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In line with the objectives of the Journal, ***the Editor seeks articles and research papers (4000-8000 words), case studies based on research and experience (2000-4000 words) and book reviews (within 1500 words) for publication.*** All articles and papers are referred for a double-blind independent review by peer experts, apart from a similarity check. The authors are requested to allow the Editor at least two months' time for communicating the decision regarding publication of the papers. Authors may be required to revise their work in the light of the observations made by the referees or to accept the amendments made by the Editor. Authors may submit contributions electronically (**at E-mail: kindler.aimk@gmail.com with a copy to protik.basu@aim.ac.in**) with an undertaking that the contribution is original work of the author and exclusively for 'Kindler'.

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Editorial Note

The year 2020 saw the visit of SARS-CoV-2 virus and the entire human population grappled with a powerful pandemic, as people suffered and perished, economies fell and business management processes needed much restructuring. “Stay Home Stay Safe” was the buzzword and Work-From-Home became the norm as most communications were on the Internet to “break the chain of transmission of the virus”.

Much research evolved around how businesses re adapted to a new normal. This issue contains a research, providing vision on such issues. Besides the issue also has research on geriatric financial security, an analysis on the cost of ownership of diesel and electric vehicles and the possibility of a shift to renewable energy sources.

I wish the readers an insightful journey and safety and health.

Dr Swapna Datta Khan

Editor

FOREWORD BY ASSOCIATE PROFESSOR

Welcome to the cognitive world, Kindler, a bi-annual journal of the Army Institute of Management Kolkata. Kindler provides a scope for researchers across the globe to share their research inputs. The journal aims at covering vast domain of interdisciplinary studies with an objective to attract thoughtful scholarship that is of relevance to corporate, academic and society at large. The papers selected in this journal undergoes a strict double blind peer review process. I wish all contributors and readers a very rich and rewarding experience.

**Dr. Ayan Chattopadhyay
Associate Editor**

Geriatric Financial Security-A Survey Based Study of Senior Citizens of Belghoria, North 24 Parganas, West Bengal

Praveen Kaur*, Dr Tanupa Chakraborty**

ABSTRACT

The United Nations has projected that the world elderly population will reach 2.1 billion by 2050. It has become a world-wide concern. In India, the elderly people constituted 9.4% of the total population in 2017 as per the World Population Ageing Highlights by the United Nations. Population ageing has both social and economic implications. Financial security refers to a state of having a regular and stable flow of income that makes a person economically independent so as to enable him to take his own decisions and make his own choices. In the present scenario, importance should be given on ensuring financial security of the elderly, which will help them to lead an independent life. The particular interest of this study is to evaluate the level of financial security and its association with the various financial factors for the senior citizens belonging to both labour and non-labour group.

Key words: Population ageing, Financial security, Labour and Non-Labour group

Introduction

Population ageing is a shift in the median age of a population from those belonging to the young age to those belonging in the old age. Simply, it is a rapid increase in the proportion of geriatrics in the population of a particular region. The United Nations has projected that the world elderly population will reach 2.1 billion by 2050. It has become a world-wide concern with the rise in non-working vis-à-vis working population in the economy. In India, the population belonging to the 65+ years constitutes 6.72% (male 42,054,459 and female 47,003,975) of the total population as per Central Intelligence Agency (CIA) World Factbook 2020 estimates (2021). It is expected to increase to around 300 million by 2050. The primary reason behind this phenomenon is the increase in the average life expectancy, decline in the fertility, advances in the medical field, development of the society leading to an improvement in the standard of living of the people.

Population ageing has both social and economic implications. As a result of population ageing the old age dependency ratio increases. The productive capacity of the nation also reduces due to the reduction in number and ageing of the workforce leading to a fall in the output growth of a nation. With an increase in the elderly population, on one hand, the tax income of the government is reduced, and on the other, the government spending increases in the form of adopting various social security measures like pension schemes, health care schemes, setting old age homes etc. for the welfare of the elderly.

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Population ageing has both social and economic implications. As a result of population ageing the old age dependency ratio increases. The productive capacity of the nation also reduces due to the reduction in number and ageing of the workforce leading to a fall in the output growth of a nation. With an increase in the elderly population, on one hand, the tax income of the government is reduced, and on the other, the government spending increases in the form of adopting various social security measures like pension schemes, health care schemes, setting old age homes etc. for the welfare of the elderly.

In this fast-moving time, people lead a very hectic and stressful life. The growing competition in the work place has left very little family time in the hands of people. In such a scenario, taking care of the elders in the family is often seen as a burden by the young people and this leads to their preference of living in nuclear families leaving behind their elderly parents. This creates a situation of loneliness, helplessness and neglect for the elderly. It thus becomes a responsibility of the government to ensure that the elderly lead a respectful, independent and secured life.

One of the parameters to lead a secured life is 'financial security'. Financial security refers to a state of having a regular and stable flow of income that makes a person economically independent so as to enable him to take his own decisions and make his own choices. When a person is able to meet his own expenses, support his standard of living and is also ready to meet any emergency requirement of money in the unforeseen future, that person is said to be financially secured. In the present scenario it is vital to ensure that the elderly are financially secured because it is often seen that those old people, who have a stable flow of income or those who have the ownership of some kind of property/ financial assets, are respected more and they lead a dignified, satisfied and independent life. They are able to support, take better care of themselves and meet the increased healthcare expenses related to old age.

So, in order to explore geriatric financial security, the study is divided into six sections. The literature review is discussed in section 2. Section 3 deals with the objectives of the study. Research method of the study is highlighted in section 4. Section 5 discusses the analysis and findings. Finally, section 6 concludes the study.

Literature Review

Direct evidence in the area of financial security of senior citizens belonging to both labour and non-labour is scarce. But there is evidence relating to the economic condition of the senior citizens as a whole. Some of the studies also highlight the social conditions of the senior citizens. A survey of the existing literature is made in the following paragraphs in this regard.

Bhat and Dhruvarajan (2002) found that the younger generation seeks economic independence and this has reduced the dependence of the families on the rural lands which was once a reason for strong family ties. Thus, there is a change in the attitude of the younger towards the elderly in the family, which has left the elderly with a lack of social and economic security leading the path for the adoption of policies for the wellbeing of the elderly. Kumar (2003) pointed out that the government has introduced a number of policies to ensure the security of

the elders. The government has introduced retirement benefits for the workers of the organized sector, economic security benefits for the unorganized sector workers, and also old age pension for the elderly of the rural areas. These efforts are largely criticized for their inefficiencies in implementation, coverage and effectiveness, suggesting adoption of measures for the immediate reform of these measures. Kaushal (2014) in an empirical study concluded that there has been an expansion of the old age pension schemes. The public pension has a negative impact on the employment of the elderly men who have a lower education, but it has no impact on the employment of similar elderly women. If the pension increases by Rupees 100, the employment of elderly men with primary or less education decreases by one to three percentage points. Pension income increases the family expenditure especially on medical care and education, signifying utilization of the pension amount for improving the condition of living. Singh (2013) pointed out that though the government has introduced a number of policies for the welfare of the elderly, they lack social and economic security and lead a life of financial instability, loneliness and disrespect. The pension funds need to be better developed to fulfill its requirements, and also the government should spread financial literacy, and introduce newer financial instruments to address the issue of population ageing in a better way. Krishnaswamy et al. (2008) observed that the Indian elderly face political, social, economic and health challenges. Decline in financial security is a major concern of the Indian elderly due to the lack of financial resources. To address these issues, the Government has introduced the National Policy for Older Persons. The government has implemented various schemes under the policy for the welfare of the old persons like providing financial assistance to set up and run old age homes, providing non institutional services and meeting their basic needs of good food and medicines. Arokiasamy et al. (2012) found that older Indians face economic instability as 90% of them have no pension support. Also, those aged 60 or above constitute 39% of the labour force and it is as high as 45% in the rural areas. More than two third of the Indian elderly live in rural areas which acts as a barrier to their easy access to financial institutions like banks, insurance companies etc. In a cross-sectional study in Udupi Taluk, Karnataka, Lena et al. (2009) concluded that there was a need for a larger number of old age counseling centers for the elderly to take care of their physical and psychological needs. The stringent rules for eligibility to the social security measures should be relaxed to some extent to increase its coverage so as to benefit a greater number of old people.

Primarily, studies based on the overall economic and social condition of the senior citizens have been carried out. Not many studies have been conducted to determine which factors are associated with the financial security of the senior citizens. Also, a comparison of the financial security of the senior citizens belonging to two distinct groups- labour and non-labour, has not been conducted earlier. In the backdrop of the above literature survey, the present study intends to fulfill the said research gap.

Objective of the Study

In view of the research gap identified above, the primary objective of this study is to understand the level of financial security of the old age people belonging to the age group of 60-70 years, and to find out the association between financial security and other financial factors for the senior citizens belonging to both labour and non-labour class.

More specifically, the study intends to:

1. find out whether the senior citizens are financially secured, and
2. evaluate the association between financial security of the senior citizens and various financial factors like sector of work, amount of monthly income, amount of monthly expenditure, number of assets owned etc.

Research Method

The study is based on primary data. A total of 116 senior citizens belonging to the age group of 60-70 years and residing in Belghoria, North 24 Parganas District of West Bengal are surveyed. Out of the 116 senior citizens surveyed, 58 belong to the labour group and remaining 58 to the non-labour group designing it as a paired sample. The members of the Belghoria center of the West Bengal Labour Welfare Fund Board are interviewed for collecting data from the labour group. The data for the non-labour group are collected from the senior citizens living in the area of Belghoria.

Convenience Sampling and Snow Ball Sampling techniques are used to collect the primary data from both the labour and non-labour groups over the period July to September 2018. The primary data is collected in the form of a survey with the help of a well-structured questionnaire. The questionnaire consists of twenty-seven questions. It is divided into two parts- demographic information and financial information. The first nine questions relate to demographic information covering age, gender, marital status, number of children, living arrangements, highest level of education etc. The rest of the questions seek financial information covering employment status, sector of work, amount of monthly income, amount of monthly expenditure, ability to invest, contribution towards family expenditure, financial support by other family members etc.

From the questionnaire, 'Ability to Invest' is taken as a proxy for financial security. Those people who are able to invest are considered as 'financially secured' and those who are unable to invest are considered as 'financially unsecured'. Only those people, who are able to save some portion of their income after meeting their necessary and required expenditures, are able to invest to earn benefits in future. Accordingly, those respondents who are able to invest their surplus income are considered financially secured. 'Ability to invest' is, therefore, the dependent variable while various other financial factors are the independent variables, and the type -labour and non labour group are taken as the layer variables for doing the cross tabulation.

The collected data are analyzed statistically by running Chi Square test for independence in the software package SPSS. The chi-square test for independence, also called Pearson's chi-

square test, is used to find if there is a relationship or association between two categorical variables. Accordingly, the following hypothesis is framed.

Null hypothesis (H₀): Financial security of senior citizens is independent of the various financial factors.

Alternative hypothesis (H_a): Financial security of senior citizens is not independent of the various financial factors.

The test statistic for the Chi-Square Test of Independence is denoted as χ^2 , and is computed as:

$$\chi^2 = \sum_{i=1}^R \sum_{j=1}^C \frac{(o_{ij} - e_{ij})^2}{e_{ij}}$$

Where, o_{ij} is the observed cell count in the i^{th} row and j^{th} column of the table
 e_{ij} is the expected cell count in the i^{th} row and j^{th} column of the table, computed as –

$$e_{ij} = \frac{\text{row } i \text{ total} * \text{col. } j \text{ total}}{\text{grand total}}$$

The quantity $(o_{ij} - e_{ij})$ is sometimes referred to as the *residual* of cell (i, j) , denoted as r_{ij} .

The calculated χ^2 value is then compared to the critical value obtained from the χ^2 distribution table with degrees of freedom $df = (R - 1) * (C - 1)$ and chosen confidence level, where R is the number of rows and C is the number of columns. If the calculated χ^2 value > critical χ^2 value, then we reject the null hypothesis, otherwise not.

For some statistical observations, the value of Fisher's Exact Test is considered in place of χ^2 . This test gives an exact p value even when the sample size is small. The value of Fisher's Exact Test is considered when the expected frequency in 20% of the cells of the contingency table is less than 5.

Further, the strength of association (if any) between financial security and the financial factors is measured by calculating the Cramer's V. It is a measure used to test association between two nominal variables.

The Cramer's V is calculated as follows:

$$\phi_c = \sqrt{\frac{\chi^2}{N(k - 1)}}$$

Where,

ϕ_c = Cramer's V

χ^2 = Pearson Chi Square statistic for the aforementioned test

N = Sample size involved in the test

k = Lesser number of categories of either variable

The value of Cramer's V lies between 0 and 1, where a value of 0 of Cramer's V indicates no relationship, while a value of 1 of Cramer's V indicates perfect relationship.

A value of 0.2 or less of Cramer's V indicates weak relationship, and a value between 0.21 and 0.3 of Cramer's V indicates moderate relationship. A value greater than 0.3 of Cramer's V indicates strong relationship.

Analysis and Findings

A general demographic analysis of the respondents is given in table 1. The table reveals both the frequency and percentage of age group, marital status, number of children, living arrangement, highest level of education and employment status of all the 116 respondents comprising both labour and non-labour group.

