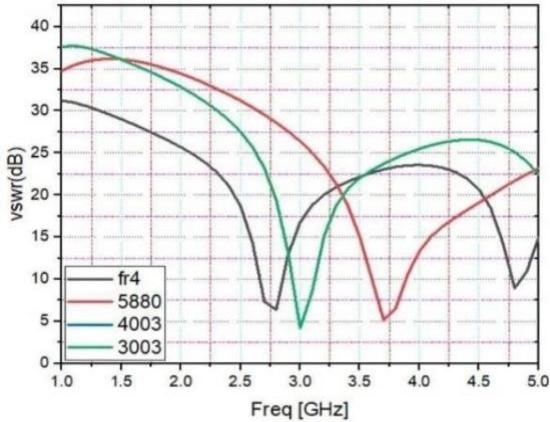


Fig14: VSWR of triangular patch with various substrates

Fig 15 provides the gain of the antenna with various substrates with triangular patch and the gain is calibrated with at least a cut off of 3dB or more. The RO 3003™ provides a better gain with a maximum of 12.40 dB at 3.6GHz. With this it can be concluded that the antenna with RO 3003™ material has a gain of 12.40dB at 3.6GHz and a very good return loss and VSWR.

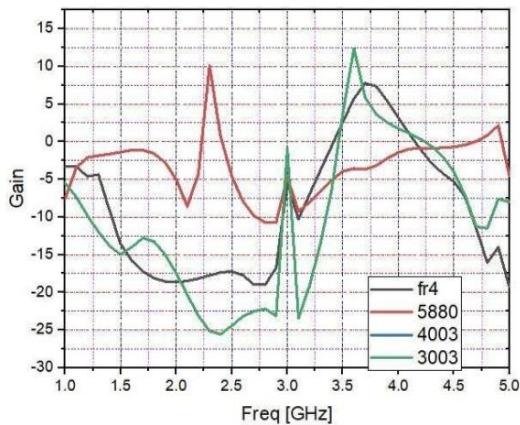


Fig 15: Total Gain of triangular patch with various substrates

Fig 16 shows impedance plot for the triangular patch antenna with various substrates under consideration. From here it can be observed that RO 3003 has an average impedance of 44 ohms.

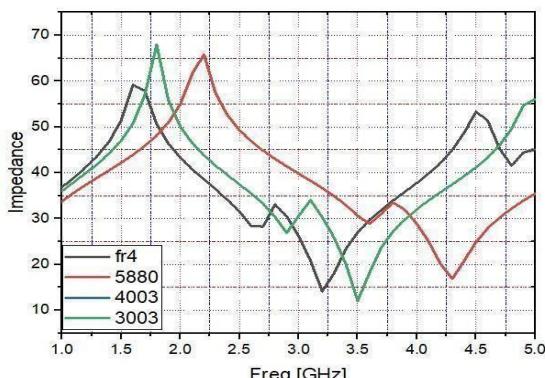


Fig 16: Impedance matching of triangular patch with various substrates

3.4 Square Patch

In this section, I will discuss simulation results achieved using a square patch for all the four substrates used in design. Fig17 provides the simulation results of return loss. The minimum return loss is achieved using Duroid 5880™, and it is -18.33dB at 2.9 GHz and it is a single band. The minimum return loss for FR4 material is observed at two different positions of the antenna, at 2.1GHz (-16.59dB) and at 4.2 GHz(-15.05dB). The Rogers RO 4003™ substrate design provided two resonating points at 2.4GHz and 4.8GHz with return loss of -12.42dB and -13.21dB, respectively. Rogers RO 3003™ substrate provided a single band with frequency of 2.6GHz with return loss of -11.23dB. Depending on the simulation results achieved, Duroid 5880 substrate material was found to have a better return loss compared to other three substrate antennas.