Category		Frequency	Percentage
Age	60-65	83	71.6
	66-70	33	28.4
	Total	116	100.0
Marital Status	Married	106	91.4
	Unmarried	6	5.2
	Widower	4	3.4
	Total	116	100.0
Number of Children	0	5	4.3
	1	61	52.6
	2	45	38.8
	3	5	4.3
	Total	116	100.0
Living Arrangement	Alone (with/without spouse)	21	18.1
	With children	56	48.3
	With other family members (with/without children)	39	33.6
	Total	116	100.0
Highest level of education	Primary	2	1.7
	Secondary	27	23.3
	Higher Secondary	50	43.1
	Graduation	37	31.9
	Total	116	100.0
Employment Status	Retired	88	75.9
	Still working	19	16.4
	Retired but working somewhere else	9	7.8
	Total	116	100.0

Table 1: Demographics of Senior Citizens (Source: Own survey calculations)

The demographic analysis reveals that out of the 116 respondents, 83 belong to the age group of 60-65 years and another 33 belong to the age group of 66-70 years. 106 respondents are married, 6 are unmarried and 4 are widowed. The number of children of 61 respondents is 1 child each, for 45 respondents is 2 children each, for 5 respondents is 3 children each and the remaining do not have any child. 21 respondents live alone (with/without spouse), 56 respondents live with their children and the remaining 39 live with other family members (with/without children). 37 respondents are graduates, 50 have passed higher secondary education, 27 have passed secondary education while the remaining 2 possess only primary education. Out of the 116 respondents 88 are retired, 19 are still working and the remaining 9 are retired but working somewhere else. Thus, a majority of the respondents belong to the age group of 60-65 years, are married, have one child, live with their children and are retired. Only a few of the respondents are unmarried, widower, possess only primary education and are retired but working somewhere else.

The statistical result of the cross tabulation between 'ability to invest' and the 'sector in which the respondents worked / are still working' is presented in table 2. Public sector, private sector and self-employed are the three sectors of employment considered for the study. For the labour group, 30 respondents are from the public sector and 28 are from the private sector. For the non-labour group, 15 are from the public sector, 22 are from the private sector and 21 are self-employed.

Type		Value	df	Asymp. Sig. (2-sided)
Labour	Pearson Chi-Square	.244	1	.621
	Cramer's V	.065		.621
Non Labour	Pearson Chi-Square	26.516	2	.000
	Cramer's V	.676		.000

Table 2 : Chi Square test result of cross tabulation between Ability to Invest and Sector of Work

For the labour group, the value of the test statistic $\chi^2 = .244$, $df = 1$ and $p = .621$. Since the p value is greater than .05, we cannot reject the null hypothesis that there is no association between ability to invest (financial security) and sector of work for the senior citizens belonging to the labour group.

However, for the non-labour group, the value of the test statistic $\chi^2 = 26.516$, $df = 2$ and $p = .000$. Since the p value is less than 0.05, we reject the null hypothesis accepting the alternative proposition that there is an association between ability to invest (financial security) and sector of work for the senior citizens belonging to the non-labour group. Also, the value of Cramer's V = .676. Therefore, there is a strong association between ability to invest (financial security) and

sector of work for the senior citizens belonging to the non-labour group, but not so for the labour group sampled.

The statistical result of the cross tabulation between 'ability to invest' and whether the 'respondents have a stable source of income (monthly/ quarterly)' is presented in table 3. Only 6 respondents from the non-labour group do not have a stable source of income.

Type		Value	df	Asymp. Sig. (2-sided)
Labour	Pearson Chi-Square	*		
	Cramer's V	*		
Non-Labour	Pearson Chi-Square	7.771	1	.005
	Cramer's V	.366		.005

Table 3: Chi Square test result of cross tabulation between Ability to Invest and Stable Source of Income

* No statistics for the labour group are computed because Stable Source of Income is a constant as the respondents belonging to the said group have a stable source of income.

For the non-labour group, the value of the test statistic $\chi^2 = 7.771$, $df = 1$ and $p = .005$. Since the p value is less than .05, we reject the null hypothesis and it can be said that there is an association between ability to invest (financial security) and stable source of income for the senior citizens belonging to the non-labour group. Also, the value of Cramer's V= .366. Therefore, we can conclude that there is a strong association between ability to invest (financial security) and stable source of income for the senior citizens belonging to the non-labour group.

The statistical result of the cross tabulation between 'ability to invest' and the 'amount of monthly income' of the respondents is presented in table 4. The monthly income of the respondent's range between less than Rupees 5000 in a month to more than Rupees 50,000 in a month.

Type		Value	df	Asymp. Sig. (2-sided)
Labour	Pearson Chi-Square	14.299	2	.001
	Cramer's V	.497		.001
Non Labour	Pearson Chi-Square	33.834	4	.000
	Cramer's V	.764		.000

Table 4: Chi Square test result of cross tabulation between Ability to Invest and Amount of Monthly Income

For the labour group, value of the test statistic $\chi^2 = 14.299$, $df = 2$ and $p = .001$. For the non-labour group, the value of the test statistic $\chi^2 = 33.834$, $df = 4$ and $p = .000$. Since the p value is less than .05 for both the groups, we reject the null hypothesis that there is no association between ability to invest (financial security) and amount of monthly income for the senior citizens belonging to the labour as well as non-labour class.

For the labour group, the value of Cramer's $V = .497$. For the non-labour group, the value of Cramer's $V = .764$. Therefore, we can conclude that there is a strong association between ability to invest (financial security) and amount of monthly income for the senior citizens belonging to the labour group and a very strong association between ability to invest (financial security) and amount of monthly income for the senior citizens belonging to the non- labour group.

The statistical result of the cross tabulation between 'ability to invest' and the 'amount of monthly expenditure' of the respondents is presented in table 5. The amount of monthly expenditure of the labour group range between Rupees 1000 to Rupees 5000. The amount of monthly expenditure of the non- labour group range between Rupees 3000 to Rupees 8000. The expenditure incurred only for the respondents was considered.

Type		Value	df	Asymp. Sig. (2-sided)
Labour	Pearson Chi-Square	15.173	6	.019
	Cramer's V	.511		.019
Non Labour	Pearson Chi-Square	8.431	5	.134
	Cramer's V	.381		.134

Table 5: Chi Square test result of cross tabulation between Ability to Invest and Amount of Monthly Expenditure

For the labour group, the value of the test statistic $\chi^2 = 15.173$, $df = 6$ and $p = .019$. Since the p value is less than .05, we reject the null hypothesis and infer that there is an association between ability to invest (financial security) and amount of monthly expenditure for the senior citizens belonging to the labour group. Also, the value of Cramer's $V = .381$. Therefore, we can conclude that there is strong association between ability to invest (financial security) and amount of monthly expenditure for the senior citizens belonging to the labour group.

For the non-labour group, the value of the test statistic $\chi^2 = 8.431$, $df = 5$ and $p = .134$. Since the p value is greater than .05, we cannot reject the null hypothesis that there is no association between ability to invest (financial security) and amount of monthly expenditure for the senior citizens belonging to the non-labour group.

The statistical result of the cross tabulation between 'ability to invest' and 'whether the respondents are dependent on others' is presented in table 6. A total of 6 respondents from the labour group and 8 respondents from the non-labour group of the sample are dependent on others for their financial requirements.

Type		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Labour	Pearson Chi-Square	8.834	1	.003		
	Fisher's Exact Test				.004	.004
	Cramer's V	.390		.003		
Non-Labour	Pearson Chi-Square	12.625	1	.000		
	Fisher's Exact Test				.001	.001
	Cramer's V	.467		.000		

Table 6: Chi Square test result of cross tabulation between Ability to Invest and Dependency on Others

For the labour group, the value of the test statistic $\chi^2 = 8.834$, $df = 1$ and $p = .003$. The p value of Fisher's Exact test is .004.

For the non-labour group the value of the test statistic $\chi^2 = 12.625$, $df=1$, $p= .000$. The p value of Fisher's Exact Test is .001.

Since the p value for both the groups is less than .05, we reject the null hypothesis and infer that there is an association between ability to invest (financial security) and dependency on others for the senior citizens belonging to both the labour and the non-labour groups.

For the labour group, the value of Cramer's V = .390, and for the non-labour group, the value of Cramer's V is .467. Therefore, we can conclude that there is a strong association between ability to invest (financial security) and dependency on others for the senior citizens belonging to both the labour group and the non-labour group.

The statistical result of the cross tabulation between 'ability to invest' and 'whether the respondents contribute towards family expenditure' is presented in table 7. 52 respondents from both the labour and non-labour group each contribute towards family expenditure.

Type		Value	df	Asymp. Sig. (2-sided)
Labour	Pearson Chi-Square	4.416	1	.036
	Cramer's V	.276		.036
Non Labour	Pearson Chi-Square	.903	1	.342
	Cramer's V	.125		.342

Table 7: Chi Square test result of cross tabulation between Ability to Invest and Contribution Towards Family Expenditure

For the labour group, the value of the test statistic $\chi^2 = 4.416$, $df = 1$ and $p = .036$. Since the p value is less than $.05$, we reject the null hypothesis and infer that there is an association between ability to invest (financial security) and contribution towards family expenditure for the senior citizens belonging to the labour group.

The value of Cramer's $V = .276$. Therefore, we can conclude that there is a moderate association between ability to invest (financial security) and contribution towards family expenditure for the senior citizens belonging to the labour group.

For the non-labour group, the value of the test statistic $\chi^2 = .903$, $df = 1$ and $p = .342$. Since the p value is greater than $.05$, we cannot reject the null hypothesis that there is no association between ability to invest (financial security) and contribution towards family expenditure for the senior citizens belonging to the non-labour group.

The statistical result of the cross tabulation between 'ability to invest' and 'number of assets owned' by the respondents is presented in table 8. 27 respondents belonging to the labour group own only one asset, while 40 respondents belonging to the non-labour group own two/three assets and 17 own four/five assets.

Type		Value	df	Asymp. Sig. (2-sided)
Labour	Pearson Chi-Square	.037	1	.847
	Cramer's V	.025		.847
Non-Labour	Pearson Chi-Square	8.783	2	.012
	Cramer's V	.389		.012

Table 8: Chi Square test result of cross tabulation between Ability to Invest and Number of Assets Owned

For the labour group, the value of the test statistic $\chi^2 = .037$, $df = 1$ and $p = .847$. Since the p value is greater than $.05$, we cannot reject the null hypothesis that there is no association between ability to invest (financial security) and number of assets owned for the senior citizens belonging to the labour group.

For the non-labour group, the value of the test statistic $\chi^2 = 8.783$, $df = 2$ and $p = .012$. Since the p value is less than $.05$, we reject the null hypothesis and accept the alternative proposition that there is an association between ability to invest (financial security) and number of assets owned for the senior citizens belonging to the non-labour group.

The value of Cramer's $V = .389$. Therefore, we can conclude that there is a strong association between ability to invest (financial security) and number of assets owned for the senior citizens belonging to the non-labour group.

The statistical result of the cross tabulation between 'ability to invest' and 'whether the respondents have taken any loan' is presented in table 9. 14 respondents from the labour group and 9 respondents from the non-labour group have taken a loan.

Type		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Labour	Pearson Chi-Square	1.589	1	.207		
	Fisher's Exact Test				.235	.171
	Cramer's V	.166		.207		
Non-Labour	Pearson Chi-Square	5.561	1	.018		
	Fisher's Exact Test				.047	.027
	Cramer's V	.310		.018		

Table 9: Chi Square test result of cross tabulation between Ability to Invest and Loan

For the labour group, the value of the test statistic $\chi^2 = 1.589$, $df = 1$ and $p = .207$.

The p value of Fisher's Exact Test = .235. Since the p value is greater than .05, we cannot reject the null hypothesis that there is no association between ability to invest (financial security) and loan for the senior citizens belonging to the labour group.

For the non-labour group, the value of the test statistic $\chi^2 = 5.561$, $df = 1$ and $p = .018$.

The p value of Fisher's Exact Test = .047. Since the p value is less than .05, we reject the null hypothesis and accept the alternative proposition that there is an association between ability to invest (financial security) and loan taken by the senior citizens belonging to the non-labour group.

The value of Cramer's V = .310. Therefore, we can conclude that there is a strong association between ability to invest (financial security) and loan for the senior citizens belonging to the non-labour group.

The statistical result of the cross tabulation between 'ability to invest' and 'whether the respondents have family support' is presented in table 10. Only 21 respondents from the labour group have the support of their family, while 34 respondents from the non-labour group have the support of their family.

Type		Value	df	Asymp. Sig. (2-sided)
Labour	Pearson Chi-Square	10.769	1	.001
	Cramer's V	.431		.001
Non-Labour	Pearson Chi-Square	2.643	1	.104
	Cramer's V	.213		.104

Table 10: Chi Square test result of cross tabulation between Ability to Invest and Family Support

For the labour group, the value of the test statistic $\chi^2 = 10.769$, $df = 1$ and $p = .001$. Since the p value is less than .05, we reject the null hypothesis. Hence, there is an association between ability to invest (financial security) and family support for the senior citizens belonging to the labour group.

The value of Cramer's V = .431. Therefore, we can conclude that there is a strong association between ability to invest (financial security) and family support for the senior citizens belonging to the labour group.

For the non-labour group, the value of the test statistic $\chi^2 = 2.643$, $df = 1$ and $p = .104$. Since the p value is greater than .05, we cannot reject the null hypothesis that there is no association between ability to invest (financial security) and family support for the senior citizens belonging to the non-labour group.

Conclusion

This study intends to elaborate the association between financial security of the senior citizens and the various financial factors. The statistical analysis of the data collected in the preceding section reveals that out of the 58 senior citizens surveyed from the labour group, only 33 are financially secured, while out of the 58 senior citizens surveyed from the non-labour group, only 39 are financially secured. There is an association between financial security and amount of monthly income, amount of monthly expenditure, dependency on others, contribution towards family expenditure and family support for the senior citizens belonging to the labour group. All the senior citizens belonging to the labour group have a stable source of income. There is an association between financial security and sector of work, stable source of income, amount of monthly income, dependency on others, number of assets owned and loan for the senior citizens belonging to the non-labour group. Again, all the respondents belonging to the non-labour group possess some asset.

In spite of the limitations of conducting the study on a small size sample of 116 senior male citizens only from the region of Belghoria, North 24 Parganas, the present study distinguishes itself from the prior studies in a number of ways. Firstly, this study has focused on the financial security of two separate groups of senior citizens- labour group and non-labour group. Secondly, it has tried to evaluate the financial security of the senior citizens by finding out its association with a number of financial factors, and accordingly it has tried to fill up the gap in existing literature.

Also, a number of recommendations based on the suggestions given by the senior citizens surveyed, are enumerated below.

- A majority of the senior citizens belonging to the labour group reside in rented houses. They have suggested that if the Government could arrange for a rent-free accommodation or own houses, then it would reduce their burden of paying rent every month.
- The amount of monthly income in the form of pension, other interest income etc. for a majority of the senior citizens belonging to the labour group lies in the range of Rs (6000-16000). It becomes very difficult for them to manage their expenditures with such less

income, especially when almost all of them still have to contribute towards family expenditures, irrespective of their level of financial security. Hence, it is recommended to raise their amount of monthly income by increasing the pension amount, interest rates etc.

- Some of the senior citizens belonging to the labour group have expressed their interest of working even after retirement. They recommend that the Government should introduce some kind of work applicable for the senior citizens who are interested in working even after retirement in various government and non-government organizations. This will help them to contribute towards their family expenditure in a better manner.
- The senior citizens belonging to both the groups recommend reduction in the high cost of medical and healthcare expenditures.

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Comparative analysis of the Total Cost of Ownership associated with diesel and electric cars available in India

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ABSTRACT

The emergence of the strong Indian middle class has led to proliferation in the number of four wheelers on the Indian roads but have been major contributors towards degradation of the air quality. Consequently, a switch to alternative source powered vehicles, like electric vehicles has been proposed and being widely accepted throughout the world, particularly in the developed countries. India too after having long pondered their feasibility and utility, have finally indicated a switch to these 'automobiles of the future' with numerous schemes and aggressive targets. It is important to analyze their total cost of ownership in the Indian conditions, with attention to the private costs' viz. capital cost of purchase, cost of running and maintenance. Moreover, inclusion of societal costs of these vehicles which include the costs to human health and that on the climate, makes this study unique and imperative. The study helps conclude that the only way the costs of the electric vehicles attain parity with the diesel counterparts would only through reduction in initial capital costs, via economical and bulk production, and switching of electricity generation source, majority of which is through burning coal, to cleaner renewable sources.

Keywords: Total Cost of Ownership; Electric Vehicles; Social Cost; Human Cost
Introduction

In India, owning a four-wheeler has long been associated with comfort, luxury and a status symbol. With the emergence of the strong Indian middle class who aspire to have belongings which only the 'rich; could have afforded once upon a time, has led to proliferation in the number of four wheelers on the Indian roads (Elisabeth A, 2016). These automobiles apart from providing convenience to their owners, have long contributed to degradation of the quality of air, particularly with their emissions of particulate matter ^{2.5}, which has been recognized to be a prime carcinogen. These cars have been categorized as sources of mortality to humans, due to these emissions, which lead to chronic diseases (Krewski D, 2009).

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In addition, these automobiles pose a risk to the environment, particularly the climate. This can be attributed to the carbon dioxide emissions which are released into the air, and the effects of which on the environment have been well documented, as prime source of global warming on the planet (Elisabeth A, 2016). It is to be noted that the fuel efficiency of these vehicles has been improving as time has passed, but their cumulative effect has only been rising, majorly due to their constantly growing demand. This immense increase in the demand has particularly been noted in the developing countries of the world, like India (Sims R, 2014).

One of the more plausible solutions that has been going around in the world, has been a switch to alternative source powered vehicles, like electric vehicles, which in theory are said to counter the damages caused by the vehicles which run on the more conventional sources and end up costing less to the owners when compared with the conventionally fueled counterparts. So, it is not surprising to see the emergence of hybrid and electric vehicles, especially in the developed parts of the world.

India, has also been keenly looking at this as a prospective solution, and in this decade, numerous initiatives have been launched by the Indian government to push the growth of electric vehicles in the country with aggressive deadlines in place. Schemes and plans such as National Mission on Electric Mobility (NMEM), 2011; National Mission on Electric Mobility (NEMP) 2013; FAME-I 2015 and FAME-II 2019 have been the major moves made by the Indian government in order to move to a multimodal interconnected, mobile future, powered by electricity (ARAI, 2020). With such strong initiatives, making waves, it is important to investigate whether such a move, subject to current conditions, would definitely lead to a better future or not. The endorsers of electric vehicles argue that even though the electric vehicle is more expensive as compared to the diesel or petrol variant, in terms of upfront cost, these tend to be cancelled out, with the electric vehicle proving to be cheaper in the longer run, owing to their better distance coverage per unit energy and their lower maintenance costs.

This study aims to investigate this issue from the stand point of what is the effect of the electric vehicles on the environment and on the health of the people, the two major drivers which have helped push the idea of adopting in the developing countries, particularly in India. Considering that over 50% of generation in India is still achieved via burning coal, it cannot presently be concluded that the electric vehicle revolution help counteract the problems posed by the conventionally fueled vehicles. The study aims to explore this proposed solution by focusing on the total cost of ownership (TCO) of the electric vehicles by providing emphasis not just on the private costs that one has to incur i.e., the cost of purchase, the cost of fueling and the operational and maintenance costs, but also taking into account the societal costs associated with these vehicles of the future. If they are really reducing the exposure of human beings to carcinogens such as PM2.5 and really reducing the carbon footprint, has been investigated, in the Indian context.

Methodology and data

In order to evaluate the private and societal costs of the diesel and electric vehicles, only those vehicles that are presently available for sale in India have been taken into account. In order to compensate for minor differences, that can affect the study and be difficult to account for, the study will be conducted by pairing vehicles of the similar category together (Elisabeth A, 2016). In order to ensure that the pairing is uniform, the options were classified based on similar category, same manufacturer, same model, similar/ comparable variant with the only difference being the fuel type (diesel) and powertrain (electric).

Once the pairs have been established, the difference in the net present value (NPV) of the TCO of these vehicles will be calculated across the paired-up categories for a time frame of 10 years i.e., 2020-2029. The private costs will account for the actual cost of the vehicle, the fuel expenditure and the operational and maintenance costs that would be incurred along the 10-year period. The social costs will account for the costs from climate effects due to emission of CO₂ and the cost from adverse health impact on humans due to exposure to PM_{2.5}. Values corresponding to the diesel-powered vehicle will be taken as the baseline, thus an incremental NPV of less than zero would lead to the conclusion that the said electric vehicle in the said category is the preferred vehicle.

After analysing the options available in the Indian automobile market, based on the pairing approach specified, the study would be done on two pairs, SUV and diesel, which have been mentioned in Table 1 below and also in the supplement document of this study (Cardekho.com, 2020), (Zigwheels.com, 2020). In the following sections, the detailed methodology used for calculating each sub-component of capital and societal costs has been described along with the data points obtained for them.

Pair number	Category	Brand	Vehicle	Fuel
1	SUV	TATA	Tata Nexon_1.5 Revotorq XZA+ Dual Tone	Diesel
		TATA	Tata Nexon EV XZ Plus LUX	Electric
2	Sedan	Mahindra	Mahindra Verito 1.5 Executive edition	Diesel
		Mahindra	eVerito D6	Electric

Table 1: Pairing of vehicles

Calculating the initial capital costs

The prices were obtained from CarDekho.com and Zigwheels.com (Cardekho.com, 2020), (Zigwheels.com, 2020), and are current prices with respect to April 2020. For this study, manufacturer's suggested retail price (MSRP) has been used for capital costs of the vehicle. MSRP may not always be a sure shot representation for cost of manufacturing and final selling prices, since they are set by the respective automobile manufacturer, and is subject to their expectations of consumers' willingness to pay. An assumption made here is that the prices will

not vary with respect to the fuel type, but because of difference in models and make, where in the pairing approach utilized will be able to account for the differences between MSRP used and actual market price at which consumers end up buying them.

The prices captured have been presented in the Table 2 and also included in the supplement document.

Pair number	Category	Brand	Vehicle	Fuel	Price (MSRP)	Price difference
1	SUV	TATA	Tata Nexon_1.5 Revotorq XZA+ Dual Tone	Diesel	₹ 11,80,000.00	₹ 4,19,000.00
		TATA	Tata Nexon_EV XZ Plus LUX	Electric	₹ 15,99,000.00	
2	Sedan	Mahindra	Mahindra Verito 1.5 Executive edition	Diesel	₹ 8,87,000.00	₹ 1,13,000.00
		Mahindra	eVerito D6	Electric	₹ 10,00,000.00	

Table 2: Capital cost comparison

Calculating the fuel expenditure costs

For evaluating the fuel expenditure, the distance the vehicle would be covering in the time frame of 10 years was considered referring a comprehensive review, which found that distance average Indian drivers covered per year ranged from 7500 to 15,000 vehicle kilometres travel per year (VKT), with final estimates of 9300–12,200 VKT provided for large urban centres (Baidya S, 2009).

12,200 km has been used as the distance covered for the first year, and then is gradually decrease by three percent year on year, for the ten years of ownership of the vehicle. Anecdotal evidence suggests that an average person may prefer to use an electric car for shorter trips, while using diesel cars for the longer journeys. In order to compensate for these differences in the study, it has been assumed that the driver is insensitive to trip length and has equal access to both the electrical charging infrastructure as well as diesel fuel stations (Elisabeth A, 2016).

To accommodate for driving patten errors, which play an important role in fuel efficiency of the vehicle, and the disparity between data collected by Indian Driving Cycle (IDC) on fuel economy of vehicle and actual observed values, the assumption that each vehicle type has the same error between the IDC and the real-world performance has been made in the study (Elisabeth A, 2016). To evaluate the costs for expenditure for diesel vehicle, crude oil prices for the ten year period were established from forecasted valued published by Environment Impact Agency (EIA) (Petrofed-ICRA, 2016), and were transformed into gasoline prices in Delhi, India based on extensive study conducted by Petrofed-ICRA which stated for a change in price of barrel of

crude oil from 70 USD to 120 USD, which leads to increase in price of gasoline in Delhi by INR 20/litre (Petrofed-ICRA, 2016), from which diesel prices were calculated based on working paper of IMF which suggested that there needs to be a difference of INR 10/ litre between the gasoline and diesel prices in India (Rahul A, 2013). For the sake of current reflection of prices, the study deploys a price difference of INR 20/ litre. Later, a discounting factor of 10% was used to calculate the discounted value of the diesel prices obtained.

The fuel efficiency stated by the vehicle manufacturer served as the distance covered per litre of fuel consumed for first year (Cardekho.com, 2020), (Zigwheels.com, 2020). To account for change in fuel efficiency offered by the vehicle, the assumption wherein the fuel efficiency drops by one percent per year, was made. Using the information, the fuel required every year was calculated. This coupled with the discounted price of diesel gave the discounted diesel expenditure values.

The calculation for the electric vehicle also deployed similar methodology as the diesel vehicle with a few minor changes wherein charging tariffs for the ten year period were established by factoring in inflation rate projections (Knoema, 2020). The battery efficiency i.e. value for distance covered on a full charge was captured from the values published by the vehicle manufacturer, which served for first year (Cardekho.com, 2020), (Zigwheels.com, 2020). To account for change in battery efficiency in the forthcoming years, it was assumed that a one percent drop in battery efficiency occurs per year. The charging tariffs were discounted using a discounting factor of 10% and the results for the discounted expenditure of charging the electric vehicle were arrived for the 10-year period. The comparative data has been provided in Table 3 of this research paper and Table 8 of the supplement document.