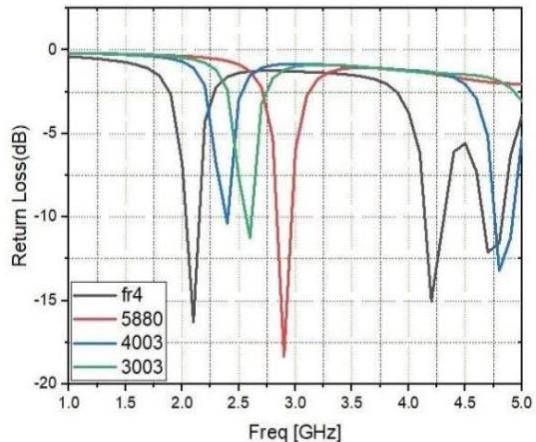


Fig 17: Return loss of square patch with various substrates

Fig 18 below shows VSWR plot for square patch antenna with all four substrates. From here it is clear that VSWR for Duroid 5880™ is least with value 2.5dB, for FR4 it is 3dB, for RO 3003 it is 5dB and for RO 4003 the value is 5.3dB.

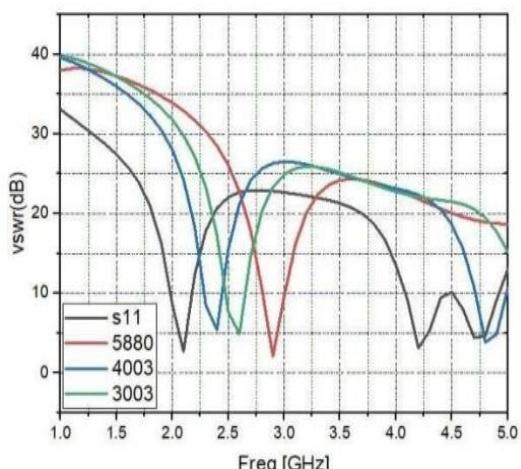


Fig 18: VSWR of square patch with various substrates

Fig 19 provides the gain of the antenna with various substrates with square patch and the gain is calibrated with at least a cut off of 3dB or more. The RO 4003™ provides a better gain with a maximum of 21.57 dB at 4.2GHz. The FR4 substrate material antenna achieved a total gain of 11.98dB at 2.8GHz. With this, I can conclude that the antenna with RO 4003 material has a gain of 21.57dB at 4.2GHz and has a very good return loss and VSWR.

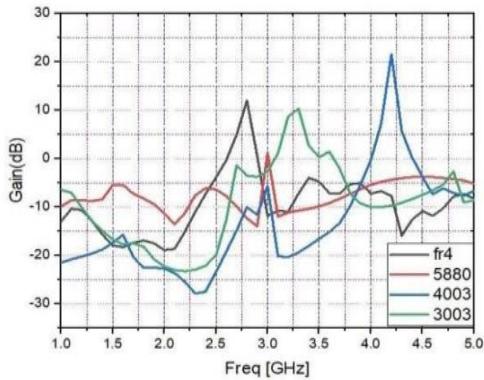


Fig19: Total Gain of square patch with various substrates

Fig 20 below provides impedance matching of antenna with all four substrates. From here it can be seen that RO 4003 has an average impedance of 53.8 ohms which is near to the perfect impedance of 50 ohms.

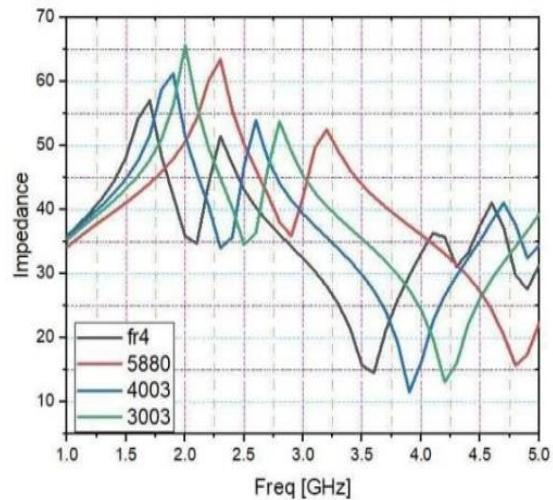


Fig20: Impedance matching of square patch with various substrates

Table 3 illustrates the information regarding the resonating frequencies, return loss and bandwidth comparison for all the four shapes and all the substrates keeping the minimum return loss of -10dB.