Calculating the operational and maintenance costs

For evaluating servicing costs, data for the diesel fuelled vehicles was taken from CarDekho.com portal, which published the values for the first six services, with all barring the first service been equally spaced out by 12 months. A similar pattern was mirrored for the remaining time frame. In the time frame engine oil, oil filter, air filter, fuel filter, coolant prices are considered, and have again been taken from CarDekho.com (Cardekho.com, 2020). The price specific to servicing costs charged by the dealers have been excluded from the analysis, so as to maintain uniformity. For the electric vehicles, it has been reported that mainly two major components need to be replaced in an electric car- Air filter and climate control filter which need to be changed in every two years and three years respectively (Ethan Jupp, 2020). It is to be noted that this is not an exhaustive list, but due to the lack of publicly available data in the Indian context, the study proceeds with this as the guiding approach. Moreover, parts of the car such as brake pads need to be replaced in electric vehicles also, but the pairing approach adopted helps in negating the effect these prices would have on the vehicle. The prices of these components have been adjusted for inflation, beyond the six services for which prices have been specified in CarDekho.com (Cardekho.com, 2020). The results have been represented in Table 4 of this paper and Table 9 of the supplement document.

Year	SUV discounted fuel expenditure			Sedan discounted fuel expenditure		
	Diesel	Electric	Difference	Diesel	Electric	Difference
2020	₹ 37,064.88	₹ 13,908.75	-₹ 23,156.13	₹ 32,605.81	₹ 21,780.69	-₹ 10,825.12
2021	₹ 34,159.52	₹ 12,635.99	-₹ 21,523.53	₹ 30,049.98	₹ 19,841.46	-₹ 10,208.53
2022	₹ 31,220.13	₹ 11,471.75	-₹ 19,748.38	₹ 27,464.21	₹ 18,064.87	-₹ 9,399.34
2023	₹ 28,342.39	₹ 10,417.22	-₹ 17,925.17	₹ 24,932.67	₹ 16,453.68	-₹ 8,478.99
2024	₹ 25,776.63	₹ 9,722.39	-₹ 16,054.24	₹ 22,675.59	₹ 15,166.64	-₹ 7,508.95
2025	₹ 23,458.72	₹ 8,830.36	-₹ 14,628.36	₹ 20,636.54	₹ 13,814.46	-₹ 6,822.08
2026	₹ 21,349.18	₹ 8,013.63	-₹ 13,335.55	₹ 18,780.78	₹ 12,740.01	-₹ 6,040.77
2027	₹ 19,384.28	₹ 7,266.14	-₹ 12,118.14	₹ 17,052.27	₹ 11,592.58	-₹ 5,459.69
2028	₹ 17,649.00	₹ 6,788.03	-₹ 10,860.97	₹ 15,525.75	₹ 10,685.39	-₹ 4,840.35
2029	₹ 16,070.80	₹ 6,149.22	-₹ 9,921.58	₹ 14,137.41	₹ 9,712.50	-₹ 4,424.91
Total		SUV	-₹ 1,59,272.04		Sedan	-₹ 74,008.72

Table 3: Fuel expenditure cost comparison

Calculating the human costs due to PM_{2.5}

To evaluate the costs of these damages, the emission characteristic from typical diesel (Diesel Net, 2020) and electric vehicle were established. The emissions from electric vehicle have been attributed to the fact that these vehicles are still primarily powered using the electricity generated by burning coal (Mittal M, 2014). Once these emissions were calculated in terms of grams of PM_{2.5} released into the atmosphere for very kilometre travelled (for the electric vehicles, emissions were adjusted for PM_{2.5} in grams for every kilo what hours of energy used to cover one kilometre), then their corresponding change in ambient concentration was evaluated, which was then used to calculate the difference in the population incidence, to evaluate the effect on human life. Once this was ascertained, the health damages were monetized using the concept of value of a statistical life (James K, 2011). In order to account for the 10-year life cycle, the earlier assumption which stated the drop in efficiency by one percent year on year, served here too, enabling in increasing the amount of emissions by one percent every year. To arrive at the present costs, a social discounting factor of four percent was used.

Year	Service number	Year of ownership	SUV discounted expenditure			Sedan discounted expenditure		
			Diesel	Electric	Difference	Diesel	Electric	Difference
2020	1,2	1	₹ 2,354.55	₹ 0.00	-₹ 2,354.55	₹ 3,688.18	₹ 0.00	-₹ 3,688.18
2021	3	2	₹ 2,140.50	₹ 214.05	-₹ 1,926.45	₹ 3,352.89	₹ 214.05	-₹ 3,138.84
2022	4	3	₹ 3,057.85	₹ 225.73	-₹ 2,832.13	₹ 3,367.39	₹ 225.73	-₹ 3,141.67
2023	5	4	₹ 1,769.00	₹ 177.07	-₹ 1,591.93	₹ 2,770.99	₹ 177.07	-₹ 2,593.91
2024	6	5	₹ 2,725.84	₹ 0.00	-₹ 2,725.84	₹ 2,519.08	₹ 0.00	-₹ 2,519.08
2025	7	6	₹ 1,573.69	₹ 346.82	-₹ 1,226.87	₹ 2,829.26	₹ 346.82	-₹ 2,482.43
2026	8	7	₹ 2,427.23	₹ 0.00	-₹ 2,427.23	₹ 2,243.11	₹ 0.00	-₹ 2,243.11
2027	9	8	₹ 1,401.29	₹ 140.26	-₹ 1,261.03	₹ 2,116.68	₹ 140.26	-₹ 1,976.42
2028	10	9	₹ 2,161.32	₹ 159.06	-₹ 2,002.26	₹ 2,271.54	₹ 159.06	-₹ 2,112.48
2029	11	10	₹ 1,247.78	₹ 124.90	-₹ 1,122.88	₹ 1,884.80	₹ 124.90	-₹ 1,759.90
Total				SUV	-₹ 19,471.16		Sedan	-₹ 25,656.03

Table 4: Maintenance cost comparison

Change in ambient concentration (Δc) in ($\mu\text{g}/\text{cubic metre}$) was calculated for each year and is given by the equation (1) (Krewski D, 2009).

$$\Delta c = \frac{iF \times Q}{BR \times P} \quad (1)$$

Where,

Intake fraction (iF) value in ppm;

Breathing Rate (BR): 14.5 cubic metre/ day;

Population exposed to change in ambient concentration of $\text{PM}_{2.5}$ (P).

The change in the effect of health of humans due to exposure to the said change in ambient concentration of $\text{PM}_{2.5}$, referred to as change in population level incidence level (Δy), calculated for every year of ownership is given by the equation (2) (Johanna L, 2012).

$$\Delta y = y_0 \times P \times (e^{\beta \Delta c} - 1) \quad (2)$$

Where,

Population exposed to change in ambient concentration of PM_{2.5} (P);

Baseline incidence for the population (y_0);

Effect estimate (β);

(Δc) is change in ambient concentration (Δc) in $\mu\text{g}/\text{cubic metre}$.

After the population incidence level (Δy) were calculated, they were monetized into the costs of health effects, by using the metric, Value of a statistical life (VSL), corresponding to India.

These values were discounted using social discounting factor of four percent to arrive at their present valuation.

Calculating the climate costs due to CO₂

To estimate the societal costs due to CO₂ emissions, the values of the global damages developed for the US government, referred to as the Social Cost of Carbon (SCC) were used. These values represent the marginal cost of the impacts caused by emitting one extra ton of greenhouse gas at any point in time, inclusive of 'non-market' impacts on the environment and human health.

The emission of CO₂ for a car for a particular year was recorded in metric tons for a year using the same methodology followed for recording the PM_{2.5} emission values. Similar assumption of decrease in efficiency of the battery by one percent very year, leading to increase in the concentration of CO₂ emitted in grams per kilometre travelled by one percent per year. Then the social cost of carbon cost was calculated and were discounted to arrive at the present evaluation using four percent as the social discounting factor.

Results

Initial capital costs

The diesel vehicle cost relatively less when compared to their electric counterparts, particularly in the SUV segment as compared to the sedans. This is due to a larger power requirement, along with other powerful features which have come to be associated with the SUV segment.

Fuel expenditure costs

The difference in expenditure towards fuelling was found to greatly in favour of electric vehicles, especially in the case of electric SUV, where this difference was more pronounced. This interesting observation can be put down to the high distance coverage offered by the electric SUV for a unit of energy consumed, as compared to its sedan counterpart.

Operational and maintenance costs

The electric vehicle performed well above their diesel counterparts, across the SUV and sedan categories, owing to the minor changes maintenance works required in servicing an electric vehicle, as compared to numerous component changes required at regular intervals for a diesel vehicle.

Private costs

Overall calculations for private costs show that the effect of savings in costs has been more prominent in the sedan category, which can be put down to the relatively smaller price difference in the initial capital costs between the diesel sedan and electric sedan. The results have been presented in Table 5 of this paper and Table 10 of the supplement document.

	Pair Category	Pair Price difference for MSRP	Pair Fuel expenditure difference	Pair maintenance cost difference	Cumulative Difference
1	SUV	₹ 4,19,000.00	-₹ 1,59,272.04	-₹ 19,471.16	₹ 2,40,256.79
2	Sedan	₹ 1,13,000.00	-₹ 74,008.72	-₹ 25,656.03	₹ 13,335.26

Table 5: Cumulative private costs

Human costs

Greater reduction in the cost inflicted on humans was seen across the SUV category as compared to that of the sedan. This can be mainly attributed to the fact that the electric SUV taken under consideration is far more efficient and is giving out less amount of PM_{2.5} in the atmosphere, for every kilometre that it covers, thus accounting for lower human costs. The results have been presented in Table 6 of this research paper and with detailed calculations in Table 13 of the supplement document.

Year	Discounted monetized cost difference	
	SUV	Sedan
2020	-₹ 1,604.17	-₹ 532.45
2021	-₹ 1,511.16	-₹ 501.58
2022	-₹ 1,423.54	-₹ 472.50
2023	-₹ 1,341.01	-₹ 445.10
2024	-₹ 1,263.25	-₹ 419.29
2025	-₹ 1,190.01	-₹ 394.98
2026	-₹ 1,121.01	-₹ 372.08
2027	-₹ 1,056.01	-₹ 350.51
2028	-₹ 994.79	-₹ 330.18
2029	-₹ 937.11	-₹ 311.04
Total	-₹ 12,442.07	-₹ 4,129.71

Table 6: Discounted cost on human health due to PM_{2.5} exposure

Climate costs

With respect to the climate costs, the SUV category once again outperformed the sedan category in terms of the cost inflicted on the climate. This can be mainly attributed to the fact that the electric SUV is efficient and is giving out less amount of CO₂ in the atmosphere, whereas the electric sedan with its comparatively lower efficiency coupled with greater amount

of CO₂ being released in the atmosphere per kilometre covered, leads to a relatively greater associated cost. The results have been presented in Table 7 of this research paper and with detailed calculations in Table 14 of the supplement document.

Year	Difference: Discounted SCC	
	SUV	Sedan
2020	-₹ 1,067.32	₹ 544.22
2021	-₹ 968.85	₹ 549.25
2022	-₹ 878.55	₹ 551.52
2023	-₹ 795.79	₹ 551.37
2024	-₹ 719.96	₹ 549.08
2025	-₹ 650.53	₹ 544.93
2026	-₹ 586.99	₹ 539.16
2027	-₹ 528.87	₹ 531.98
2028	-₹ 475.75	₹ 523.60
2029	-₹ 427.21	₹ 514.19
Total	-₹ 7,099.82	₹ 5,399.31

Table 7: Cost to climate due to CO₂ emissions

Societal costs

The SUV category has clearly outperformed the sedan category in terms of the societal costs. The net costs have reduced under the SUV category due to the relatively better performance of the electric SUV compared to the diesel variant, whereas the cost attributable to damage to society have increased across the sedan category for the 10 years life time, considered for the study. The results can be summarized as shown in Table 8 of this paper and of Table 15 of the supplement document.

Pair Category	Pair difference cost for effects on human health (PM2.5)	Pair difference cost for effects on climate (CO2)	Cumulative Difference
SUV	-₹ 12,442.07	-₹ 7,099.82	-₹ 19,541.89
Sedan	-₹ 4,129.71	₹ 5,399.31	₹ 1,269.60

Table 8: Cumulative social costs

Total cost of ownership

The study shows that even after the lifecycle of 10 years, electric variants are considerably expensive across the SUV category, particularly due to the vast difference in initial capital costs. The sedan category electric vehicle is close to breaking even with its diesel counterpart, but needs further improvement in the fuel efficiency to reduce power expenditure.

A comparative view of the results found can be seen in Table 9 of this paper and in Table 16 of the supplement document.

Pair Category	Pair Price difference for MSRP	Pair Fuel expenditure difference	Pair maintenance cost difference	Pair cost difference for effects on human health (PM2.5)	Pair cost difference for effects on climate (CO2)	Cumulative difference
SUV	₹ 4,19,000.00	-₹ 1,59,272.04	-₹ 19,471.16	-₹ 12,442.07	-₹ 7,099.82	₹ 2,20,714.90
Sedan	₹ 1,13,000.00	-₹ 74,008.72	-₹ 25,656.03	-₹ 4,129.71	₹ 5,399.31	₹ 14,604.86

Table 9: Total cost of ownership

Conclusion

The results show us that over the course of the lifetime, which was taken at 10 years for the study, the electric variants have been successful to some extent in bridging the cost difference when compared to their diesel rivals, but not to the extent, where one can be completely convinced to purchase them, as a more 'economical' option. Several assumptions were made during this study, which may/ may not have significant impact on the results, but those can be explored further in subsequent studies related to the topic, for example, the cost from NOx and SO2 which are also emitted, the effect of resale values of the car, extensive impact of temperatures upwards of 45 degree Celsius, driving patterns, etc. However, the cost difference which we obtained, can serve as a guideline to policy makers to decide on the level of subsidy they wish to confer upon the electric cars that are being introduced in the Indian market, so as to make them more viable options for the average consumer. One more area that the study highlights, is that the electric vehicles are no better than the diesel vehicles, until and unless, these are powered from sources, which in turn do not lead to pollutions and cost the climate and human life. Till such a point is not reached, the chasm between the prices of conventionally fuelled vehicle and the electric vehicles will not be bridged, when taking a holistic view of the situation, it will just be a mere substitution effect. Another key thing we can take away from this study is, lack of a viable hatchback contender in the electric car segment in the Indian market.

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IMPACT OF CRISIS PERIOD ON CONSUMER BEHAVIOUR A STUDY OF THE FASHION INDUSTRY

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ABSTRACT

In a new world order of unlocking due to the ongoing pandemic, the study and understanding of Consumer Behavior has become essential. Consumer behavior is the study of individuals and organizations and how they select and use products and services. This research paper will highlight the set of dimensions which can be identified in the literature, and can be used to characterize and differentiate, the various perspectives on consumer behaviour in fashion industry. Fashion is a popular aesthetic expression at a particular time and place and in a specific context, especially in clothing, footwear, lifestyle, accessories, makeup, hairstyle, and body proportions.

The fashion industry has taken a hard hit due to the COVID-19 crisis. Every aspect of the fashion industry is being wrung out to dry because of what's being called 'fashion's Darwinian shakeout'. The objective of this research is to achieve a better understanding of consumer behaviour during and post crisis period in fashion industry respectively. It also aims to identify the psychological, motivational and behavioural pattern of the consumers that could be helpful in understanding the future patterns of the consumer keeping the past influences (for instance; both world wars, Great Depression and so on) in mind.

This study focuses on fashion industry and their buying behaviour in India. Qualitative and Quantitative type research design shall be used in the study. Google analytics technique is used in the research. Data is collected through structured questionnaire and also through data available online. Data is analyzed through using Excel and various statistical tools. Findings are derived from the data analysis and required sources will be given.

Key words: Consumer behaviour, Pandemic, Fashion industry

Introduction

As the world begins its slow pivot from COVID-19 crisis management to recovery and the reopening of economies, it's clear that lockdown has had a profound impact on how people live. The period of contagion, self-isolation, and economic uncertainty will change the way consumers behave—in some cases for years to come. The point to ponder over is that, will the consumer behavior will be like the one it is during lockdown, did the consumer behavior change during World war 1, World war 2, Great depression or the 2008 economic crisis, will the consumers resort back to its pre covid-19 era behavior?

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Understanding of consumer buying pattern plays an important role in the success of any business organization. The current financial downturn due to covid-19 will have a huge influence on the economic and social aspects of consumers around the globe. The consumer behaviour is a combination of customer's buying awareness combined with external motivators to result in a change in the consumer's behaviour (Kar, 2010). This is why most of the economies around the globe share one problem, because of the external influence on the internal community aspects (Chaudhuri, 2006). A crisis causes markets to contract and major changes appear in their structure (Chaudhuri, 2006). The buyers change their buying behaviour. They start to worry about their jobs and do not enjoy spending their money anymore. They postpone or reduce big amount of purchases related to leisure and entertainment. People may start buying less quantities, or switch to larger size items to avoid repeated purchases. They also start to switch brands, and focus on price rather than quality and they also start to intensify the search on the web looking for valuable bargains (Perner, 2008 & Drakopoulos, 2008).

All consumption is location and time bound. Consumers develop habits over time about what to consume, when and where (Sheth, 2020). Of course, this is not limited to consumption. And consumer behavior is highly predictable, and consumer insights based on past repetitive buying behavior at the individual level. The less predictable context are the ad hoc natural disasters such as earthquakes, cyclones and endemic/pandemic including the Covid-19 pandemic we are experiencing today. Similarly, there are regional conflicts, civil wars as well as global wars such as the World War II, cold war, and Great Depression of the late twenties and the Great Recession of 2008–2009. All of them significantly disrupted both consumption as well as production and supply chain. The focus of this study is to examine consumer behaviour during crisis and post it.

As mentioned before, all consumption and consumer behavior are anchored to time and location. Since World War II, more and more women have been working resulting in reduction of discretionary time. It is estimated that today more than 75 percent for all women with children at home are working fulltime. This resulted in the manufacture of New line of clothing; working women wear (office wear). This has also resulted in time shortage and time shift in family as well as personal consumption. There is also time shortage as the discretionary time of the homemaker is now nondiscretionary due to her employment. This time shortage has resulted in consumers ordering online and have products delivered at home.

With the Covid-19 lockdown and social distancing, consumers' choice of the place to shop is restricted. This has resulted in location constraint and location shortage. We have mobility shift and mobility shortage. Working, schooling and shopping all have shifted and localized at home. The buyer, no longer is focused on the clothing trends and has shifted to the re-wear movement. At the same time, there is more time flexibility as consumers do not have to follow schedules planned for going to work or to school or to shop or to consume therefore the culture of night suits is all time high.

Objective of The Study

The purpose of this research paper is to examine the behavior of consumers during and post crisis. The point of reference is taken the great depression of 1930's, the world war and the ongoing pandemic (novel coronavirus), to find out the attitudes of the consumer and what it is; mainly concerned with psychology, motivations, and behavior of a consumer.

Literature Review

The buying behaviour is considered a very complex phenomenon because it consists of a wide set of prior and after purchase activities" (Hansen, 2004, p. 9). There are four distinctive classes of consumer buying behaviour identified by the literature. What differentiates these classes can be observed through the frequency of occurrence, emotional involvement, decision making complexity and risk. These types are known to be: programmed behaviour; limited decision-making buying behaviour; extensive decision-making buying behaviour and impulsive buying (Arnould, 2002). Programmed behaviour (also called habitual behaviour) is distinguished by low complexity and little information search, this process is usually known as routine purchase of low-cost items that consumer is used to buy out of habit: such as coffee, newspapers, bus tickets, etc. (Learn marketing, 2008).

Limited decision-making buying behaviour involves reasonable level of decision making and relatively low amount of information search in order to generate a purchase. An example of this type can be the purchase of clothes when someone can easily get information on the product and its quality and spend short time selecting the desired outfit (East, 1997). The extensive decision-making buying behaviour is identified as being the opposing type to the limit decision-making buying behavior (Foxall and Goldsmith, 1994).

The last type of buying behavior is identified by the literature is the impulsive buying. It is a decision made unconsciously and induced by an external stimulus that would make a specific product to appear attractive and irresistible to the consumer for instance high end fashion products. (Wells and Prensky, 1997).

The Consumer Behaviour in Crisis

The consumer reacts to any change in the economic situation around him by changing his consumption. This happens due to a change in the levels of his perception of risk. Financial crisis affects the customers not only economically but also psychologically. People become more money minded. They do not want to spend money on premium products anymore, even if they still could afford to do so. They only buy necessities, switch to cheaper brands and have a more rational view on promotion. They start to compare different products and select based on price compromising quality (Nistorescu and Puiu, 2009).

The influence of the crisis on people can be reflected on their consumption. George Katona (1974) suggests that many people believe that in a few months post crisis when prices would be higher, they would have to spend more on necessities and therefore would have smaller resources at their disposal for the purchase of desirable but non-essential goods and services. Therefore inflation encourages the postponement of discretionary expenditures. G.

Katona (1974) also believes that during recession people are motivated to save because of threats related to their jobs or income. The saving rates decline as economic conditions improve.

The most important factors which model the consumer's behaviour in such a situation are: risk attitude and risk perception.

Using the risk attitude and risk perception factors, consumers can be segmented to:

- The panicked consumers: are those who have a high-risk attitude and a high-risk perception
- The prudent consumers: are those who have high risk attitude and low risk perception
- The concerned consumers: are those who have low risk attitude and high-risk perception
- The rational consumers: are those that have low risk attitude and low risk perception

It is highly observed that one of the most rigorously impacted sections of the Indian economy during a crisis is the consumer buying behavior. The most influential factor is recognized to be the external economic instability that Indian consumers experience. The depressing effects of the financial crunch which arises due to crisis, hits the overall consumers purchasing behaviour effecting both planned and unplanned buying behaviour. Every feature of the socio-economic situation has substantially changed not only the way the consumer purchases, but especially what they are buying and why they are buying. In developed countries, consumers are more economical, more responsible and more demanding than traditional consumers. Currently, consumers are increasingly aware of all aspects involved in purchase of products, from design, safety, and origin to their social and economic impact. Thus, consumers have (46International Journal of Economics & Business Administration, I (2), 2013V. Sharma, J. Sonwalkar) become more vigilant and more aware of their ability to influence the world with their consumer choices (Salzman and O'Reilly, 2010). During a crisis, a series of parallel steps have made their presence, resulted in the consumer orientation on organic products or on fair trade products. Thus, a particular point of view, the crisis served as a mini electric shock, announcing a new era, maybe the era of responsible consumption (especially in fashion industry). In Mansoor (2011) opinion, the main changes in the new consumer behaviour, which are the result of economic turbulence due to crisis, could be summarized as follows:

- The need for simplicity: During recession consumers are accustomed to limited offers and tend to simplify their demands, so that after the crisis is expected that they will continue to accept simple offers, but with greater utility.
- Temperance: Even rich people save, although they are not required to do so. This is one way they show their dissatisfaction on excessive consumption.
- Smart consumption: Consumers today are 'agile' and act quickly to price changes, with the ability to change brands looking for the lowest price, sacrificing the quality and loyalty.
- Green consumerism: The demand for environmentally friendly products has increased during the crisis.

Methodology

The type of research that will be used in this study will be such that , the study will examine the phenomenon through observations made in past using bar-graph representation and through statistical analysis from the data available on the internet.

Data Analysis

1. The results of an online survey, realized by Market Probe International (in 2009 and 2010). The study showed that most consumers surveyed, changed their consumption behaviour by adopting a logical standby or a replacement, distinguishing their purchases or dropping different brands. Thus, before being interested in the price of products, consumers are asking questions about their usefulness (64% of respondents wonder whether they really needed, 60% if the product could not find a lower price elsewhere and 59% if they can afford to acquire). In the context of crisis, perhaps contrary to many, "44International Journal of Economics & Business Administration, I (2), 2013V. Sharma , J. Sonwalkar" , quality is what comes first for the consumer before the lower price. Consumers surveyed defined quality by: looking for healthy products (42%), looking for strong and sustainable products (47%) and for responsible products.

2. A study conducted by US Bureau of Labor and Statistics on consumption of consumers during and since world war 2 and it shows that Food and clothing has a parallel decline, in contrast to the increase for the selected other major components of current consumption. Housing exceeds relative combined spending on food at home and food away from home in the later years.

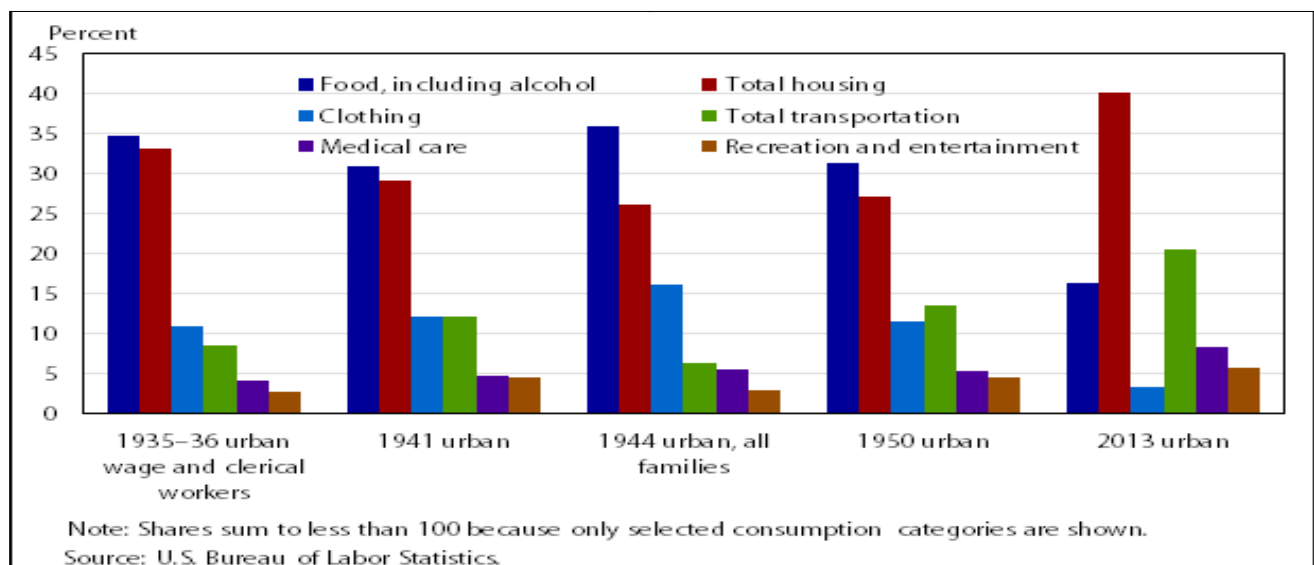


Figure 1: Consumption Shares over the years (1935-2013)

The major trend over the past 80 years has been a reduction in the share of spending on food and clothing. Clothing was 11 percent of total consumption in the 1930s, climbing during the war to 16 percent in 1944, dropping to 12 percent in the 1950s, and showing the same long-term decline in relative share as food (Fig. 2). It is now just over 3 percent of total consumption.