Antenna Description	Resonating Frequency	Return Loss(dB)	Bandwidth (MHz)
Rectangular patch with FR4_Epoxy Substrate	4.8	-24.03	300MHz
	2.4	-19.81	450MHz
Rectangular patch with Rogers RT/duroid 5880tm Substrate	3.2	-15.59	350MHz
Rectangular patch with Rogers RO4003 Substrate	4.2	-17.89 -	250MHz
	2.6	11.75	350MHz
Rectangular patch with Rogers RO3003 Substrate	2.8	-18.04	200MHz
	4.5	-14.59	300MHz
Circular patch with FR4_Epoxy Substrate	3.7	-16.73	300MHZ
	2.2	-13.27	250MHz
Circular patch with Rogers RT/duroid 5880tm Substrate	3.1	-18.05 -	400MHz
	5.0	11.63	350MHz
Circular patch with Rogers RO4003 Substrate	2.5	-12.42	300MHz
Circular patch with Rogers RO3003Substrate	2.7	-14.64	250MHz
Triangular patch with FR4_Epoxy Substrate	2.7	-7.1	150MHz
Triangular patch with Rogers RT/duroid 5880tm Substrate	3.7	-10.76	100MHz
Triangular patch with Rogers RO4003 Substrate	0.0	0.00	250MHz
Triangular patch with Rogers RO3003 Substrate	3.0	-12.65	250MHz
Square patch with FR4_Epoxy Substrate	2.1	-16.59	250MHz
	4.2	-15.05	650MHz
Square patch with Rogers RT/duroid 5880tm Substrate	2.9	-18.33	400MHz
Square patch with Rogers RO4003 Substrate	4.8	-13.21	250MHz
Square patch with Rogers RO3003 Substrate	2.6	-11.23	300MHz

Table 3: Resonating frequencies, Return loss and Bandwidth Comparison

IV. CONCLUSION

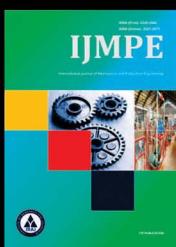
In this paper, the antenna dimensions are calibrated using the synthesis approach of back propagation algorithm in artificial neural networks trained using MATLAB. Hence one can obtain the dimensions with high accuracy at the output of the synthesis network. The ANN network is configured using 500 epochs, 1000 epochs, 1500 epochs and finally with 2000 epochs in order to calculate the least mean square error .The antenna is designed using rectangular, circular, triangular and square patches with different substrates such as FR4_Epoxy, Rogers RT Duroid 5880TM , Rogers RO 4003TM and Rogers RO 3003TM. Further the antenna is simulated using HFSS and the simulated results are analysed in the form of return loss, VSWR impedance and total gain. The antenna with rectangular patch and FR4_Epoxy as substrate provided best results compared to the remaining substrates. The antenna with circular patch Rogers RT Duroid 5880TM as substrate provided best results compared to the remaining substrates. The antenna with triangular patch and Rogers RO 3003TM as substrate provided best results compared to the remaining substrates. The antenna with square patch and Rogers RO 4003TM as substrate provided best results compared to the remaining substrates.

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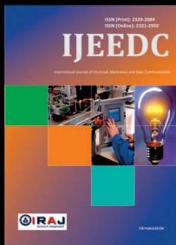
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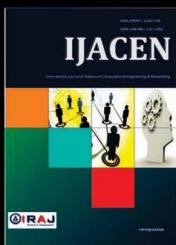
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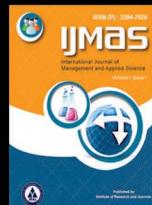
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