3. In the chart shown above (Fig.3), it is based on the study conducted by Kantar (www.kantar.com), it shows a consumer buying shift in certain products during the ongoing pandemic. For instance, if we look at the cosmetic products there has been a decrease of 23% overall in the sales of these products. Therefore, consumer becomes more conscious and frugal before buying items of luxury.

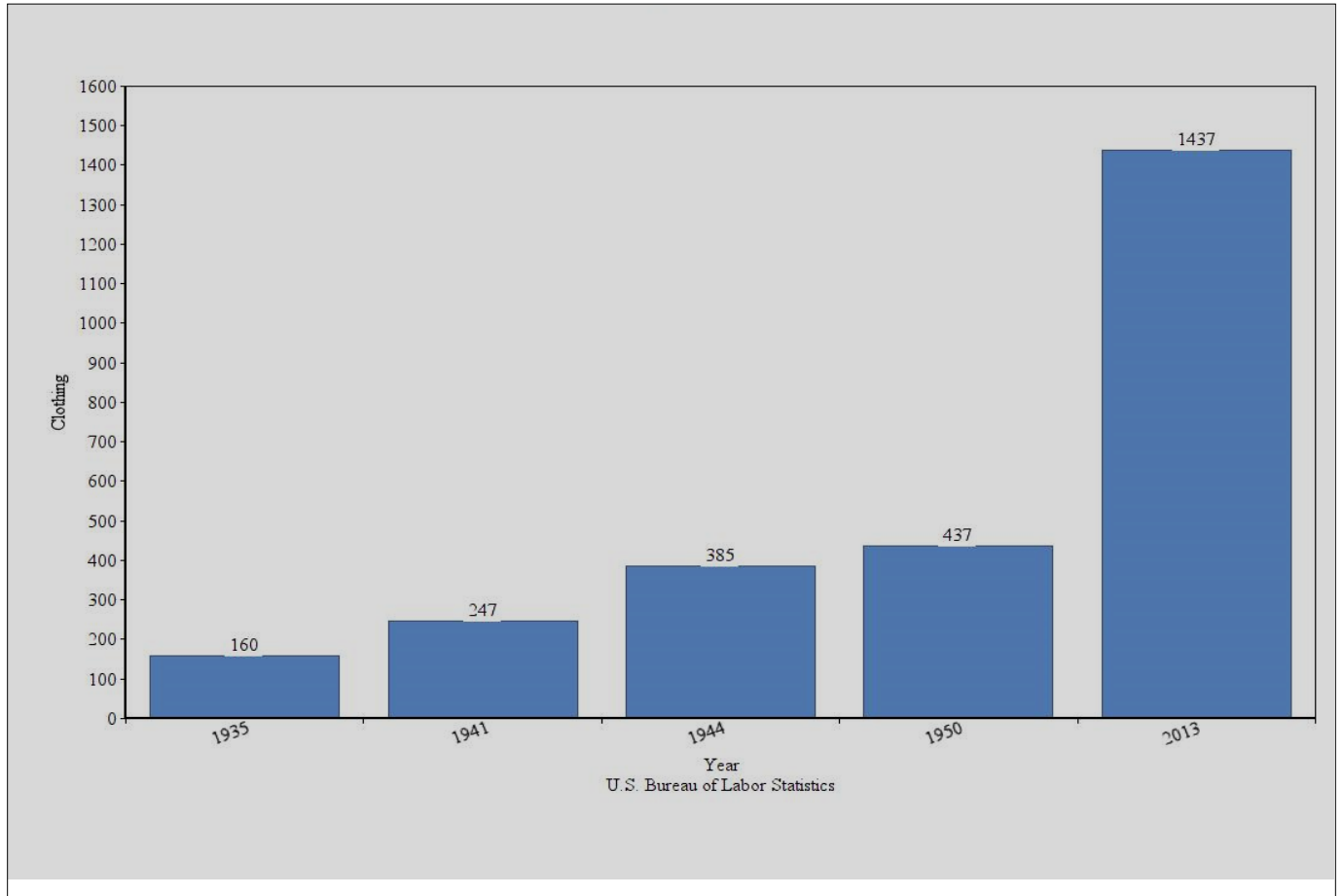


Figure 2: Major trend in clothing industry



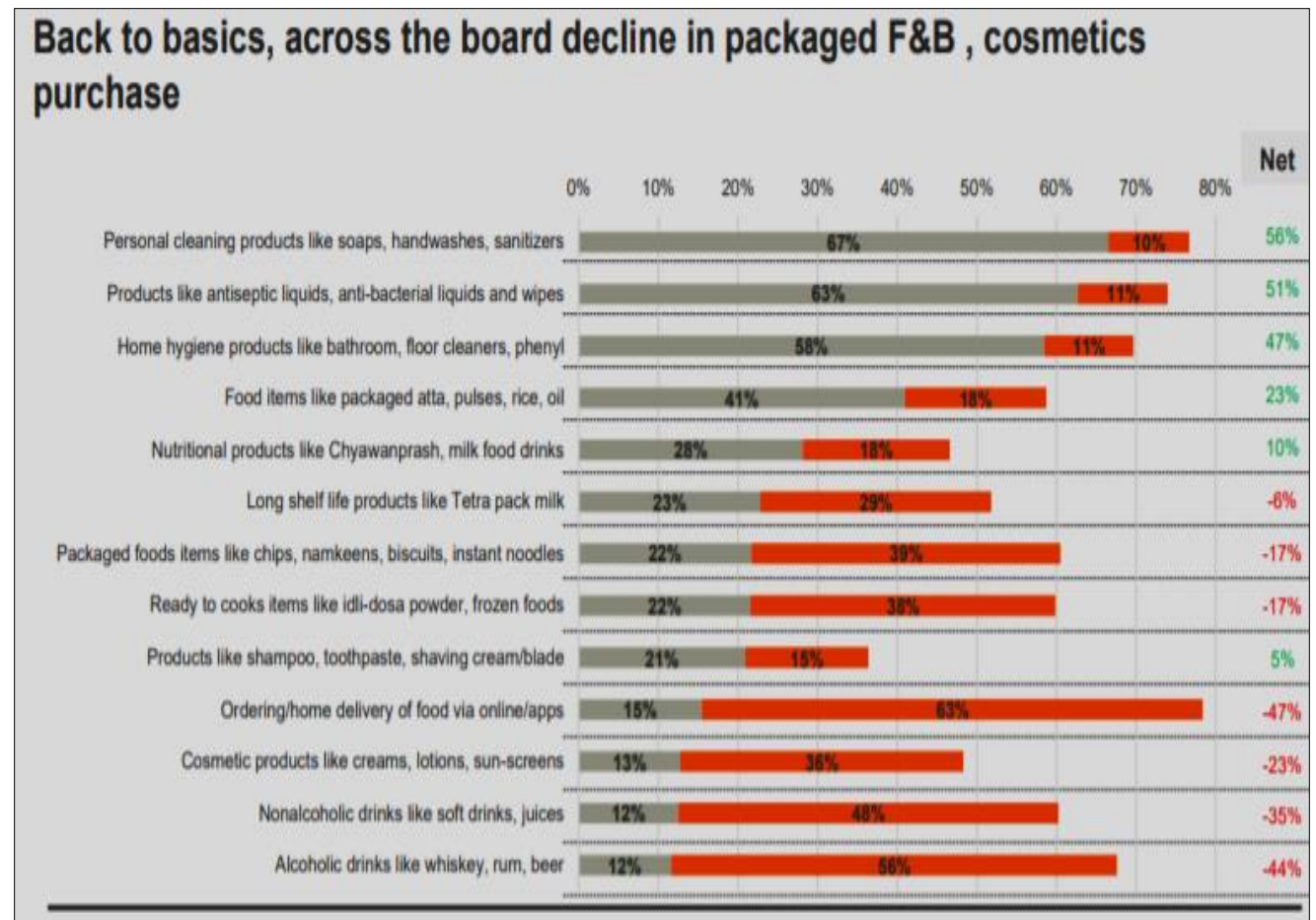


Figure 3: Consumer buying shift

4. For fashion players, 2020 will be a year of awakening. The ones who will succeed will have to come to terms with the fact that in the new paradigm that is taking shape around them, some of the old rules simply don't work. The McKinsey Global Fashion Index predicts industry growth of 3.5 to 4.5 percent in 2019 compared with a 4 to 5 percent estimate for 2018. India becomes a focal point for the fashion industry as its middleclass consumer base grows and manufacturing sector strengthens. Fashion players must redouble their efforts in this highly fragmented and challenging market where an educated and tech-savvy demographic rub shoulders with the poor and upwardly mobile users.

Discussions and Implications

1. It is expected that most habits will return back to normal when things return back to normal as was the case in past times after the crisis passes by. However, this time it is inevitable that some habits will die because the consumer under the lockdown condition due to COVID-19 crisis has discovered an alternative that is more convenient, affordable, and accessible. Examples include streaming services such as Netflix and Disney. They are likely to switch consumers from going to movie theatres or fashion shows. This is similar to ride sharing services such as Uber which is more user friendly than calling a taxi service. Due to coronavirus, consumers may find it easier to work at home, learn at home and shop at home.

People have shifted from wearing fancy brands to at leisure work wear as the work from home is the new norm. In short, what was a peripheral alternative to the existing habit now becomes the core and the existing habit becomes the peripheral to it.

2. There is a universal law of consumer behavior. When an existing habit or a necessity is given up, it always comes back as a recreation or a hobby. Examples include embroidery, hunting, fishing, gardening, baking bread, and cooking. It will be interesting to see what existing habits which are given up by adopting the new ways will come back as hobbies. In other words, will shopping become more an outdoor activity or hobby or recreation?

3. Modified Habits. In most cases, existing habits of shopping and delivery will be modified by the new guidelines and regulations such as wearing masks and keeping the social distance. This is evident in Asia where consumers wear masks before they go for shopping or use the public transit systems. Modified habits are more likely in the services industries especially in personal services such as beauty parlors, physical therapies, and fitness places.

4. New Habits: Just as we are used to security checks at the airports after 9/11, there will be more screening and boarding procedures including taking the temperature, testing for the presence of the virus and boarding the flight. All major airlines are now putting new procedures for embarking and disembarking passengers as well as meal services. As mentioned before, government policy to discourage or encourage consumption is very important to shape future consumptions.

5. As mentioned earlier a major driver of consumer behavior is technology. It has transformed consumer behavior significantly since the Industrial Revolution with the invention of automobiles, appliances, and airplanes. This was followed by the telephone, television, internet and now the social media and the user generated content. The digital technology is making wants into needs. For example, we did not miss the cell phone but today you cannot live without it. Today internet is as important as electricity and more important than television. How technology transforms want into needs has significant impact on developing new habits such as online shopping, online dating, or online anything. More importantly it has equally significant impact on the family budget between the old necessities (food, shelter, and clothing) in the new necessities (phone, internet, and apps).

6. The virtual world is becoming more interesting to consumers compared to the physical world as we have seen in video games and virtual sports. Will artificial become real? For example, is a relationship with a chatbot girlfriend more comfortable and enjoyable as compared to a real girlfriend or boyfriend? In a recent article in Wall Street Journal, Parmy Olson describes several anecdotes of how individuals are interacting with chatbots. According to the author, Microsoft Xiaoice social chatbot has more than 660 million users in China alone. In short, the artificial has become real

Conclusion

Every feature of the socio-economic situation has substantially changed not only the way the consumer purchases, but especially what they are buying and why they are buying. In developed countries, consumers are more economical, more responsible and more demanding than traditional consumers. Currently, consumers are increasingly aware of all aspects involved in purchase of products, from design, safety, and origin to their social and economic impact. Thus, consumers have become more vigilant and more aware of their ability to influence the world with their consumer choices (Salzman and O'Reilly, 2010). During any crisis a series of parallel steps have made their presence, resulted in the consumer orientation on organic products or on fair trade products. Thus, a particular point of view, the crisis serves as a mini electric shock, announcing a new era, maybe the era of responsible consumption. The lockdown and social distancing to combat the covid-19 virus has generated significant disruptions on consumer behavior. All consumption is time bound and location bound. With time flexibility but location rigidity, consumers have learned to improvise in creative and innovative ways. The work-life boundaries are now blurred as people work at home, study at home, and relax at home. Since the consumer is unable to go to the store, the store has to come to the consumer. As consumers adapt to the house arrest for a prolonged period of time, they are likely to adopt newer technologies which facilitate work, study and consumption in a more convenient manner. Embracing digital technology is likely to modify existing habits. Finally, public policy will also impose new consumption habits especially in public places such as airports, concerts, and public parks.

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ENERGY MANAGEMENT: SUBSTITUTING THE NONRENEWABLE ENERGY WITH RENEWABLE ENERGY IN WEST BENGAL

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ABSTRACT

Now a days it's very challenging to us to manage the energy for utilizing our daily needs of electricity. Our non-renewable energy resources are depleting at an alarming rate. Despite the fact that demands for electricity is steadily increasing. Most electricity comes from consumption of coal energy and that can be reduced by using renewable energy. West Bengal, like the rest of India, needs to understand the immense potential of renewable energy and focus on developing the framework for production of renewable energy. Switching to renewable energy sources for generation of electricity will prove to be an efficient management strategy from not only the economic aspect, but also the environment point of view. This will definitely induce sustainable growth and development of the state.

Keywords: Solar energy, Wind Energy, Hybrid Energy

Introduction

The demand for the provision of energy is increasing rapidly and the trend is likely to continue in future worldwide. In 2005, the worldwide electricity generation was 17450 TW h out of which 16% originated from hydro, 40% from coal, 20% from gas, 16% from nuclear, 7% from oil and only 2% from renewable sources (small hydro, wind, geothermal, etc.) Renewable energy is not only available in a wide range, but also abundant in nature. Renewable energy sector is meeting at present 13.5% of the global energy demand. Switching to renewable energy sources for generation of electricity provides beneficiary management strategies from the economic, as well as establishment of the regulatory commissions in environment point of view. According to a recent surveillance, India is endowed with vast potential of renewable energy with current energy contribution at 31.70 GW of the total installed capacity of 245 GW in the country as on 31st March 2020. In West Bengal, there are also abundant sources of renewable energy in the form of Solar, Wind, Biomass etc. According to West Bengal Renewable Energy Development Agency (WBREDA), West Bengal has an estimated potential of generating 2,206 MW (excluding solar) of electricity from Renewable Energy (RE) sources. The West Bengal Electricity Regulatory Commission (WBERC) has mandated 4 % of total procurement of electricity from RE sources as Renewable Purchase Obligation (RPO) by 2012 – 13. Nowadays A handful of enterprising renewable energy developers are now exploring how solar and wind might better work together, developing hybrid solar–wind projects to take advantage of the power-generating strengths of each — with the two technologies in tandem serving as a better replacement for climate-warming fossil fuels than either could be alone.

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Co-locating wind and solar plants can save money on grid connections, site development and approvals but that's not the only benefit. When applied to micro-grid systems, these micro-grids are finding application in places like Hawaii and India where utility prices are exorbitantly high or where communities are too remote to be tied into the macro-grid. Micro-grids powered by photovoltaics require battery storage, since people need power when the sun isn't shining, adding wind can help cut the battery costs, since the wind can (and often does) blow when the sun doesn't shine. According to our country duration of sunlight is very low in our northeast part just like Assam, Meghalaya, Nagaland, Mizoram, Arunachal Pradesh etc. Therefore, we can imply our project ideas in these areas as well as coastal areas.

Objective of Paper

The key aim of this paper is to reduce the use of non-renewable energy and implementation of renewable energy. This study emphasizes on use of solar energy, wind energy and the combination of solar and wind energy (Hybrid energy). Different studies and surveys reveal that we can use our renewable energy very easily in substitute of our conventional thermal energy. This will help us to reduce coal usage while still meeting our needs.

Area of Study

This research focuses on West Bengal (WB), which has a lot of renewable resources. With 23 districts depicted in Figure 1, West Bengal is one of India's most important states in respect to renewable energy production. Different types of climates can be found in these 23 districts. Some regions will be ideal for solar energy, and others will be suitable for wind energy. There are also certain places that are suitable for both. So, when it comes to green energy options, West Bengal is the best place to look for.

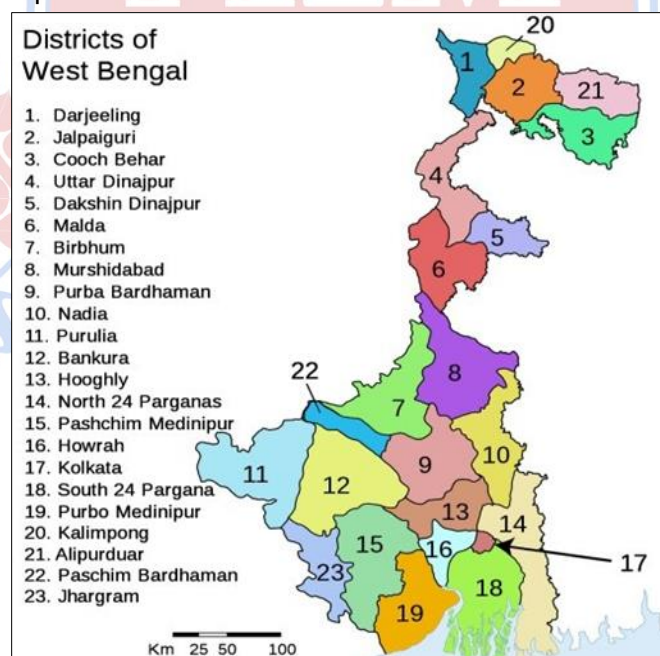


Figure 1 Districts of West Bengal

Area Demarcation for Application of Solar, Wind, Hybrid Energy

According to the variation of Solar Intensity and Wind Intensity, we can easily differentiate that 9 districts are has the potential for Solar Energy, 2 districts for Wind Energy and 12 districts for hybrid energy (Combination of Solar and Wind Energy). In Kolkata, Hooghly, South 24 Parganas, wind energy as well as Hybrid Energy can be generated in the river side areas. Districts like Jalpaiguri, Cooch Behar etc. can be considered as potential hubs for Solar Energy generation.

Serial No	Districts of West Bengal	Solar Energy	Wind Energy	Hybrid Energy
1	Darjeeling	X	Yes	X
2	Jalpaiguri	Yes	Yes	Yes
3	Cooch Behar	Yes	Yes	Yes
4	Uttar Dinajpur	Yes	Yes	Yes
5	Dakshin Dinajpur	Yes	Yes	Yes
6	Malda	Yes	Yes	Yes
7	Birbhum	Yes	X	X
8	Murshidabad	Yes	X	X
9	Nadia	Yes	X	X
10	Purulia	Yes	X	X
11	Bankura	Yes	X	X
12	Hooghly	Yes	Yes	Yes
13	North 24 Parganas	Yes	Yes	Yes
14	Paschim Medinipur	Yes	X	X
15	Howrah	Yes	Yes	Yes
16	Kolkata	Yes	Yes	Yes
17	South 24 Pargana	Yes	Yes	Yes
18	Purbo Medinipur	Yes	Yes	Yes
19	Kalimpong	X	Yes	X
20	Alipurduar	Yes	Yes	Yes
21	Paschim Bardhaman	Yes	X	X
22	Jhargram	Yes	X	X
23	PurboBardhaman	Yes	X	X

Table 1 Availability of Renewable Energy districts wise

In Purbo Medinipur we can implant the wind energy in coastal areas just like Digha, Tajpur etc. . Table 1 clearly shown the availability of renewable energy in the different districts of West Bengal.

Utilization of Solar Energy

Sunshine is much more than a key component of a successful morning jog or trip to the local park—it's an energy source that can help your community thrive. Solar energy, or the particles of sunlight that reach the Earth, is a clean, renewable energy source that can be harnessed and used to provide water heating, electricity, ventilation, and even transportation. In your communality, there are many ways to use solar energy. A photovoltaic (PV) solar system is a simple way to benefit from solar energy. As sunlight strikes a solar panel made of a

semiconductor material such as silicon, it shakes electrons out. These electrons generate an electric current as they move, which can be captured with wiring. The energy collected by the solar panels can be used right away for things like heating a pool or cooling your home during the summer, or it can be deposited in a battery for later use. Solar water heating will help you save still more money on your energy costs by heating all of your hot water needs during the summer.

Using solar energy in your Thrive Living Community has many benefits. It is a highly renewable energy source, available for use every day and easily harnessed in all areas of the world. It is also a healthier alternative to fossil fuels like oil, coal, and natural gas, which can pollute our environments and emit dangerous toxins. Solar energy also reduces a building's energy bills, and once the solar panels are installed, requires minimal maintenance, making them a very affordable way of powering your community. West Bengal is highly populated and has high solar insolation, an ideal place for generating electricity from solar energy. Because of its location between the Tropic of Cancer and the Equator, India has an average annual temperature ranging from 25 °C to 27.5 °C. This means that West Bengal has huge solar intensity.

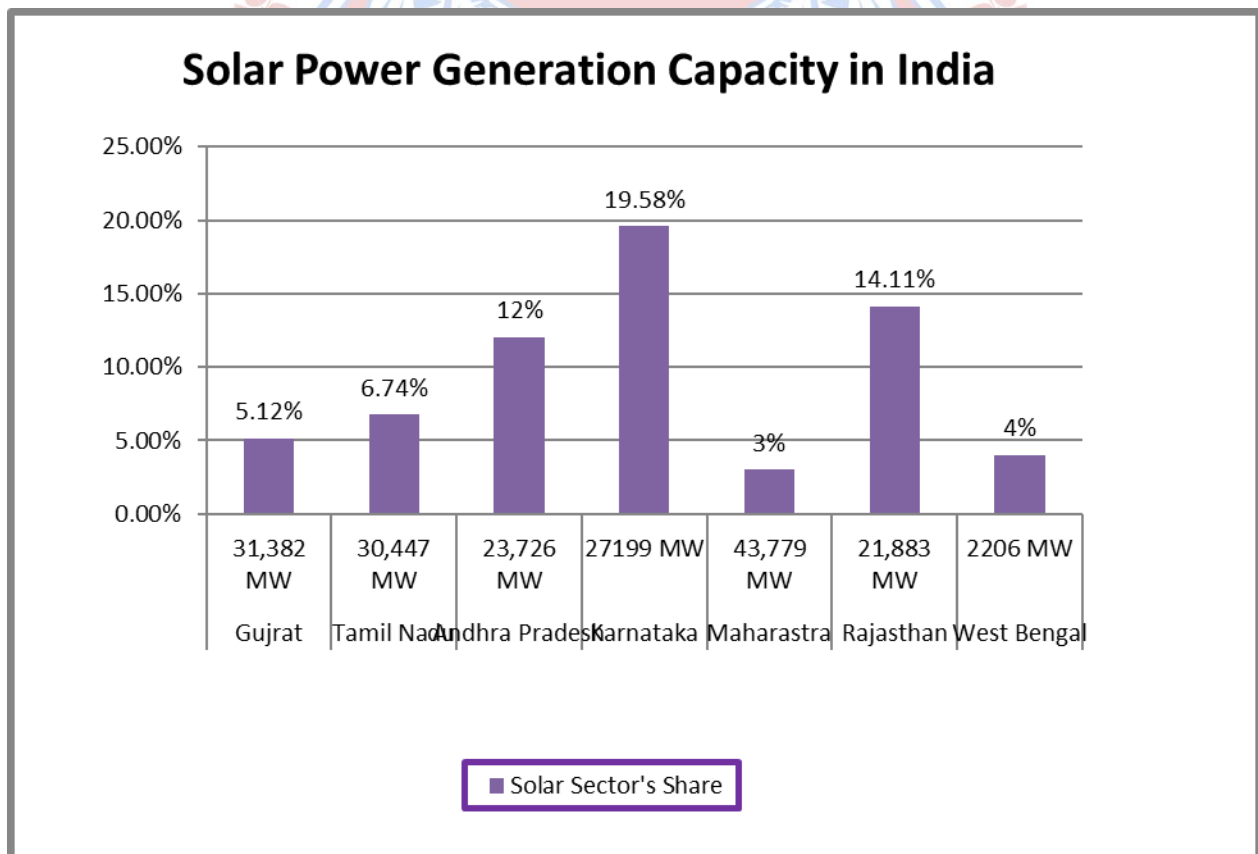


Figure 2 Solar power generation capacity in India

West Bengal has large sources of renewable energy but according to this Figure 2 we can easily see that West Bengal remains the second last position. According to the West Bengal Government, there are various upcoming projects based on Solar Energy. Recently the West Bengal Government is planning to develop floating solar power projects in a big way as it

does not require a large tract of land. Beside this, they are also exploring opportunities to take up 5 MW floating solar project on large ponds in Bandel thermal power plant area. According to the West Bengal Power Development Corporation (WBPDCL), the state is also commissioning the country's largest grid-connected floating solar project at Sagardighi thermal power plant. In our next discussion, we are trying to highlight the availability of Wind energy as well as solar energy in West Bengal. In near future, we hope that West Bengal may travel across the other states in case of producing electricity with the help of large sources of Renewable Energy. [1]

Utilization of Wind Energy

Wind is caused by the uneven heating of the atmosphere by the sun, variations in the earth's surface, and rotation of the earth. Mountains, bodies of water, and vegetation all influence wind flow patterns. Wind Turbine convert the energy in wind to electricity by rotating propeller-like blades around a rotor. The rotor spins the power supply, turning an electric motor. Three key factors affect the amount of energy a turbine can harness from the wind: wind speed, air density, and swept area.

In the case of producing electricity with the help of Wind Energy, we can use the Vertical axis Wind Turbine (VAWT)

Number	Performance	Horizontal Axis	Vertical Axis
1	Power generation efficiency	50 – 60 %	Above 70 %
2	Electromagnetic Interference	Yes	No
3	Steering Mechanism of Wind	Yes	No
4	Gear Box	Above 10 KW ; Yes	No
5	Blade Rotation Space	Quite Large	Quite Small
6	Wind Resistance Capability	Weak	Strong
7	Noise	5-60 db	0-10 db
8	Starting Wind Speed	High (2.5 – 5 m/s)	Low (1.5 – 3 m/s)
9	Maintenance	Complicated	Convenient
10	Rotating Speed	High	Low
11	Effect Of bird	Great	Small
12	Power Curve	Depressed	Full

Table 2 Comparison between Horizontal axis Wind Turbine (HAWT) and Vertical Axis Wind Turbine (VAWT)

According to the Table 2, we can easily spectator that VAWT is more efficient then HAWT. As a result, we can use VAWT to produce electricity with the help of Wind Energy.

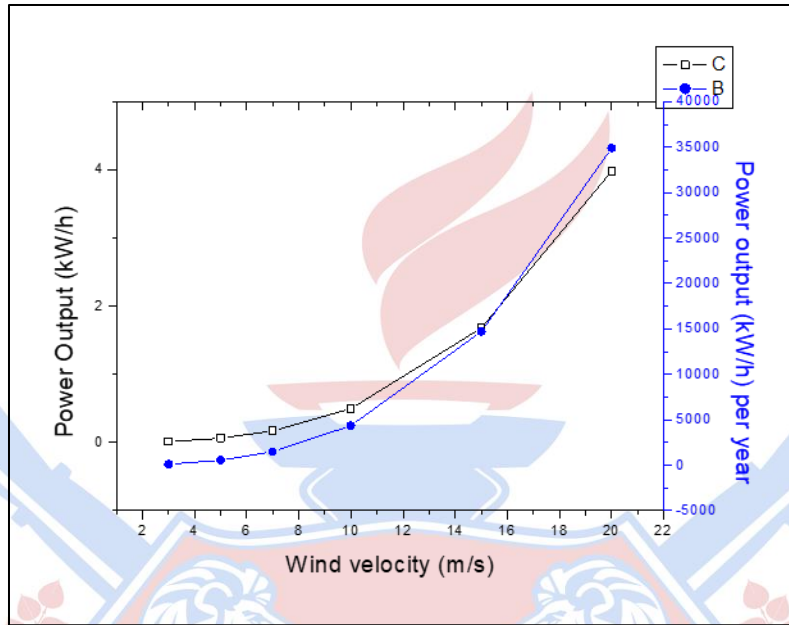


Figure 3 Power output based on wind velocity

From the Figure 3 reveals that yearly 35MW electricity can be produced with a minimum wind velocity of 20 m/s.

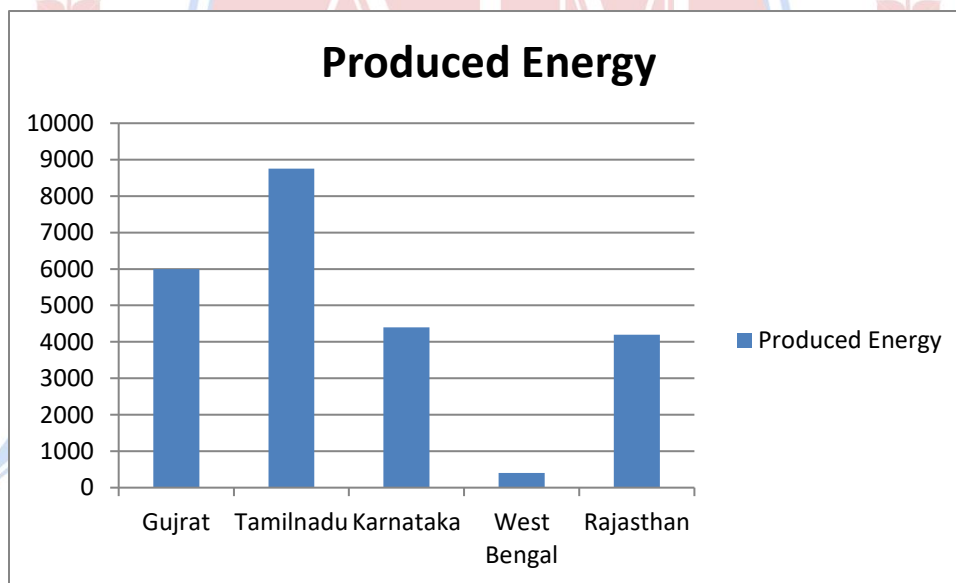


Figure 4 Production of energy state-wise

According to Figure 4, we can see West Bengal is in the last position in spite of West Bengal has a great source of Renewable Energy. Recently West Bengal Government is planning to set up a Wind Power station at Dadan Patra near Mandarmoni in East Midnapore. Besides, we are using the VAWT (Vertical Axis Wind Turbine) because according to Table 2 claim the advantages of VAWT. In near future, we hope that we can utilize properly the Renewable sources of West Bengal and we will be able to meet that deficit. [4]

Utilization of Hybrid Energy

In this part, we are trying to discuss the Hybrid Energy, the combination of Solar Energy and Wind Energy. According to many application of Renewable Energy , A small hybrid electric system that combines home wind electric and home solar electric (Photovoltaic or PV) technologies offers several advantages over either any single system .A handful of enterprising renewable energy developers are now exploring how solar and wind might work together , developing hybrid solar- wind projects to take advantages of the power-generating strengths of each – with the two technologies in tandem serving as a better replacement for climate warming fossil fuels than either could be alone .Co locating wind and solar plants can save money on grid connections , site development , and approvals but that's not the only benefit . When applied to micro grid systems, these micro grid are finding application in places like Hawaii and India where utility prices are exorbitantly high or where communities are too remote to be tied into the macro-grid. Micro-grids powered by photovoltaic's require battery storage, since people need power when the sun isn't shining, adding wind can help cut the battery costs, since the wind can (and often does) blow when the sun doesn't shine. According to West Bengal, Solar Intensity and Wind speed are variable in different places



Figure 5 Prototype model of Hybrid energy

The combination of solar cells and VAWT enables us to generate energy efficiently as shown in the Figure 5.

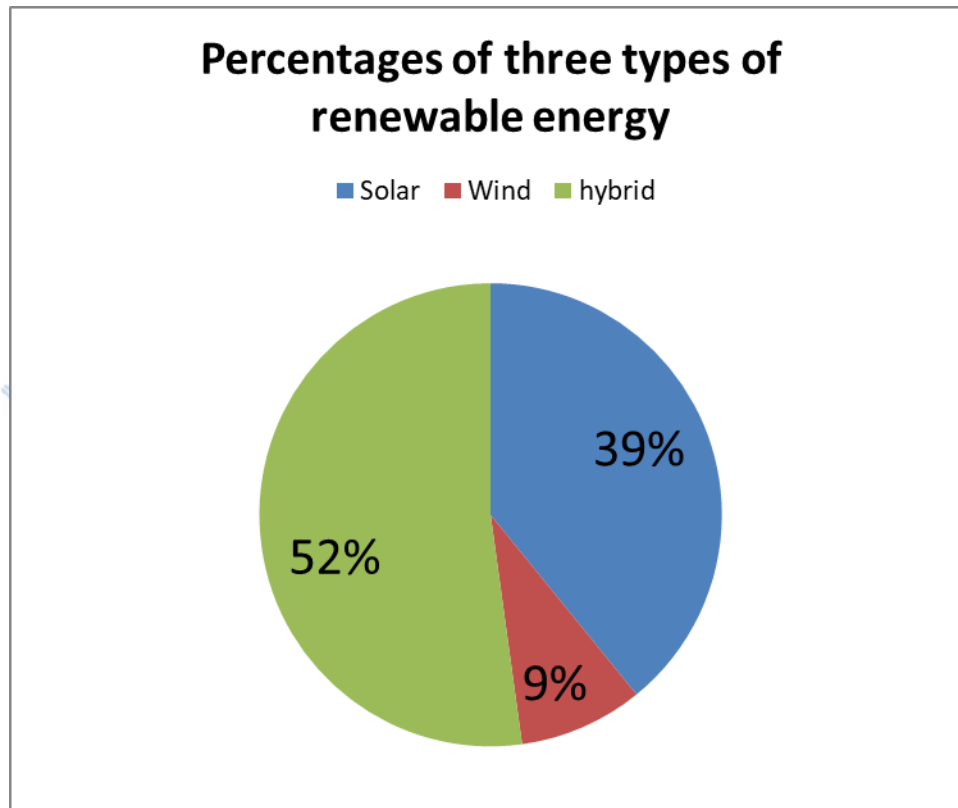


Figure 6 Scope percentages of three types of renewable energy

Figure 6 developed with respect to the Table 1 and its shows the percentage of Solar energy, Wind energy and Hybrid energy can be utilized in West Bengal. From the study it is clear that 12 districts of West Bengal have taken initiative in Hybrid Energy, 2 districts in Wind energy and 9 districts in solar energy.

Conclusion

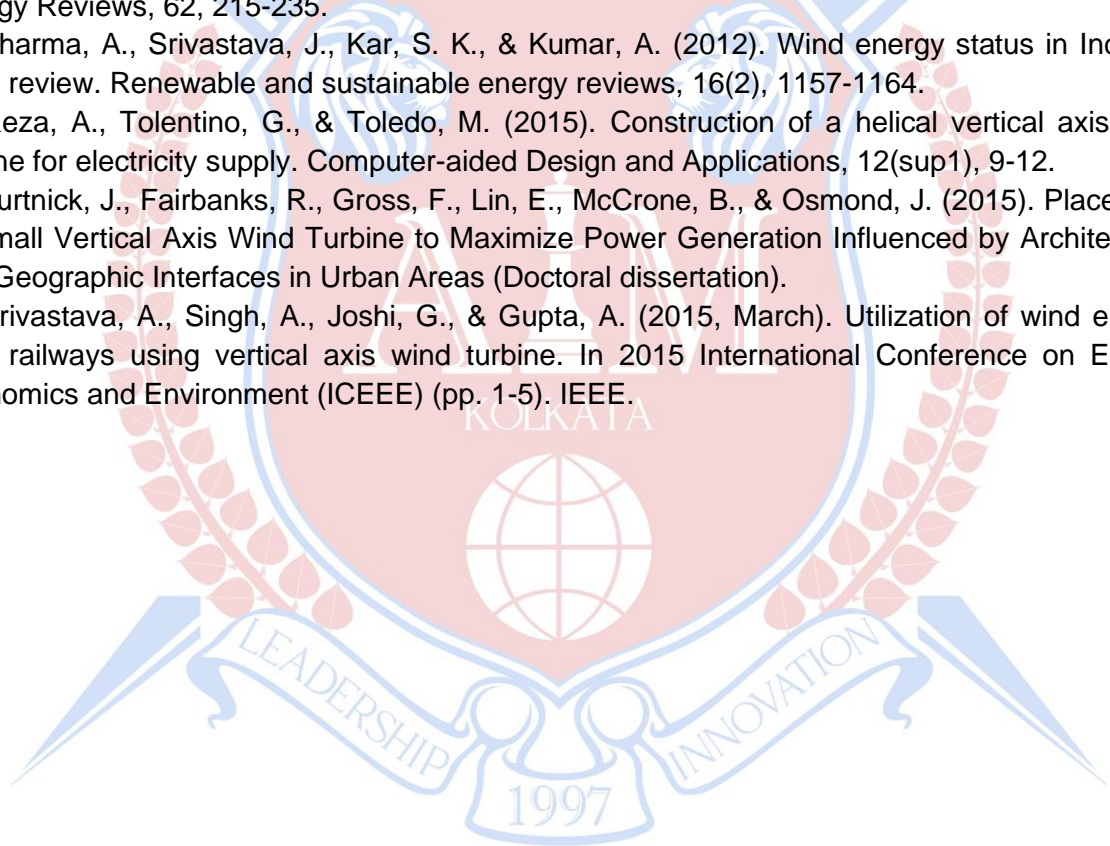
The solar and wind energy statuses in West Bengal, as well as state and district-level renewable energy statuses, have been examined in this article. West Bengal's energy consumption has been increasing at a rapid pace as the state's economy has grown. With an economy which is expected to rise at 8%–9% a year, accelerated urbanization, and rising living conditions for millions of households, demand is expected to skyrocket. West Bengal, like the rest of India, needs to understand the immense potential of renewable energy and ramp up efforts to meet the 2023 deadline. These goals are attainable, and they not only have renewable resources but also open up a new field for millions of people who are unemployed or working under the table. This momentum requires to be maintained.

Solar energy, wind energy, and a mixture of the two energy sources are more efficient and simpler to use in the production of electricity. Hence, it is important to design, develop and market newer, technologically superior sources of energy. Solar and wind energies together are more cost effective in lowering power generating unit costs. During the last few years, the government has shifted its focus to implement a robust clean energy strategy and funding systems in order to give positive signals to green power generators. These renewable sources

happen to be the ones. Undoubtedly, West Bengal has made a name for itself in the generation of renewable energy across India. It also has a lot of capacity for generating solar and wind energy, but there are some gaps. The Indian government has laid the groundwork for a broad-based green energy policy that is tailored to meet the country's rising energy demands and address the country's energy shortage. Thus, use of more green energy would in turn save the planet and pave the way for sustainable development.

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